Australian Government

Department of the Environment and Heritage

National Woodheater Audit Program

Final Report

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Executive Summary

Woodsmoke pollution from woodheaters is a major environmental problem in regions throughout Australia. Woodsmoke contains a range of air toxics pollutants, including benzene, formaldehyde and polyaromatic hydrocarbons. However, the principal pollutant associated with woodsmoke is particles.

The Australian/New Zealand Standard, AS/NZS 4013 is used to regulate the maximum particle emission rates in most States and Territories within Australia. The particle emissions performance of retail models, however, may not be the same as certification results because (a) woodheater models sold may differ from models tested in the laboratory and (b) woodheaters may have been modified, for example, to achieve longer burn times.

In recognising the need to better characterise woodheater emissions from models actually sold to the public, a National Woodheater Audit Program, with funding from Commonwealth, NSW, Victorian, Western Australian and Tasmanian environment agencies, was implemented. Retail models representing popular Australian models were purchased from retailers and tested for emissions performance under AS/NZS 4013 conditions. These results were then compared with their certified emissions values. As a concurrent exercise, the design features of key woodheater components were compared against design specifications to determine if this relatively inexpensive test is a reliable proxy for costly laboratory emissions testing.

To address these issues, the AHHA Testing Laboratory was contracted to carry out woodheater testing, both within the laboratory (AS 4013 emissions tests), and on-site design specification tests to determine if they are a reliable proxy for costly emissions testing. The 12 most popular nationally available models were tested for emissions and design specifications, with a further 35 models tested for design specifications alone.

Results from the Program showed that the extent of non-compliance was significant:

- 58% (7 out of 12) of woodheaters failed to meet AS/NZ 4013 particle emission limits

- 55% (26 out of 47) of woodheaters had one or more serious design faults that could affect performance

- 72% (34 out of 47) of woodheaters had one or more labelling faults that could affect emissions performance

An analysis of heaters tested for emissions performance showed that the presence of engineering design faults was a good indicator of emissions compliance:

- 100% (7 out of 7) of woodheaters that failed to comply with AS/NZ 4013 emission limits had one or more serious design faults

- 20% (1 out of 5) of woodheaters that complied with AS/NZ 4013 emission limits had one or more serious design faults

The most common engineering design fault associated with emissions and engineering design non-compliance was primary air inlets that were smaller than originally specified in design drawings.

These results indicate that the degree of non-compliance, in terms of emissions performance, engineering design specifications and labelling requirements, is significant and needs to be addressed by manufacturers and/or retailers. Further auditing is required to monitor the compliance of woodheaters available for retail sale. Assessment under future audits could take the form of initial engineering design testing, followed by emissions testing in cases of non-compliance.

Results also indicate that the Australian/New Zealand standard for determining emissions from woodheaters, AS/NZS 4013, may require amendment to make it more difficult for engineering modifications to be made to woodheaters and to ensure that when woodheaters have been modified during testing to meet allowed emissions under the Standard, that these modifications form the basis for woodheater design when woodheaters are subsequently mass-produced.

1) Introduction

In most Australian States and Territories, the Australian/New Zealand Standard (AS/NZS 4013 1999) for the determination of flue gas emissions from woodheaters, AS/NZS 4013, currently forms the basis for woodsmoke management, through the enforcement of the standard at the point of manufacture, sale or installation. Test procedures specified under AS/NZS 4013 include the documentation of key woodheater engineering design and labelling requirements.

Since the development of AS/NZS 4013, however, there have been some doubts that the emissions performance of woodheaters available for retail purchase complies with their certified emissions. To address this issue, woodheaters are routinely audited in many states in the US but, until recently, audits have not been conducted in Australia. Woodheater efficiencies (AS/NZS 4012 1999) and emissions performance may differ from their certified performance because (a) woodheater models sold may differ from the models tested in the laboratory, and (b) woodheaters may be modified, for example, to achieve longer burn times between refuelling. This could have adverse implications for air quality. The reduced effectiveness of certification, if it is occurring, also adds uncertainty to the calculation of woodsmoke emissions inventories and, consequently, the development of air quality management plans.

To address this issue, the South Australian Environment Protection Authority conducted a pilot woodheater audit program (EPA SA 2002). In this program, one-third of woodheaters tested did not comply with their certified emissions performance. Further testing, however, is required to develop an accurate picture of the extent of compliance on a national basis.

After consultation with those jurisdictions where woodsmoke is a major problem, it was agreed that, to obtain maximum value from audit programs throughout Australia, a coordinated approach should be adopted. This approach recognised that many woodheater models are available throughout Australia and ensures that audit programs from one jurisdiction did not merely duplicate work from another.

With the above issues in mind, DEH, along with environment agencies in NSW, Victoria, WA and Tasmania developed a $100,000 program to audit the most popular woodheater models available in Australia. The SA Environment Protection Authority also contributed to the program by making available results of their pilot audit program.

As a concurrent exercise, the engineering design specifications of selected woodheaters were compared against their documented manufacturing specifications. The aim of this exercise was to determine if design audits were a reliable proxy for costly laboratory emissions testing. This was done with a view to determining if future audit programs could rely significantly on design audits rather than laboratory emissions testing.

2) Objectives

Overall, the program sought to:

- deliver a better understanding of the true emissions performance of woodheaters available for retail sale;
- establish design parameters for a low-cost audit procedure, if it could be demonstrated that engineering design compliance equates with emissions performance compliance; and
- determine the root cause in cases of non-compliance – QA/QC shortcomings or deliberate tampering with appliance settings (air flow etc).

The above objectives were to be delivered through:

- the determination of audited and certified emissions results for 12 of the most popular Australian woodheater models;
- comparison of design specifications against test measurements for 47 of the most popular Australian woodheater models;
- the correlation of engineering design compliance with emissions performance compliance; and
- the determination of the principal engineering design and labelling factors leading to emissions non-compliance.

3) Project Design

The Australian Home Heating Association Testing Laboratory (formerly Amdel) was selected to implement the audit program.

3.1 <u>Selection and purchase of woodheaters</u>

Woodheater manufacturers, wholesalers and retailers were consulted, and a list was developed of 47 of the most popular AS/NZS certified models available in Australia (see Appendix 1). This project design reflected the program budget ($100,000), the cost of testing ($4,800 per emissions test, $250 per engineering design specification test), the cost of "leasing" new woodheaters (around $700 per model), and the number of tests needed to satisfy statistical requirements.

From the list of 47 woodheaters, 12 models representing four popular models available from NSW, three from Victoria, two from Tasmania, and one each from ACT, Queensland and WA, were selected for particulate emissions and efficiency testing. These models were also tested for design specifications against manufacturers' drawings that were submitted when initially certified, and for labelling compliance.

Woodheaters representing the above 12 models were purchased from retailers, at their premises, by AHHA staff. To ensure impartiality, environment protection agency officers from relevant jurisdictions accompanied AHHA staff to retailers' premises and supervised the random selection of woodheaters.

The remaining 35 models were assessed through a comparison of their manufactured key engineering design specifications against specifications from drawings supplied by manufacturers for the initial certification. Emissions testing was not conducted on these models. Again, relevant environment protection agency officers supervised the random selection of retail models to be assessed.

3.2 Test methods - emissions and engineering design specification testing and labelling

Particulate emissions testing, engineering design specification testing, and labelling compliance were determined in accordance with AS/NZS 4013, with standard test procedures followed. These variables, along with an assessment of their potential for influence on woodheater particle emissions, are documented in Appendix 2. AHHA Testing Laboratory is NATA registered for all tests under this program.

4) Results and Discussion

4.1. Emissions testing

Of the 12 woodheater models selected for emissions testing, seven (58%) were found to emit more than 4g of particles per kg of fuel burnt (the emissions limit specified in AS/NZS 4013). Some models emitted significant higher particle levels than their certified results, with one model found to emit almost 10 times its certified value (Appendix 3).

In a pilot South Australian Audit Program (SA EPA 2002), two out of six woodheaters tested (33%) failed to comply with their certified emissions value.

4.2. Engineering design specification and labelling compliance testing

All woodheater models were tested for compliance with engineering design drawings as submitted to the original test laboratory. Of the 47 woodheater models tested, 26 (55%) had deviations from the original designs that could adversely affect emissions performance. Only five models (11%) did not have any significant engineering design or labelling faults. Full results of engineering design testing are at Appendix 4.

All 47 models were also tested for compliance with labelling requirements under AS/NZS 4013. Of these, 34 models (72%) had one or more labelling faults that could adversely affect emissions performance. Full results of labelling compliance testing are at Appendix 4.

Incorrect labelling can affect emissions performance if (a) the correct fuel type to be burnt is not specified, then operators may burn fuels that produce greater emissions than those tested during certification and (b) the stated power output is lower than the true power output for a woodheater, then operators may choose to run these models at low air flows to lessen heat generation, and consequently create more unburnt fuel and particles. However, it should be noted that the practice of overstating power output by manufacturers is more prevalent.

4.3. Correlation between emissions performance and design compliance

All 12 models tested for emissions performance were also tested for compliance with their engineering design specifications.

Of the models that did not comply with AS/NZS 4013 particle emissions limits, all seven (100%) had one or more engineering design faults that could affect emissions performance, as specified in Appendix 3. Of the five models that complied with AS/NZS 4013 emission limits, only one model (20%) had one or more engineering design faults. Results of the comparison between emissions performance and engineering design compliance are presented in Appendix 3.

Six out of seven (86%) woodheaters that failed to comply with AS/NZS 4013 particle emission limits had smaller-than-specified primary air inlets, while one (14%) had baffle plates of incorrect dimensions and construction materials. Results of emissions testing, and associated engineering design non-compliances, are at Appendix 3.

These results indicate that relatively inexpensive design specification testing (around $250/test) can be a reliable proxy for costly emissions testing (around $6,000/test).

4.4 Woodheater labelling and engineering design faults leading to non-compliance

A summary table of key engineering design and labelling factors that can adversely affect emissions performance (as documented in Appendix 2), and the extent of compliance with certified results is shown in Tables 1 – 3.

The principal cause of non-compliance with design specifications was smaller-than-specified primary air inlets (40% of woodheaters tested did not comply because of this). In addition, the degree of labelling non- compliance was significant, with 45% of woodheaters being incorrectly labelled in terms of power output, and 60% of woodheaters incorrectly labelled in terms of the types of fuel allowed to be burnt.

Table 1 Non-Compliances - Labelling

AS/NZS 4013 section 10, Marking	**% Non-Compliance**
Name and address of manufacturer	N/A*
Model name and design identification	N/A*
Statement of compliance to AS/NZS 4013:2001	N/A*
Fuel type/s identified	N/A*
Statement of test power output and efficiency results in accordance with AS/NZS 4012	45
Fuel type/s identified	N/A*
Label, BURN ONLY “Fuel type”, visible when fuel door open	60

*N/A – Not assessed, as deemed to be non-critical in influencing emissions

Table 2 Non-Compliances – Operation Manual

AS/NZS4013 Section 8.2, Operation & installation manual	**% Non-Compliance**
Water Heating Facility (coil/booster) - If stated optional fitment, was heater tested with facility fitted	15
Multiple air controls (if fitted) – operation described and as per test report	0
Fan – operation (settings) described and as per test report	9

Table 3 Non-Compliances – Engineering Design

AS/NZS4013 Section 8.2(d), Design specifications	**% Non-Compliance**
Water heating facility specification	4
Fan specification	N/A*
Firebox liner dimensions and composition (firebricks, etc)	2
Secondary air tube/s or inlets –	
Air tube dimensions and number	0
Location	6
Orientation of air holes	0
Hole sizes and number	2
Secondary air preheat box / chambers –	
Dimensions	0
Location	0
Air inlet dimensions	11
Firebox outer convection shell dimensions	N/A*
Firebox dimensions (includes ash-pan & firebox doors)	2
Primary air outlets (preheat chambers, air-wash plate) –	
Dimensions (include air-wash plate gaps and angle)	0
Primary air inlets –	
Maximum setting dimensions	N/A*
Minimum setting dimensions	40
Baffle plate –	
Dimensions	6
Material composition	6
Location (vertical and horizontal)	6
Flue spigot -	
Location	0
Diameter	0

*N/A – Not assessed, as deemed to be non-critical in influencing emissions

4.4 Determination of root causes for failure

The root causes of engineering design non-compliance are quality control problems or deliberate modification by manufacturers and/or retailers. Quality control problems arise when check mechanisms are insufficient to detect and/or correct inadvertent manufacturing faults. Deliberate modifications include those made to achieve longer burn times, and the use of cheaper woodheater construction materials.

Additionally, the possibility exists that some engineering faults may be due to a lack of understanding by manufacturers of AS/NSZ 4013 requirements.

4% of models had faulty water heating specifications, 2% had non-complying secondary air tubes/inlets, 2% had incorrect firebox dimensions, 6% had incorrect baffle plate dimensions, and 6% had incorrectly located baffle plates. These defects indicate poor quality control.

11% of models had incorrectly sized secondary air inlet dimensions in the secondary air preheat box. These faults were predominantly a result of poor welding and again indicate poor quality control.

40% of woodheaters tested had smaller-than-specified primary air inlets (interestingly, a number also had larger-than-specified inlets). These design faults are likely a result of deliberate manufacturing practices, as narrowing the primary air inlet diameter will increase burn times.

6% of woodheaters tested had baffle plates made from unspecified materials. This is also likely to be deliberate, as cheaper steel can be substituted for more costly ceramic baffle plates. There is also the possibility that the substitution has occurred because steel baffle plates are less likely to be broken than ceramic ones.

5) Conclusions

Results from the national woodheater audit program demonstrate that the extent of non-compliance, in terms of emissions performance (58%), engineering design specifications (55%), and labelling requirements (72%), is significant. The most common engineering design fault associated those woodheaters that failed to meet their certified emissions performance was primary air inlets that were smaller than specified in design drawings.

When emissions performance was compared to compliance with submitted engineering design specifications, very good correlation was obtained. This indicates that future audit programs can be based on an initial assessment of engineering design compliance, with emissions testing to confirm findings in cases of failure.

A continuing audit program is therefore justified, until it is demonstrated that woodheaters available for retail sale are likely to comply with relevant standards.

A nationally coordinated approach offers the most efficient use of limited jurisdictional resources. To ensure the cost-effectiveness of future audit programs, a sound strategy is to initially conduct engineering design specification checks with emissions testing to follow, if woodheaters fail to comply with their original engineering specifications.
The effectiveness of AS/NZS 4013 as a means for regulating woodsmoke emissions must be questioned, with more than half the certified models tested failing to comply with their certification.

Findings from this program indicate a need to review the current system of certification and to introduce further measures to improve compliance. It is essential that there is ongoing dialogue between manufacturers, Standards Australia and relevant government agencies will be important to ensure that future manufacturing standards and test procedures are geared towards improving air quality.

Appendix 1

Woodheater Models Selected for Audit Program

Woodheater Model
Coonara Classic Bay
Heatcharm Settler
Jindara Riverina
Jindara Flinders
Logaire Laredo
Logaire Micros
Nectre 15
Kemlan Coupe
Masport Klondike
Masport Toronto
Masport Panorama
Norseman Silhouete GL
Norseman Oakwood Slimline
Lopi Endeavour 380NT
Woodland Heritage 500R
Eureka Solitiare
Osburn 2400
Morso 1410
Ultimate 10
Ultimate 17
Ultimate 24
Ultimate 25
Osburn 1800 Bay
Clean Air Medium

Woodheater Model
Norseman Lumberjack (NSW #1)*
Masport Arcadia (NSW #2)*
Ultimate 18 (NSW # 4)*
Jindara Kimberley (ACT #1)*
Ultimate Radiant (NSW #3)*
Heatcharm C600 Series 5 (VIC #3)*
Saxon Blackwood Series 3 (TAS #1)*
Kemlan Super Nova 2 (QLD #1)*
Eureka Diamond (VIC #1)*
Eureka Emerald (TAS #2)*
Jarrahdale Innovator (WA #1)*
Clean Air Small (VIC #2)*
Kent Somerset
Kent Jindabyne
Norseman Nevada
Kent Country Classic
Jotul F100
Woodland 1000
Arrow 1800
Coonara Compact
Coonara Medium
Ultimate 20 Elite
Masport Pittsburgh

*Popularity ranking within State for woodheaters selected for emissions testing

Woodheater Test Variables

'Critical' – Variation in item would adversely affect the level of particulate emissions. Either by influencing the way the consumer operates the heater or directly affecting the performance of the heater.

Item	Comments

AS/NZS 4013 section 10, Marking:-	
Name and address of manufacturer	**Not critical (except to provide audit trail)**
Model name and design identification	**Not critical (except to provide audit trail)**
Statement of compliance to AS/NZS 4013:2001	**Not critical (except to provide audit trail and consumer info)**
Fuel type/s identified	**Not critical (except to provide audit trail and consumer info)**
AS/NZS4012 section 8, Marking:-	
Statement of test power output and efficiency results in accordance with AS/NZS 4012	**Critical (understating power output can lead to operators using lower primary air flows to reduce power output)**
Fuel type/s identified	**Not critical (consumer info only)**
AS/NZS 4012 section 8.3, Fuel types:-	
Label, BURN ONLY "Fuel type", visible when fuel door open	Critical **(e.g. hardwood, softwood or coal briquettes produce significantly different emission performances. Without correct label consumer may use inappropriate fuel)**
AS/NZS4013 Section 8.2, Operation & installation manual:-	
Water Heating Facility (coil/booster) - If stated optional fitment, was heater tested with facility fitted	Critical **(e.g. water boosters can have severe adverse effect on emission performance. As a result the minimum primary air setting is set higher when tested)**
Multiple air controls (if fitted) – operation described and as per test report	Critical **(incorrect operation in some cases may significantly increase emissions)**
Fan – operation (settings) described and as per test report	Critical **(e.g. most heaters tested with fan off on low air control setting as per manufacturer's instruction manual at time of test. Operation of fan on low burn rate can significantly affect emission level. Excessive chilling of firebox)**

Item	Comments
AS/NZS4013 Section 8.2(d), Design specifications:-	
Water Heating Facility specification	Critical **(size of unit can affect amount of heat removed from firebox and hence affect combustion performance at low burn rates. This affects emissions)**
Fan specification	**Not critical (unless fan output significantly increased, then may excessively chill firebox. Variation would need to be large)**
Firebox liner dimensions and composition (firebricks, etc)	Critical **(affects heat transfer characteristics and thermal mass of firebox which alters combustion temperatures and emissions. Reduction of thermal mass and insulating characteristics is usually detrimental to emissions)**
Secondary air tube/s or inlets – **Air tube dimensions and number** **Location** **Orientation of air holes** **Hole sizes and number**	All critical **(any variation affects temperature, volume and velocity of secondary air entering firebox which affects combustion performance and emissions))**
Secondary air preheat box / chambers – **Dimensions** **Location** **Air inlet dimensions**	All critical **(any variation affects temperature, volume and velocity of secondary air entering firebox which affects combustion performance and emissions. This includes *increase* in inlet dimensions. Unlike primary air, too much secondary air can be detrimental, especially with hardwood. This is primarily an issue on the low primary air control settings)**
Firebox outer convection shell dimensions	**Not critical (other than differing between convection and radiant models. Radiant models tend to produce higher emissions than convection models due to greater**

	heat transfer characteristics, everything else being equal.)
Item	**Comments**
Firebox dimensions (includes ash-pan & firebox doors)	Critical **(Any variation of shape of firebox affects turbulence and residence time of combustion gases in firebox combustion zone. This affects combustion performance and emissions)**
Primary air outlets (preheat chambers, air-wash plate) – **Dimensions (include air-wash plate gaps and angle)**	Critical **(any variation affects temperature, volume and velocity of primary air entering firebox which affects combustion performance and emissions).**
Primary air inlets – **Maximum setting dimensions** **Minimum setting dimensions**	**Not critical unless variation is large.** Critical. **(Note: Any reduction will adversely affect emissions. An *increase* in the minimum primary air setting is not critical and may lower emissions.)**
Baffle plate – **Dimensions** **Material composition** **Location (vertical and horizontal)**	All critical **(any variation affects heat transfer characteristics, fuel/air residence time, fuel/air turbulence and thermal mass of firebox which alters combustion temperatures and emissions. Reduction of thermal mass and insulating characteristics is usually detrimental to emissions. Any change in dimensions affects residence time and turbulence.)**
Flue spigot - **Location** **Diameter**	Critical **(If location and diameter change by large amount it may affect the residence time, heat transfer characteristics and burn rate which affect emissions.)**

Appendix 3

Emissions and engineering design non-compliances for 12 selected models

Model Id	Certified Emission (g/kg)	Tested Emission (g/kg)	Design Faults	Labelling Faults
1	1.9	4.2*	Incorrect secondary air preheat box dimensions	Power/efficiency incorrect
2	2.4	2.7	None	Water heating facility incorrect
3	3.1	7.1*	Primary air inlets too small	Fuel type unspecified
4	3.7	2.3	None	Fuel type unspecified
5	2.0	5.2*	Primary air inlets too small	Fuel type unspecified
6	2.0	1.7	Primary air inlets too small	Power/efficiency incorrect Fuel type unspecified
7	2.1	9.0*	Primary air inlets too small	None
8	3.6	10.3*	Primary air inlets too small	Fuel type unspecified
9	<5.5	3.2	Incorrect baffle plate dimensions Incorrect baffle plate composition	Fuel type unspecified
10	3.4	10.6*	Incorrect baffle plate dimensions Incorrect baffle plate composition	Fuel type unspecified
11	4.0	1.8	None	Power/efficiency incorrect Fuel type unspecified
12	1.8	17.7*	Primary air inlets too small	Power/efficiency incorrect Fuel type unspecified

*Denotes non-compliance with maximum particle emissions allowed under AS/NZS 4013

Engineering Design Specification and Labelling Compliance Results

Model Id	Design Faults	Labelling Faults
13	Incorrect secondary air inlet dimensions	Power/efficiency incorrect
14	Incorrect secondary air inlet dimensions	Power/efficiency incorrect
15	Incorrect secondary air inlet dimensions	Power/efficiency incorrect
16	Incorrect secondary air inlet dimensions	Power/efficiency incorrect
17	Primary air inlets too small	Power/efficiency incorrect Fuel type unspecified
18	Incorrect secondary air inlet hole size/number	Fuel type unspecified
19	Primary air inlets too small	Power/efficiency incorrect Fuel type unspecified
20	None	None
21	None	None
22	None	None
23	None	Power/efficiency incorrect Fuel type unspecified
24	None	Fuel type unspecified
25	Primary air inlets too small	Power/efficiency incorrect Fuel type unspecified
26	Incorrect water heating specification Primary air inlets too small	Power/efficiency incorrect Fuel type unspecified
27	Incorrect water heating specification Incorrect firebox dimensions Primary air inlets too small Incorrect firebrick configuration	Power/efficiency incorrect Fuel type unspecified
28	None	Power/efficiency incorrect Fuel type unspecified
29	Incorrect fan specification Primary air inlets too small	Fuel type unspecified
30	None	Fuel type unspecified
31	None	None
32	None	None
33	Incorrect fan specification Primary air inlets too small	None
34	Incorrect fan specification	Power/efficiency incorrect
35	Incorrect fan specification	None
36	None	Fuel type unspecified
37	Primary air inlets too small Incorrect baffle plate dimensions Incorrect baffle plate composition	Power/efficiency incorrect Fuel type unspecified
38	None	Fuel type unspecified

Model Id	Design Faults	Labelling Faults
39	Primary air inlets too small	Fuel type unspecified
40	Primary air inlets too large	Power/efficiency incorrect Fuel type unspecified
41	Primary air inlets too large	Power/efficiency incorrect Fuel type unspecified
42	Secondary air inlet location Primary air inlets too small Baffle plate location	Power/efficiency incorrect Fuel type unspecified
43	Secondary air inlet location Primary air inlets too small Baffle plate location	Fuel type unspecified
44	Secondary air inlet location Baffle plate location	Fuel type unspecified
45	None	Fuel type unspecified
46	None	Fuel type unspecified
47	None	Power/efficiency incorrect