POTENTIAL OF HOT ROCKS IN CHRISTCHURCH

NATURAL RESOURCES ENGINEERING
PROJECT – ENNR 425

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EXECUTIVE SUMMARY

This report investigates the potential of Hot Rocks as a manufactured fuel for domestic use in Christchurch. It examines both the environmental and economic comparisons of Hot Rocks against other fuels such as wood and coal.

The major topics covered include:

- The present situation in Christchurch, focussing on air pollution and its effects
- Regulations that are in place, or proposed concerning domestic solid fuel burners
- The method of production of Hot Rocks
- A desktop correlation in order to estimate emission levels of Hot Rocks in burners meeting future requirements
- A comparative study of combustion properties and economics between wood and Hot Rocks
- Steps that need to be taken to ensure the viability of Hot Rocks as a manufactured fuel.

There are advantages to be gained through utilising manufactured fuels such as Hot Rocks, produced from waste products for domestic purposes. Waste that would otherwise be sent to a landfill is recycled into a useful product. This product also compares favourably to natural alternatives such as wood and coal - Hot Rocks produce burning characteristic equal or superior to that of natural fuel alternatives.

With the restrictions soon to be placed on coal and the proposed new regulations, public awareness on the issue of solid fuels has increased; hence it is an ideal time to enter the manufactured fuels market.

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1. Introduction

Christchurch City experiences severe smog each winter. These high levels of winter air pollution are caused through a combination of climatic, topographical and emission factors. The emissions can be separated into different sources such as those attributed to vehicles, domestic home heating and industry. Since government regulations do not give the Regional Council any opportunity to enforce restrictions on vehicle usage, emissions from domestic home heating have become the issue to try to reduce.

Also, recently with the planning of a new landfill for Christchurch, issues such as waste minimisation and recycling have become more recognised. General world trends are heading towards a more energy efficient society, with the decline of fossil fuels such as coal and oil. Hence, a fuel produced from municipal waste products, with associated low air pollution levels would create a positive impact in aiding the mitigation of both Christchurch's air pollution and waste disposal problems.

This report outlines in detail, the air pollution and waste disposal problems experienced within Christchurch as a result of domestic activities. After examining relevant air quality criteria, research carried out on Combustible Fire Bricks, along with a desktop comparison between Hot Rocks and Pinus Radiata, on a series of alternative solid fuel burners, in order to determine the possibility of Combustible Fire Bricks as an alternative fuel will be outlined. From this a environmental comparison and economic analysis has been conducted against commonly utilised domestic home heating fuels such as wood and coal, in order to determine the potential of the Fire Bricks, as a less offensive and environmentally friendly alternative fuel to other solid fuels.

2. Problem Overview

High levels of smog are currently experienced in Christchurch, with the most significant pollutant being PM_{10}; (these are particles contained within the air that have a diameter of less than 10 microns). The main producer of PM_{10} is through the combustion of solid fuels such as coal and wood for both domestic and industrial purposes.

Christchurch's smog problem is recognised nationally. It is not only a nuisance and aesthetically unappealing but also results in a variety of health related illnesses.

Another environmental problem Christchurch experiences is disposal of municipal waste. Recycling and reuse of municipal waste through the production of low emission fuel products from the waste may result in a reduced demand on landfills that are currently nearing capacity.

2.1 Christchurch Air Quality

Christchurch's poor air quality is amplified by the city's geographic location and calm winter weather conditions. During the winter months, anticyclonic (little or no wind) conditions cause strong night cooling and the consequent development of an inversion layer, resulting in the prevention of air pollution dispersion. A temperature inversion usually occurs when the temperature increases proportional to height in the lower atmosphere. This results in the formation of a very stable layer of air, which restricts the vertical transportation of any contaminants away from ground level. (CRC, 1998) The cold and frosty conditions associated with inversions, are the same conditions in which many of Christchurch's residents tend to utilise their solid fuel burner. Generally these conditions are exhibited one out of every three nights during the winter, causing noticeable levels of air pollution. (Andrews, 1994)

Within Christchurch, PM_{10} is the pollutant of most concern. Significant emissions of PM_{10} result from the combustion of coal and wood. Following an emissions inventory carried out in Christchurch by the National Institute of Water and Air Research, (NIWA) for the Canterbury Regional Council, it was found that 90% of the PM_{10} contaminant load found in the ambient air is a direct result of domestic home heating using combustion processes.

Within Christchurch, on a typical winter's night, approximately 14,000 open fires, 3,700 enclosed coal-burning devices and 31,000 enclosed wood burning devices are utilised. (CRC, 1998) In addition to these, thousands more open fires and enclosed solid-fuel burning devices are used occasionally.

A regional energy survey carried out indicated that in 1995, 64,580 tonnes of wood and 10,218 tonnes of coal were burnt for domestic purposes. This produced an estimated 13,000 tonnes of suspended particulate matter. (CRC, 1998) As Christchurch's population continues to increase, these levels will also increase proportionally.

The problem of emissions from domestic home heating devices is accelerated through the following conditions:

- high moisture content in the fuel being burnt,
- the banking up of fires overnight and,
- inefficient combustion techniques caused through the operation of older enclosed burners.

The most recent winter for which data is available is 1996. This shows that the 24-hour guideline for PM_{10} (Appendix A) of $50\mu gm^{-3}$ was exceed on 28 days throughout the 1996 winter. Up until 30 September 1997, the same guideline regarding PM_{10} had been exceeded on 30 separate occasions. On six of these occasions, the data exceeded $120\mu gm^{-3}$. Figure 1 below, shows the number of days the 24-hour average PM_{10} concentrations have exceeded the guidelines from 1988 to 1996.

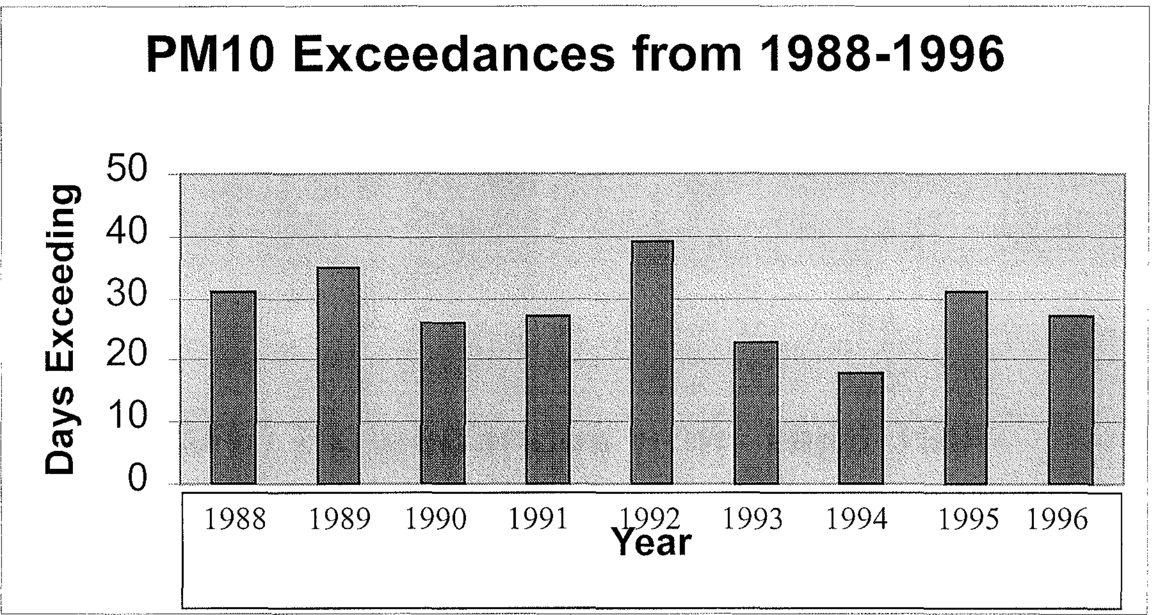

Figure 1 – PM_{10} Exceeding the 24-hour Guideline from 1988 to 1996, (CRC, 1997)

2.2 Adverse Effects of Air Pollution on Human Health

The excessive concentrations of PM_{10} often found in Christchurch over the winter months can result in a variety of health problems. These health problems stem from the respiratory system being inefficient at expelling PM_{10}. Once the particles are lodged in the lung, a notable proportion of them can not be expelled. Currently Christchurch's high concentrations of PM_{10} result in health problems ranging from minor irritations to the eyes and nose, to the magnification of current illnesses amongst susceptible groups and may even result in the premature death of those with serious cardiac and respiratory problems.

Particles that are less the 10 microns in diameter can not be seen. Consequently, also can not be avoided, even by remaining indoors during periods of high pollution.

Those particles that are less than 2.5 microns in diameter are called fine particles. Figure 2, on the following page, indicates that the particulate size is important in determining its ability to penetrate into the lungs, resulting in adverse health effects.

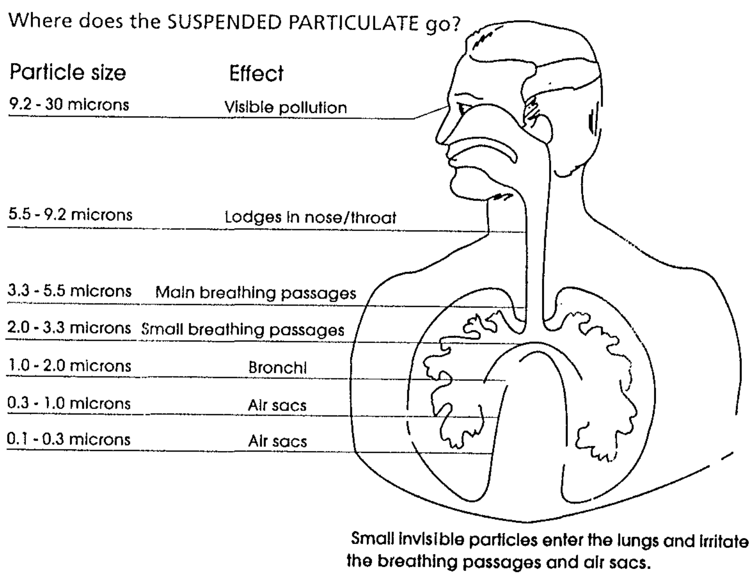

Figure 2 – Suspended Particulates in the Lung, (CRC, 1998)

If the current trends of increasing PM_{10} levels continue, the following estimates of adverse health effects may result in:

- Increased use of medications for asthma, bronchitis and other respiratory disorders,
- Extra doctor visits and hospital admissions for breathing related problems,
- Irritation of eyes, throat, sinuses and breathing passages,
- Annual loss of over 82,000 work days during which peoples activities may be restricted,
- Between 21-29 hastened deaths of people already suffering from cardiopulmonary and respiratory disorders (emphysema) annually,
- More allergies and asthma attacks,
- Increased susceptibility of all people but especially children and the elderly, to viruses causing colds and flu. (CRC, 1997).

2.3 Tangata Whenua Values

Air pollution decreases the value of clean air as taonga (treasure) to Tangata Whenua. Air, as a resource, is important to Tangata Whenua due to its interrelationship with other resources including water, flora and fauna, and its life supporting capacity.

Previous consultation has revealed that Tangata Whenua want 'all harmful contaminants removed from air discharges and the cessation of all harmful discharges into air which threaten the life-supporting capacity of air, land and water.' (CRC, 1993)

2.4 Amenity Effects

Christchurch is nationally recognised for its image as the 'Garden City'; however, this is tarnished every winter by the reoccurance of smog.

Christchurch's tourism numbers are increasing, both domestic and international visitors alike. In 1996, the total population on census night (5 March) was 314,118, an increase in the total population of 7.6% since 1991. It may be assumed that the growth rate for the total population is a reflection of the increased proportion of non-resident population in the city on census night. (Barber, 1998)

Christchurch City also has an international reputation for its natural recreational features and is known as an ideal training ground – with the sea, flat plains and mountains. With the up-and-coming Sydney Olympics in the year 2000, Christchurch may be home to many athletes resulting from its close proximity to Sydney. However, the smog problem it experiences may leave those athletes with more than a sour taste in their mouths.

2.5 Regional Waste Disposal

Annually 240,000 tons of municipal waste is disposed of by the Christchurch City Council. The waste is proportioned as follows: 40% domestic and 60% commercial waste. This results in costs of $9.6 million annually. (Cosgrove, 1998)

Any attempt at recycling or reusing this waste will have positive effects on both the local environment and economy.

Recently kerbside recycling has been introduced to Christchurch in order to attempt to decrease quantities of waste to be disposed of and increase innovation in recycling.

3. Required Emission Standards

3.1 New Zealand Ambient Air Quality Guidelines

The World Health Organisation (WHO) established air quality guidelines with the aim of protecting health in 1987. These were the guidelines on which the Ambient Air Quality Guidelines for New Zealand (Ministry for the Environment) were based. (See Appendix A) Currently the New Zealand Ambient Air Quality Guideline for PM_{10} is a maximum average of 120 μgm^{-3} over any 24-hr period.

The Canterbury Regional Council, on its own initiative has reduced these guidelines further still, adopting a 24 hr guideline for PM_{10} of 50μgm^{-3} not to be exceeded more than once annually. (CRC, 1998)

3.2 Transitional Regional Plan

The Transitional Regional Plan is the current regulation than is able to be enforced relating to the use of non-specified fuels in approved solid fuel burners and open fires.

It states "Fuels that have not been approved (successfully tested) in an approved domestic solid fuel burner may not be utilised, as it is an non-complying activity, within the Clean Air Zone (Christchurch) Order 1977." (Section 9c, iv)

This clearly indicates that under current legislation, Hot Rocks may be burnt in open fires only, as the Transitional Regional Plan has no regulations in place regarding open fire use. Further details of the Transitional Regional Plan can be found in Appendix B. But under the proposed Regional Plan, Hot Rocks will not be able to be utilised at all after 30 September 2001, when open fires are phased out, unless it is a certified fuel.

The current situation on the installation of domestic solid fuel burners and their PM_{10} emissions is dependent on the burner holding a Clean Air License. A Clean Air License has the following conditions:

- A solid fuel burner with particulate emissions greater than 3g/kg can no longer be installed, unless the application for installation occurred two years ago when the standards for particulate emissions were based on NZS 4703:1992. (5.5g/kg)
- A solid fuel burner with particulate emissions between 1.5 – 3.0g/kg can continue to be installed until 30 September 2002.
- A solid fuel burner with particulate emissions less than 1.5g/kg can be installed and must be installed after 30 September 2002.

It is assumed that the useful lifetime of a domestic solid fuel burner is 15 years, so gradually as the burners are replaced with those that meet the particulate emission standard at that time, pollution as a result of PM_{10} will decrease to acceptable levels.

3.3 Clean Air Zone (Christchurch) Order 1977, Amendment #4, 1988/1997

This amendment is with regards to authorised fuels and those fuels that are prohibited. It states:

- firewood must have a moisture content less than 25%
- coal or oil derived fuel must have a sulphur content less than 1%
- fuel must only be burnt in a burner authorised for the Clean Air Zone 1997.

Further details of this amendment can be viewed in Appendix C.

3.4 Draft Natural Resources Regional Plan, Part A: Air

Recently the Draft Natural Resources Regional Plan, Part A: Air was published as a guide by which air quality issues may be addressed throughout the Christchurch region.

This document proposes to regulate activities, through regional rules, which address:

- The discharge of contaminants to air from solid fuel-burning devices which meet specific emission criteria,
- The discharge of contaminants to air from existing solid fuel burning devices (except those meeting specific emission criteria) 15 years after original installation in any dwelling or building,
- The discharge of contaminants to air from open fires in any dwelling or other building,
- The discharge of contaminants to air from the combustion of fuel in any domestic heating device,
- The discharge of contaminants to air from the combustion of coal or coal derivatives in any domestic heating device,
- The discharge of contaminants to air from domestic heating devices resulting in objectionable or offensive smoke or odour detectable beyond property boundary,
- The discharge of contaminants to air from fuel-burning equipment used by industrial or trade processes,
- The discharge of contaminants to air from the combustion of any material in the outdoors. (CRC, 1998)

A detailed set of the rules can be viewed in Appendix D.

The intentions of the Draft Natural Resources Regional Plan, Part A: Air can be placed into three categories:

- Coal use,
- Open fire use,
- Woodburners.

3.4.1 Coal Use

The Plan proposes that domestic coal burning should be prohibited in the Christchurch Clean Air Zone 2000 from 30 September 1998, unless it is within a burner that may, in the future, meet the Regional Councils 1.5g/kg emission criteria, of which none currently do.

The reasons for the proposed ban on coal are as follows:
- The high levels of particulate generated by coal burning,
- The small number of householders currently utilising coal (compared to the amount of particulate produced),
- The alternative fuel sources available to most coal users,
- Immediate and significant reductions of PM_{10} concentration at relatively low cost,
- The smell of burning coal is offensive to many people,
- Soiling caused by coal smoke.

The benefits brought about by the ban on coal are thought to be:
- Coal is relatively expensive to burn
- Ban will decrease the PM_{10} concentration by approximately 20%
- Decrease in unpleasant odours and soiling
- Christchurch will be a more healthier and attractive place to live.

3.4.2 Open Fire Use

Open fires are proposed to be phased out within the Christchurch Clean Air Zone 2000 from 30 September 2001. This is inclusive of fireplaces and open hearths capable of burning any fuel type.

This proposal has been put forward due to the following:
- Nearly half of the measured concentrations of suspended particulate in ambient air in Christchurch originate from the combustion of solid fuels in open fires.
- The estimated 14,000 households that regularly use open fires will, in the long run save money through improved fuel efficiency.

The benefits of the ban on open fire use are:
- PM_{10} emissions and nuisance effects of smoke from open fires will be reduced, hence air quality improved,
- More heat output – open fires lose at least 80% of the heat produced up the chimney and bring cold air into the home when not being utilised.

3.4.3 Woodburners

The Plan proposes that enclosed domestic solid fuel burners (which do not meet the Council's emission criteria of less than 1.5g/kg) will be phased out from 30 September 2002, or 15 years after the date of installation.

This proposal is due to the following:
- Suspended particulate concentrations will not be reduced enough to meet the health target for PM_{10} if burners do not meet this criteria,
- Enclosed solid fuel burners have an average useful lifetime of 15 years,
- Older burners are more polluting than modern types,
- Educating people on choosing the right type of heating for their needs.

The benefits of this proposal are:
- Older burners will slowly be replaced with cleaner methods of heating
- PM_{10} emissions and nuisance effects produced by inefficient combustion fuels will be reduced by gradually removing older appliances.

The above draft is in association with the proposed Christchurch Clean Air Zone 2000.

Effective from 30 September 2002, the maximum PM_{10} emissions allowed will be 1.5g, applying to appliances prior to sale, not those already installed within the extend clean air zone. (CRC, 1998) Appendix L has a list of approved woodburners.

3.5 Key Air Quality Indicators

The Canterbury Regional Council has identified and are currently monitoring the following air quality indicators in association with their air quality assessment program for Christchurch:

- Suspended Particulate (PM_{10}),
- Carbon Monoxide (CO),
- Sulphur Dioxide (SO_2),
- Nitrogen Dioxide (NO_2),
- Lead (Pb),
- Ozone (O_3).

These have been specifically selected for monitoring, although they are present in ambient air, as they are known to result in adverse human health effects. (CRC, 1997)

4. Hot Rocks – The Product

Combustible Fire Bricks, until recently, were marketed by Meadow Fresh under the name of Hot Rocks; they are briquettes made from recycled materials. They are comprised of waste coal, paper and plastic. The mix proportions by dry weight are 60% coal, 25% paper and 15% plastic. (Meadow Fresh, 1996) The bricks are a block of solid fuel approximately 150 x 100 x 50 mm in size and weigh about 400g. (Richards & Storm, 1989) See below in Figure 3, some Hot Rocks.

Figure 3 - Hot Rocks

Meadow Fresh marketed the Hot Rocks as:

- clean burning solid fuel alternative,
- having smoke emissions below New Zealand Standards,
- ideal to assist burning of wood that is not totally dry,
- ideal for banking up woodburners overnight,
- light, clean and convenient to handle,
- environmentally safe,
- utilises recycled newspaper and milk bottle, plastic/cartons,
- better heating efficiencies than Radiata Pine a low burnrate settings,
- slow burning for maximum heating efficiency,
- easy to ignite,
- can be burnt in conjunction with wood and coal,
- ideal for woodburners. (Meadow Fresh, 1996)

4.1 Raw Materials

4.1.1 Waste Paper

Waste paper makes up a major proportion of the contents of the Fire Bricks, as its advantages as a combustible product outweigh its disadvantages, seen below in Table 1:

Advantages	Disadvantages
Good reliable material source	Hard to shred and process
Consistent moisture content	Large volumes of ash produced
Higher heating value than wood after compression	Produces low density pellet
Burns cleanly	
Ability to aid in bonding	

Table 1 - Advantages and Disadvantages of the Inclusion of Waste Paper in Hot Rocks, (Cosgrove, 1998)

Generally, the most common waste paper used to produce the Hot Rocks is newsprint due to its source of cellulosic fibre. In most cases, any paper based from wrapping paper or cardboard is acceptable due to its long fibres. The type of paper selected in the production process of the Hot Rocks is influenced by:

- For optimum strength, the repulped furnish should include adequate fibre quality,
- For ease of repulping, the paper should not be plastic or wax coated,
- To optimise the burning qualities and minimise the ash content of the Combustible Fire Bricks, use of heavily filled papers ie; wallpapers and polished papers should be restricted in use,
- To avoid the dispersion of heavy metals in the environment, heavily coloured papers printed with inorganic inks should not be used. (Richards & Storm, 1989)

4.1.2 Waste Plastic

There are two types of plastic compounds, thermoplastics and thermosetplastics. Thermosetplastics are not recyclable since once they have initially been formed; heat or pressure can change them no further. Consequently, this report is more concerned with thermoplastics, since they are recyclable, (ie; can be reformed through the application of heat and pressure), although, can not be recycled are reused as food packaging

There are seven basic types of thermoplastics, as shown on the following page in Table 2:

Plastic Type	Use	Code
PET Polyethylene Terephthalate	Soft drink bottles, some shampoo & detergent bottles	1
HDPE High Density Polyethylene	Milk bottles, household cleaners, supermarket bags	2
PVC Polyvinyl Chloride	Detergent bottles, some shampoo bottles, film for meat wrapping	3
LDPE Low Density Polyethylene	Bread Bags	4
PP Polypropylene	Bread Bag Tags, jars, some wrapping films	5
PS Polystyrene	Yoghurt and margarine containers, meat trays	6
- All other resins and mixed plastic		7

Table 2 - Plastic Type and Recycling Code, (CCC, 1994)

Each different plastic type is given a code from one to seven, this international coding system assists with the sorting of waste and recyclable plastics. The code is found within the recycling triangle.

The codes, which are deemed safe for combustion, are 1, 2, 4 and 5; these contain plastics, which are basically comprised of polyethylene (PE), and polypropylene (PP). These two plastic types (PE and PP) are derived from crude oil. Whereas other plastics (such as those with code 3) contain halogens (such as chlorine), these are unacceptable to be included in Hot Rocks due to the chemicals contained in the fumes expelled when burnt. Consequently, only plastic milk containers (code number 2, HDPE, high-density polyethylene) are included in the Hot Rocks. The inclusion of the plastic milk bottles is for two reasons:

- The ready availability of waste plastic milk bottles in the market place and,
- The assurance, through easy identification, that the only plastic incorporated into the Fire Bricks is HDPE. (Richards & Storm, 1989)

As previously stated, other plastics with codes 1, 4 and 5 are also acceptable for use in the Hot Rocks, however, they would be required to be thoroughly cleaned to remove any contamination and may cause problems in the production process with blocking the shredder.

4.1.3 Waste Coal

The inclusion of coal fines in the Hot Rocks affects the heat output, combustion and lifetime of the Fire Bricks. Coal with low moisture and ash content, produces a higher heating value - hence increase the heat output of the Hot Rocks. Preferentially, coal fines should be no larger than 6 mm in diameter in order to combine successfully with the plastic HDPE and paper to form the Bricks.

4.2 Production Process

The process by which the Hot Rocks are produced is shown below in Figure 4:

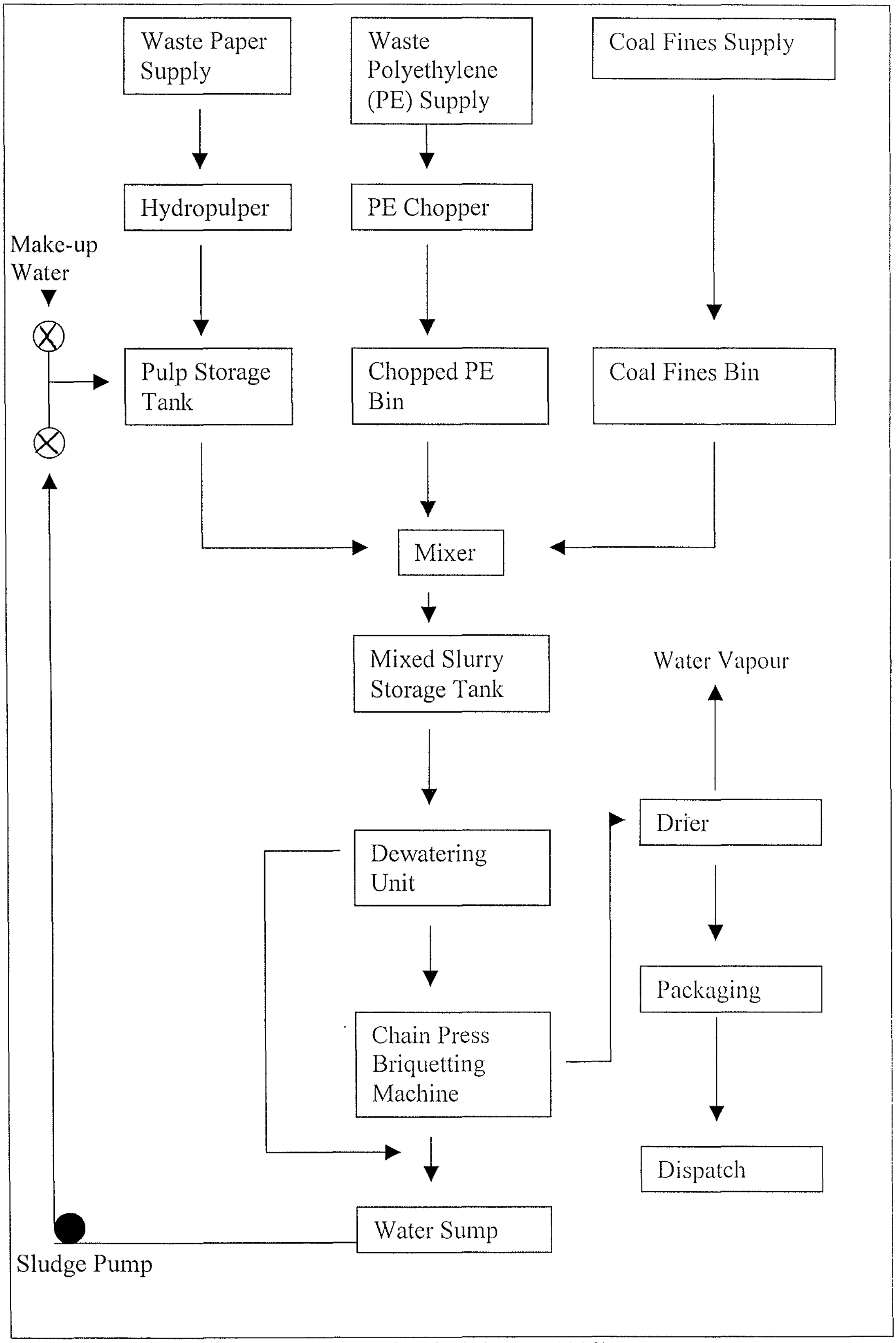

Figure 4 - Briquetting Process - (Richards & Storm, 1989)

4.2.1 Paper Pulping

As stated, newsprint is the most common type of paper used, it is repulped with water through a hydropulper (mechanical impeller); this creates shear forces that act on the paper, reducing it to a pulp. This pulp remains at a viscosity, which is pumpable, and the pulp will continue to remain in suspension, provided the water is not drained off. In most cases, the pulp is stored in a tank and is then ready for mixing with the coal fines. (Richards & Storm, 1989) See Figure 5, below for view of pulper and mixer.

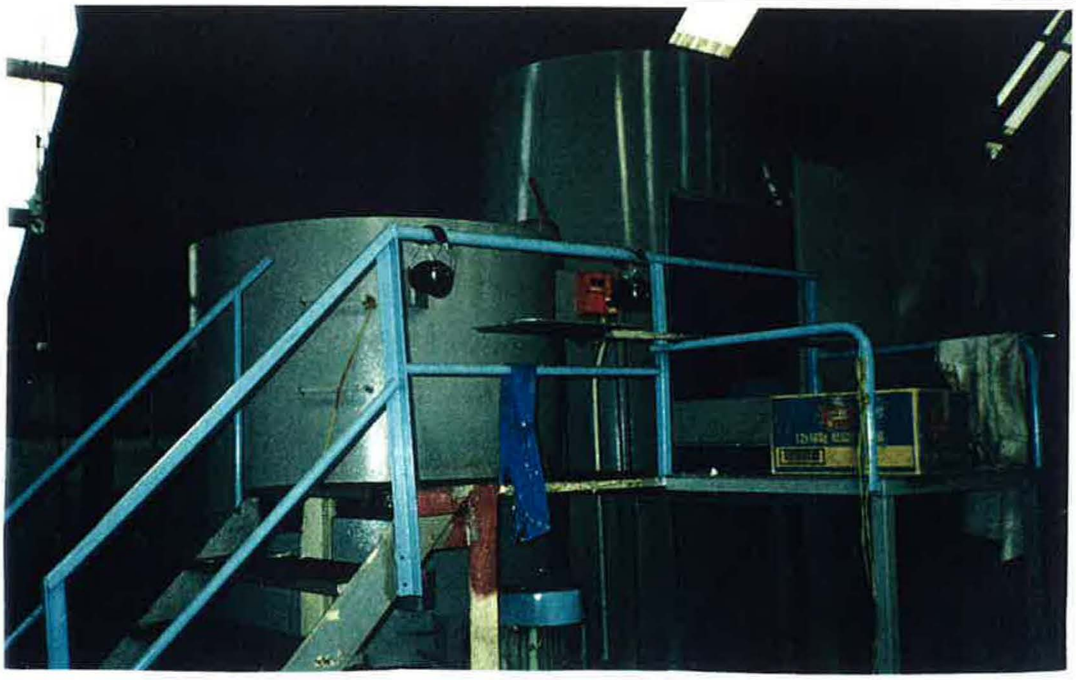

Figure 5 – Hydropulper and Mixer

4.2.2 Coal Fines

The quality of the coal fines used in the production of the Hot Rocks affects the final burning properties of the Hot Rocks, however the type of coal used is not extremely critical.

The fines used in the Hot Rocks are the undersized particles from the coal washing and grading process at a mine. These fines are generally regarded as waste and are dumped; hence their use limits the environmental impact of coal mining.

4.2.3 Polyethylene

The Hot Rocks Factory is positioned adjacent to the Meadow Fresh Factory, Dunedin, and enables ease of delivery to the factory of the two litre HDPE containers. Following this, they are then shredded into small particles no larger than the size of a little fingernail. These HDPE particles are then stored for inclusion in the Hot Rocks.

4.2.4 Mixing

The paper pulp, coal fines and shredded plastic are mixed with large quantities of water. This mixture is continually stirred until it reaches a density at which the material can meet the handling and conveying requirements to transport it to be formed into briquettes and the dewatering process.

4.2.5 Bonding Process

The bonding of the cellulose fibres within the briquettes occurs effectively due to the locking together of small fibrils, which act as minute hooks. The process of locking together the fibrils best occurs through the removal of the water from the slurry, this allows the fibres to move from a mobile, to a compact environment. (Richards & Storm, 1989)

4.2.6 Briquetting

In order for the briquetting process to occur, a chain press briquetter was developed. This machine simultaneously shapes, dewaters and compacts the briquettes while they are travelling in a continuous forward motion. When the moisture content and production rate of the green Hot Rocks has been determined, a constant feedrate of similar quality pulp transported onto the chain press will result in a continuous flow of blocks throughout this process.

As the blocks continue through this process, dewatering is constantly occurring, the blocks are continually compacted and squeezed into shape. The water obtained from the dewatering process is clean enough to for it to be recycled back into the hydropulper.

The maximum production rate of the briquetting process is approximately 2 tonne/hour of green briquettes. (Richards & Storm, 1989) Following this process, the bricks are set aside for drying.

4.2.7 Drying

The drier must provide not only heat, but also ventilation around each brick, as a large amount of moisture is expelled from the Hot Rocks during the drying process. For this reason, a tunnel drier is utilised, and the bricks are arranged on racks that can be progressively moved through the drier. The tunnel drier is designed to:

- Decrease the moisture from 50% to approximately 7%,
- Achieve uniform drying without setting fire to the plant,
- Cope with the required continuous production rate. (Richards & Storm, 1989)

The tunnel drier operates on the principle of counter flows, the Hot Rocks and the hot drying air flow in opposite directions. Also, as stated, any moisture-laden air must be continually released to the atmosphere via a flue. See Figure 6, on the following page, for a view of the tunnel drier.

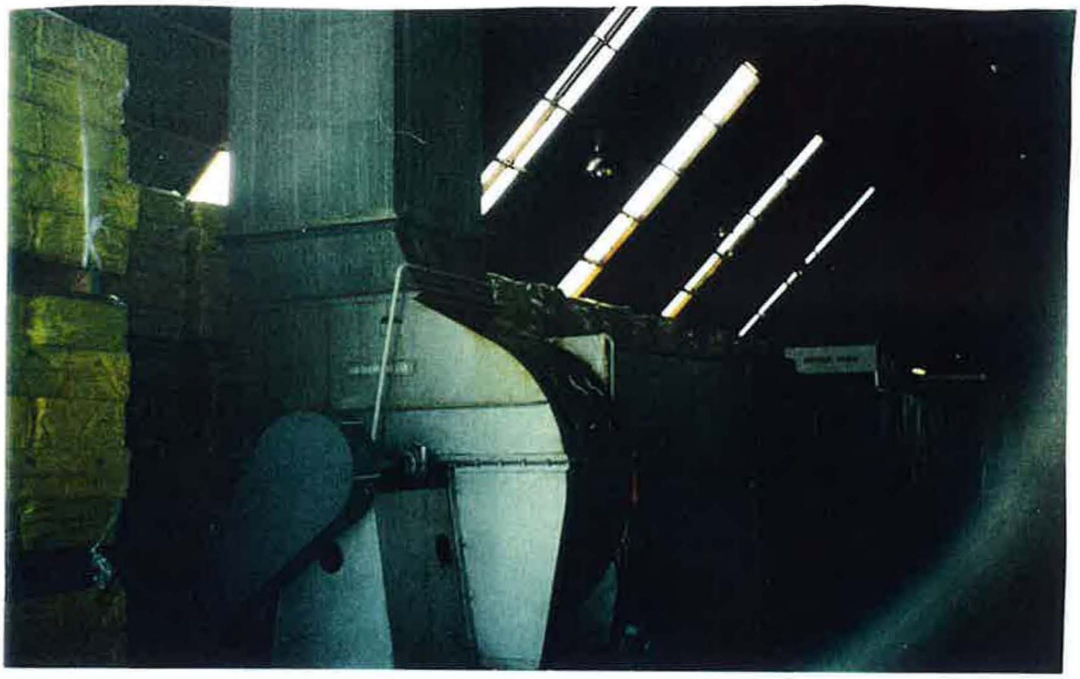

Figure 6 – Tunnel Drier

The time, in which the racks remain within the oven, is largely dependent on the required moisture content of the final Hot Rocks. After the time required for adequate drying to obtain this moisture content, the rack of dry Hot Rocks at the hot end of the oven is removed and the remaining racks are pushed closer to the hot end of the oven, making room for green Hot Rocks to be stored at the cooler end of the oven. Hence, the tunnel driver approaches continuity.

A diesel heater provides heat for the drying process.

Finally, the Bricks are allowed to cool in ambient air. These Hot Rocks are then packaged.

4.2.8 Packaging

Hot Rocks used to be packaged in shrink packs of 24 and were transported throughout Southland and Otago. Figures 7 and 8 show the packaging machine and the final product, respectively.

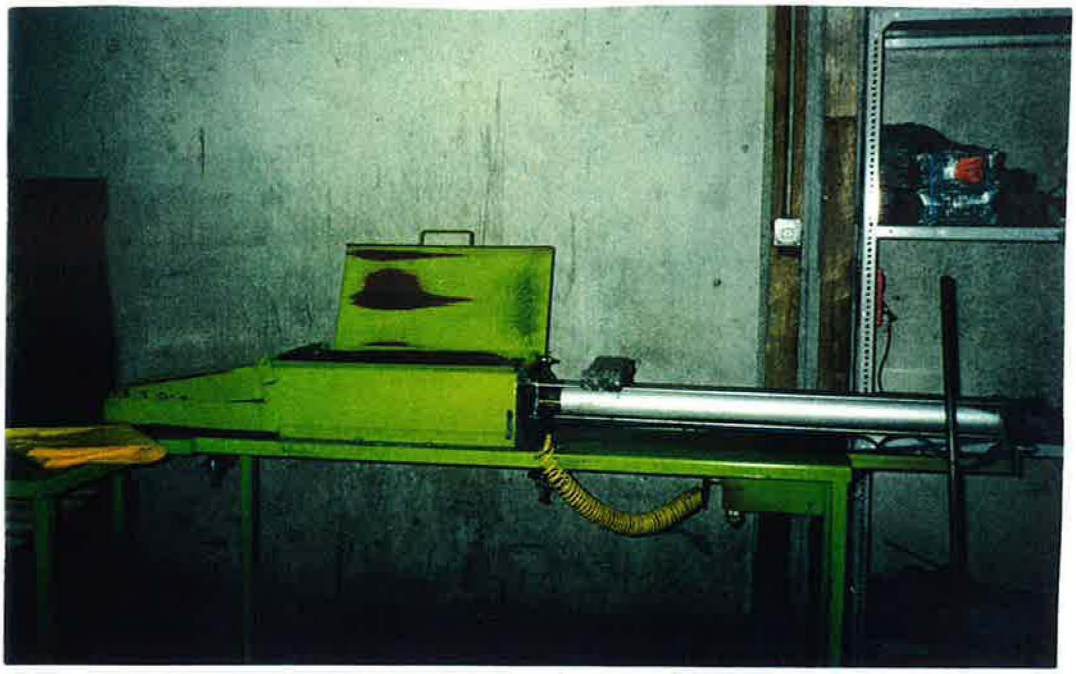

Figure 7 – Packaging Machine

Figure 8 – Packaged Hot Rocks

4.3 Previous Tests

4.3.1 1980's

During the early 1980's the Industrial Processing Division of the DSIR first developed the Combustible Fire Bricks. This development was specifically aimed at:

- reducing the winter smog in the Christchurch Clean Air Zone 1977, and
- recovering energy from combustible wastes, such as paper, plastic, sawdust and coal dust.

During this period of time, a smokeless fuel was thought to play a role in improving Christchurch's air quality, and also to decrease a glut of wastepaper from recycling programs.

Tests were carried out on the raw materials contained within the Combustible Fire Bricks; these results are shown below in Table 3:

Solid Fuel	**Average Heat Output under Test Conditions used, kW**	**Measured Particulate Emission g/h**	**Permitted Particulate Emission g/h**
Coal			
Strongman (Test 1)	3.2	>15	6.1
Strongman (Test 2)	2.3 - 6.3	21 - 49	5.8 - 7.1
Paper-Bonded Strongman Coal Briquettes			
20% Paper 80% Strongman	2.7	6.7	5.9
30% Paper 70% Strongman	2.6	7.8	5.9
50% Paper 50% Strongman	4.0	3.8	6.3
70% Paper 30% Strongman	4.0	5.8	6.3
Wood			
Dry Pine	2.9	8.6	6.0
Damp Pine	3.5	9.5	6.2

Table 3 – Combustion Tests on Different Compositions of Hot Rocks and Pine, (Richards & Storm, 1989)

The Cawthron Institute and CRANZ carried out these tests in 1978 - 1980, on different compositions of the Combustible Fire Bricks, (excluding plastics) in comparison with Pinus Radiata.

The tests, in most cases, showed that Paper-bonded Strongman Coal Briquettes had lower particulate emissions than damp or dry pine. However, these particulate emissions generally were higher than the permitted particulate emissions, as was the case for Pinus Radiata.

However, due to the cost of drying the Combustible Fire Bricks and limited technological advance in this area, no further research or pilot tests were carried out.

4.3.2 September 1995

In September 1995, Coal Research Limited carried out a series of comprehensive tests in their Home Heating Test Centre in Lower Hutt for Meadow Fresh, who were interested in the production of the Combustible Fire Bricks. These tests were specifically carried out due to the proposed incorporation of plastics into the Fire Bricks.

From these tests, which included testing different formulations, power output, efficiency, particulate emissions and flue gas analysis, the following results were obtained in Table 4:

Formulation Number	**Paper, wt %**	**Tetra Rex, wt %**	**HDPE, wt %**	**Bituminous Coal, wt %**	**Gross Calorific Value MJ/kg**
1	20	0	5	75	26.4
2	20	2.5	5	72.5	27.2
3	20	5	5	70	27.1
4	20	10	5	65	26.8
5	20	0	0	80	26.4
6	20	0	10	70	28.2
7	20	0	20	60	30.6
8	20	2.5	7.5	70	27.6

Table 4 - Special Formulations Designed to Evaluate the Performance of "Hot Rocks" containing "Granulated HDPE and/or Tetra Rex Beverage Containers, (Richards, 1995)

All of the tests were carried out in a HMF Merlin 3 Woodburner, which had already been tested using Pinus Radiata, and had met NZS 7403 for it to qualify as an approved appliance.

These tests were carried out using the methods of NZS 7402:1992 and NZS 7403:1992. These standard methods actually apply to the testing of solid fuel burning appliances, such as enclosed coal burners, wood burners and pot belly stoves. The methods were not developed to test solid fuels, although the standards do specify the types of fuels which are to be burnt in the testing process and Hot Rocks is not one of them. (Richards, 1995)

4.3.2.1 Flue Gas Emissions

At the time the tests were conducted, there were no standards relating to flue gas emissions (apart from particulate matter) from a solid fuel domestic burner, as a consequence, a flue gas analysis was not required as a part of NZS 7403:1992. However, due to the inclusion of plastics into the Combustible Fire Bricks, a flue gas analysis was carried out, as requested by Hot Rocks Ltd, to ensure the incorporation of plastics was not any more detrimental to air quality than wood or coal.

Analyses carried out on the gases included:

- carbon dioxide,
- carbon monoxide,
- methane,
- ethane,
- propane.

No analyses were conducted regarding the determination of dioxins or furans due to the high costs associated with the testing procedure. However, it was thought that because levels of those toxic compounds in the flue gases from domestic woodburners is very low, no difference would be expected with the use of Hot Rocks. This is especially the case since the inclusion of PVC and any other halogenated plastic has been avoided.

When testing the flue gas composition, it was carried out on a continuous basis using an automated gas chromatograph with a detector capable of analysing the required gases.

See Table 5 below, for the results of flue gas emissions and the mean concentration of the major organic flue gas components.

Fuel	Gas Component Concentrations, mean instantaneous volume %					
	Burnrate Setting	**Carbon Dioxide**	**Carbon Monoxide**	**Methane**	**Ethane**	**Propane**
Pinus Radiata	**Low**	10.1	1.56	0.25	0.011	Trace
	High	10.7	0.6	0.08	0.004	Trace
"Hot Rocks" Form 1	**Low**	7.5	0.64	0.02	0.002	0.0003
	High	4.5	0.26	Trace	Trace	0.011
"Hot Rocks" Form 5	**Low**	8.8	0.87	0.06	0.005	None

Table 5 - Mean Concentrations of Major Organic Flue Gas Components, (Richards, 1995)

From the above table, it can be seen that Hot Rocks (Formulation 1), when burnt under the same conditions as Pinus Radiata, emitted similar, sometimes, considerably lower concentration of each of the monitored gases.

It is important to note that generally all fuels followed order of magnitude difference between the analysed gases as shown in Equation 1.

Carbon dioxide ≈ 10*Carbon Monoxide ≈ 100*Methane ≈ 1000*Ethane
≈ 10000*Propane *Equation 1 (Richards, 1995)*

The specific quantities of the gases released to the atmosphere could not be obtained, as the mean flow rate of the flue gas up the flue was not known.
When comparing the different formulations, formulation 1 with HDPE and formulation 5 without the inclusion of HDPE, it appears that the presence of HDPE has little effect on the flue gas emissions. The only noticeable difference was on the low burnrate setting, where a small amount of propane was present in the emissions with the inclusion of HDPE.

Further tests would be required from the 1995 results to verify and ensure the presence of propane would not cause a detrimental effect to the environment.

Table 6, below, shows the fuel properties and combustion data from the tests carried out in 1995 in a HMF Merlin 3 Woodburner.

Fuel	Moisture Content, wt %	Ash Content, wt %	Gross Calorific Value, MJ/kg	Burn Rate	Wt Fuel Burnt, kg
Hot Rocks 1	3.8	3.7	29.78	Low	3.3
				High	3.25
Hot Rocks 5	7.7	3.6	27.9	Low	3.3
				High	
Pinus Radiata	16 -20	0.19	17.93	Low	3.35
				High	3.35

Fuel	Duration, min	Fuel Consumption kg/h	Average Power Output, kW	Space Heating Efficiency, %	Particulate Emission, g/kg
Hot Rocks 1	378	0.5	2.7	62.3	5.25
	129	1.4	6.2	51.2	3.68
Hot Rocks 5	437	0.4	2.4	68.4	4.21
Pinus Radiata	170	1	3.5	58.5	3.7
	67	2.5	7.8	51.4	3.59

Table 6 – Summary of Results Comparing 'Hot Rocks' and Pinus Radiata burnt in an HMF Merlin 3 Woodburner according to NZS 7402:1992 & 7403:1992, (Richards, 1995)

The important features these tests show are:
- Formulation 1 of Hot Rocks has a gross calorific value of 30MJ/kg, in comparison with 18MJ/kg for Pinus Radiata

- Hot Rocks produced average power outputs, at both low and high burn rate settings, slightly lower than Pinus Radiata
- Hot Rocks held the average power outputs twice as long as Pinus Radiata did.

4.3.2.2 Particulate Emissions

The standards against which these tests were compared were NZS 7403:1992. These standards state "For compliance with this standard, an appliance without a catalytic converter shall have an appliance particulate emission factor not greater than 5.5g/kg." (Appendix E)

In this standard, the method that the particulate emissions are calculated, is the mean of three tests at high, medium and low burn rates. However, when the above testing occurred, it only took place on low and high burnrates, hence it is only an estimate of particulate emissions. This estimate was carried out as accurately as possible by taking one third of the sum of twice the high fire figure and the low fire figure. (Equation 4) This gave the following results:

- Pinus Radiata 3.63 g/kg
- Form 1 Hot Rocks 4.20g/kg

In 1995, it was the opinion of Coal Research Ltd when testing various brands of woodburners using Pinus Radiata, that if the low fire particulate emission were less than 5g/kg, the appliance would pass the emission test.

From Table 6, it can be seen that Formulation 1, exceeds the standard of 5g/kg on the low fire setting, however, with the high fire setting figure of 3.68g/kg and the medium fire setting figure (from which previous experience shows it would correlate closely to that of the high fire setting), would decrease the average value below 5g/kg.

However, it must also be acknowledged that these tests were carried out using a non-specified fuel in an appliance that was approved with NZS 7403:1992 (Pinus Radiata) at that time.

Hot Rocks were tested in an approved woodburner (HMF Merlin 3) and the results obtained were compared with those found through using a specified fuel. (Pinus Radiata, with a moisture content of 16 - 20%) The results in Table Six, on the previous page, indicate that the particulate emissions obtained by burning Hot Rocks in the Merlin 3 Woodburner will probably be lower than those stated in the Standards (NZS 7403:1992), hence, the Merlin 3 burning Hot Rocks in all probability, would pass the particulate emission test. However, it is important to note that this is only applicable to this burner.

Also from the combustion tests carried out in 1995, it was observed that the Hot Rocks burnt <u>physically</u> more like wood than coal, although coal is a major constituent of the Hot Rocks.

5. Desktop Correlation

The preferable method to accurately determine the emissions from Hot Rocks in an approved solid fuel burner is through testing and monitoring them in a series of appliances that meet the year 2000 requirements. However, this testing is outside the scope of this study, hence a desktop correlation was carried out, which will give an approximate indication of whether or not the Hot Rocks have a good chance of meeting the proposed regulations. This desktop correlation was carried out on a variety of installed domestic solid fuel burners.

The desktop correlation entailed obtaining values for combustion properties such as fuel consumption, heat output, efficiency and particulate emissions for Hot Rocks and Pinus Radiata and comparing these with values obtained for Pinus Radiata in burners that meet the new year 2000 regulations. The following equation was the basis for the correlation:

$$\frac{\text{Hot Rocks}_{(\text{Merlin - efficiency})}}{\text{Pinus Radiata}_{(\text{Merlin - efficiency})}} = \text{Multiplier} \qquad \textit{Equation 2}$$

The above equation was applied to all combustion properties – Burn Time, Fuel Consumption, Average Heat Output, Efficiency and Particulate Emissions. The values obtained from this equation were averaged, giving a multiplier by which values from the approved burner could be altered by to obtain estimated values for Hot Rocks. This equation is displayed below:

$$\text{Pinus Radiata}_{(\text{Woodsman Matai – efficiency})} * \text{Multiplier} \qquad \textit{Equation 3}$$

These correlations were carried out on both high and low burn rates. An average of the three runs on the high burnrate setting and the three runs on the low burnrate setting was taken to determine the mean values for both settings. Following this, since the standard method for particulate emissions is calculated as the mean of the three tests at high, medium and low burnrates, it is only possible to estimate the particulate emissions using the following equation:

$$\text{Estimate} = (1/3) * ((2*\text{high burnrate value}) + \text{low burnrate value}) \qquad \textit{Equation 4}$$

These correlations were undertaken for a Woodsman Matai, Dante Freestander and Jayline, which all currently meet the year 2000 requirements of 1.5g/kg of particulate emission. Also correlations were carried out on a Horizon 450, which meets the 1.5 - 3.0g/kg and is able to be installed until 30 September 2002, but its clean air license only lasts until 31 March 1999. Correlations were also carried out on a Horizon 600, which meets the 3.0 – 5.5g/kg standard and can be installed until 31 March 1999.

The results obtained through carrying out this correlation are summarised on the following pages in Tables 7, 8 and 9. It is vital to note these results are only estimates and must be verified through a physical testing procedure in order to obtain certification for the fuel. This correlation is only a starting point that tends to indicate the fuel many met the requirements, subject to further testing.

5.1 High Burnrate Setting

	Burn Time (min)	Fuel Consumption (kg/hr)	Avg Power Output (kW)	Efficiency (%)	Particulate Emission (g/kg)
High Burnrate Setting					
Merlin					
Hot Rocks	129	1.4	6.2	51.2	3.68
Pinus Radiata	67	2.5	7.8	51.4	3.59
Woodsman Matai					
Est. Hot Rocks	61.2	3.5	8.3	60.4	0.7
Pinus Radiata	57.8	3.3	7.8	57.0	0.6
Jayline Classic					
Est. Hot Rocks	85.7	2.9	6.4	65.0	0.8
Pinus Radiata	80.8	2.8	6.0	61.3	0.8
Dante Freestander					
Est. Hot Rocks	NA	NA	NA	NA	0.6
Pinus Radiata	NA	NA	NA	NA	0.6
Horizon 450					
Est. Hot Rocks	65.8	3.7	10.9	66.8	1.7
Pinus Radiata	62.1	3.5	10.3	63.0	1.6
Horizon 600					
Est. Hot Rocks	67.4	5.1	13.2	59.7	1.7
Pinus Radiata	63.5	4.8	12.5	56.3	1.6

Table 7 – Comparison of Burning Properties on High Burnrate Setting

The Merlin domestic solid fuel burner, in which the Hot Rocks were tested, has the highest particulate emission value on the high burnrate setting. This is more than twice that estimated for all of the burners on which the correlation occurred.

Carrying out the correlation on the Woodsman Matai, Jayline Classic and Dante Freestander, which all meet the year 2000 requirements proposed by the Canterbury Regional Council, show that based on the data gathered from the Merlin test with the Hot Rocks, the PM_{10} levels produced by the Hot Rocks in the new burners meet the requirements.

In all cases with the solid fuel burners on which the correlation occurred, the burners efficiencies were estimated to be higher when utilising Hot Rocks as a fuel. The average power output was also higher when using Hot Rocks. However, fuel consumption, on a kg per hour basis, was greater using the Hot Rocks in comparison with Pinus Radiata.

5.2 Low Burnrate Setting

	Burn Time	Fuel Consumption	Avg Power Output	Efficiency	Particulate Emission
	(min)	(kg/hr)	(kW)	(%)	(g/kg)
Low Burnrate Setting					
Merlin					
Hot Rocks	378	0.5	2.7	62.3	5.25
Pinus Radiata	170	1	3.5	58.5	3.7
Woodsman Matai					
Est. Hot Rocks	116.6	2.3	6.3	80.5	1.2
Pinus Radiata	97.5	1.9	5.3	67.3	1.0
Jayline					
Est. Hot Rocks	117.8	2.8	6.5	76.9	1.4
Pinus Radiata	98.5	2.3	5.4	64.3	1.2
Dante Freestander					
Est. Hot Rocks	NA	NA	NA	NA	1.3
Pinus Radiata	NA	NA	NA	NA	1.1
Horizon 450					
Est. Hot Rocks	135.0	2.3	8.3	92.1	5.8
Pinus Radiata	112.9	1.9	6.9	77.0	4.9
Horizon 600					
Est. Hot Rocks	125.7	3.4	8.9	68.2	8.0
Pinus Radiata	105.1	2.9	7.4	57.0	6.7

Table 8 – Comparison of Burning Properties on Low Burnrate Setting

When considering those certified burners, for which the correlation occurred, on a low burnrate setting, the PM_{10} emissions increased considerably in comparison with the same fuels at the high burnrate setting. This is a result of inefficient combustion caused by restricted air intake.

Both the Horizon 450 and 600, have PM_{10} levels above that required for the year 2000 regulations, however, these burners were manufactured several years ago, not meeting these new requirements, although they are able to be installed until approximately the year 2000.

Again, the efficiency of the burners was greater using the Hot Rocks as a fuel in comparison with Pinus Radiata. Also, the average heat output was higher with the Hot Rocks. Pinus Radiata, again has a lower fuel consumption, on a kg per hour basis, than that of the Hot Rocks, possibly due to its higher moisture content.

5.3 Medium Burnrate Setting

	Burn Time (min)	Fuel Consumption (kg/hr)	Avg Power Output (kW)	Efficiency (%)	Particulate Emission (g/kg)
Medium					
Merlin					
Est. Hot Rocks	101.3	2.0	6.4	53.8	3.6
Est. Pinus Radiata	212.0	1.1	5.0	54.9	4.2
Woodsman Matai					
Final Est. Hot Rocks	79.7	3.1	7.6	67.1	0.8
Est. Pinus Radiata	71.0	2.8	7.0	60.4	0.8
Jayline					
Final Est. Hot Rocks	96.4	2.9	6.4	69.0	1.0
Est. Pinus Radiata	86.7	2.6	5.8	62.3	0.9
Dante Freestander					
Final Est. Hot Rocks	NA	NA	NA	NA	0.9
Est. Pinus Radiata	NA	NA	NA	NA	0.8
Horizon 450					
Final Est. Hot Rocks	88.9	3.2	10.0	75.2	3.1
Est. Pinus Radiata	79.0	3.0	9.2	67.7	2.7
Horizon 600					
Final Est. Hot Rocks	86.8	4.5	11.8	62.5	3.8
Est. Pinus Radiata	77.4	4.2	10.8	56.6	3.3

Table 9 – Comparison of Burning Properties on Medium Burnrate Setting

The medium burnrate setting is the setting on which the Canterbury Regional Council bases its regulations.

From the correlations that took place, it was found that the domestic solid fuel burners that meet the year 2000 requirements, are authorised clean air burners with the certified fuel of Pinus Radiata emitting PM_{10} less than 1.5g/kg, also meet the requirements when burning Hot Rocks. The Jayline Classic has the highest estimated PM_{10} emission rate when burning Hot Rocks of 1.0g/kg, which is still considerably less than the proposed regulations. However, when examining the PM_{10} emissions for the Horizon 450, which with the authorised fuel of Pinus Radiata meets the 1.5-

3.0g/kg requirements, it has been estimated that burning Hot Rocks in this stove will not meet these requirements, although it is only slightly above this value. But again, when looking at the results obtained through the correlation carried out on the Horizon 600 burner, which currently with the authorised fuel of Pinus Radiata meets the 3.0-5.5g/kg standard, Hot Rocks easily fall within this limit.

Again, efficiencies, average heat output and fuel consumption, on a kg per hour basis, are all greater for Hot Rocks in comparison with Pinus Radiata.

Generally, the above table indicates that with the recent technological advance in the manufacture of domestic solid fuel burners, PM_{10} levels emitted from the combustion of Hot Rocks easily meet the proposed standards set by the Canterbury Regional Council. (See Appendix J for more detail) However, tests will need to be carried out to ensure this is the case.

5.4 Technological Advance impacting on PM_{10} Emissions

Figure 9 below, shows the variation in particulate emissions according to burner type:

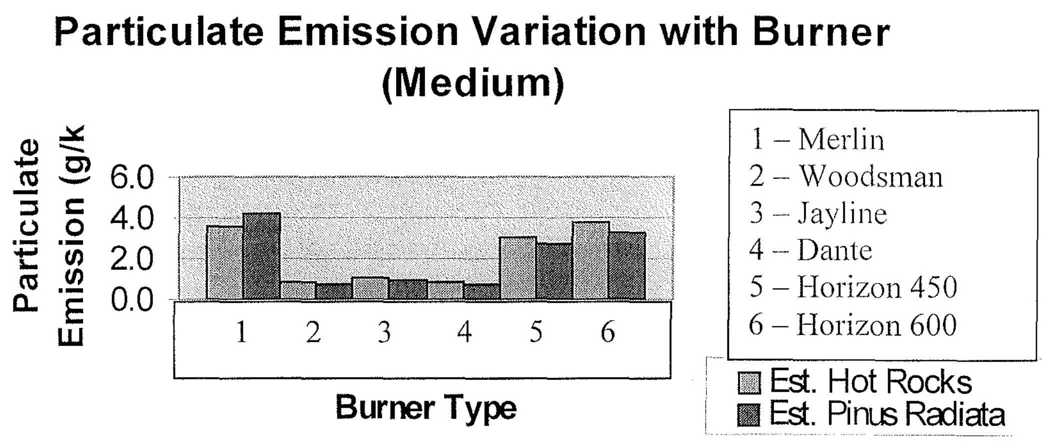

Figure 9 – Particulate Emission Variation with Burner Type on Medium Setting

In Figure 9, it can be seen that on the medium burnrate setting, PM_{10} varies considerably in conjunction with improved solid burner manufacturing techniques. Those burners most recently manufactured with baffles and secondary air chambers create the most efficient combustion conditions, hence decreasing PM_{10} emissions. For further information on domestic solid fuel burner technology see Appendix J. To see comprehensive test runs and data for each burner, on which the correlation was carried out, see Appendix K.

6. Combustion Factors Comparison - Fire Bricks, Wood, Coal

Below in Table 10 is a series of combustion properties shown for coal, wood and Hot Rocks.

Fuel Type	Moisture (%)	Ash (%)	Volatile Matter (%)	Fixed Carbon (%)	GCV (MJ/kg)	Sulphur (%)
Coal	9.4	4.3	35	51.2	28.9	0.3
Wood	30	.6	58.4	11	17.93	0.01
Hot Rocks	6.87	3.34	38.57	50.94	29.78	0.28

Table 10 - Combustion Properties

The properties for the combustion of Hot Rocks including Ash, Volatile Matter, Fixed Carbon and Sulphur are estimates based on Table 1 in Appendix F and the percentage of each of the raw materials within the Fire Bricks. (See Section 4) Hence these values are only estimates.

In comparison with coal and wood, Hot Rocks have very low moisture content, this will enhance combustion conditions, as very little heat is required to initially dry out the fuel. Combustion can occur almost instantaneously; hence few fumes adversely impacting on air quality will be released at this point when comparing Hot Rocks with coal and wood. (Combustion processes of coal and wood can be found in Appendix G).

From the estimates made, a greater percentage of ash is produced when considering Hot Rocks, than that of wood, but not of coal, due to the fact that the Hot Rocks consist of 60% of coal.

The volatile matter resulting from the combustion of the Hot Rocks is considerably less than that of wood and slightly higher than that of coal. This is a result of newsprint and HDPE milk bottles having very low values for volatile matter.

Fixed carbon from the Hot Rocks is again, similar to that of coal, it is almost five times higher than that of wood.

The gross calorific value for Hot Rocks is again, similar to that of coal, this indicates that Hot Rocks and coal release more energy, hence heat, per unit weight than wood.

All fuels examined in Table 10 have sulphur contents less than 1% of the total fuel output, coal has a slightly larger output than the Hot Rocks and wood is approximately one tenth of the value of coal and Hot Rocks.

This table shows that the general combustion properties of the Hot Rocks follow that of coal, this is a consequence of a large proportion (60%) of the Hot Rocks being comprised of coal.

7. Personal Observation

On 17 September 1998 half a dozen Hot Rocks were burnt on a Tropicair Horizon 600 appliance, which meets the 3.0 – 5.5 g/kg emission standard and can be installed until 31 March 1999. The testing process lasted for approximately two hours. The Hot Rocks were burnt with wood.

The Hot Rocks ignited much faster than the wood; this can be contributed to the fact that a large proportion of the Hot Rocks consists of paper. It may also be as a result of the Hot Rocks having a significantly lower moisture content than that of wood (6% and approximately 20% respectively). The lower moisture content in the Hot Rocks indicates less heat energy is required from the flames to dry them sufficiently for ignition.

It was noticed, shortly after ignition that occasionally, the flames were blue in colour, this was attributed to the burning of the plastic HDPE milk containers.

The Hot Rocks were slow burning and after approximately three-quarters of an hour of burning time, they were still in their original brick form, however considerably smaller in size. The bricks burnt evenly from the outside into the centre.

Considerable heat output was given off at the high burnrate setting, comparable to that of wood. When the solid fuel burner was adjusted to the low burnrate setting, combustion slowed. From these tests, the Hot Rocks, especially on the low burnrate setting, burnt so slowly that they could possibly last for up to nine hours, keeping a fire in overnight.

Generally, the Hot Rocks are relatively clean to handle, unlike coal.

The major advantage of the Hot Rocks is that they can be burnt in conjunction with other fuels, making both fuels last longer.

8. SWOT Analysis

A SWOT analysis has been carried out on the Hot Rocks, this identifies strengths, weaknesses, opportunities and threats they may be subject to. This approach allows a simple, yet all-encompassing view of the product and it's potential.

8.1 Strengths

- Convenient Packaging
  The Hot Rocks are shrink packaged into blocks containing twenty four bricks. These bags can be easily transported and do not allow any dampness to enter the Bricks, effecting their performance
- Ease of Handling and Storage
  This is due to the convenient packaging and the fact that the bricks are relatively clean to handle. Since the bricks are of high density, large quantities of heating potential can be stored in physically smaller areas in comparison with wood and coal. The bags can be easily stored.
- Recycling
  The Hot Rocks are manufactured from recycled materials, of which there is consistently a surplus. Utilising Hot Rocks reduces the pressure placed on fossil fuels.
- Natural Fire
  The combustion of Hot Rocks results in the warmth and comfort of a natural fire.
- Clean Burning
  Very little ash is left after the combustion of Hot Rocks. If they are burnt in an approved solid fuel burner, they will meet the proposed requirements of the Canterbury Regional Council (from the analyses carried out in this report).
- Consistent Product
  Since Hot Rocks are a manufactured fuel, the product will always have the same properties such as moisture content, ash content, heat output, etc.

8.2 Weaknesses

- Reliability of Fuel
  Due to poor demand, Hot Rocks have been removed from the market. Even at the time of production, there was only one outlet where Hot Rocks were produced.
- Package sizes
  Although the packages were a convenient size to handle, public impression was that the price/volume was expensive. It was not acknowledged by the public that the density and heating potential of the bricks is much greater than that of the same quantities of wood or coal.
- Resistance to Change
  Consumers are generally resistant to change, especially with the introduction of new technologies.
- Cost
  In Section 10, it can be seen that Hot Rocks are up to at least twice, almost three times the cost of wood and coal.

8.3 Opportunities

- Coal Ban
  This has created an opportunity for a new product; those consumers who burn coal currently will be looking for a fuel alternative after 30 September 1998.
- Need for Cleaner Burning Fuel
  Canterbury Regional Council is enforcing that fuels burnt must be clean burning, this can be offered by the Hot Rocks.
- Delivery
  It may be possible to deliver Hot Rocks free through vendors in conjunction with milk deliveries, and the consumer is charged monthly along with their regular milk account.

8.4 Threats

- New Production Technology
  The increasing technology in wood and coal burners may result in less fuel being burnt at lower emission rates, taking away from some of the advantages of manufactured fuels.
- Tightening of Canterbury Regional Council Regulations
  Canterbury Regional Council may tighten emission guidelines to a point where manufactured fuels may have to be burnt in a specialised burner.
- Combustion of Plastic
  The perceived or possibly real threat to the environment of burning plastic – this needs to be further investigated to determine its authenticity.

9. Viability of Hot Rocks

Hot Rocks Ltd closed earlier on this year due to a lack of demand for their product. In order to be a viable enterprise, production and sales would have had to be in the vicinity of 4,500 bags per month; (with each bag containing 24 fire bricks) whereas actual production was occurring at a rate of 1,500 bags per month, many of which were subject to stockpiling.

Another factor in the imminent closure of Hot Rocks was that it cost $10 -$11 to produce a bag, (no distribution costs are included in this figure) and they were selling at a price of $8.50, due to lack of demand.

The major costs of production are listed below in descending order:
1. Labour (3 employees)
2. Coal costs and associated transport costs
3. Electricity (approximately $1000 per month)

The most significant cost in the production of Hot Rocks was the labour. Investigations took place to determine if reducing the labour to two employees would decrease the cost significantly to make production viable - but this was not the case.

A major setback occurred in the production of the Hot Rocks mid 1997, as the factory went on fire, hence most of the stock was lost and very little stock could be sold. Consequently there were no indicators as to winter demand for the following year, (1998), so production this year continued, until there were significant stockpiles which were not being sold.

The predominant market for Hot Rocks was based in Dunedin and Christchurch, with approximately half of the Hot Rocks being produced being sold in each centre. They were generally sold through milk vendors and some petrol stations.

Basically, the underlying problem associated with the lack of demand (caused by market uncertainty) of Hot Rocks was a direct result of very poor marketing techniques.

In so far as research has shown, only several small advertisements for the product had been placed in newspapers and this was after production had commenced. An open day was held early in 1997, when the mayor opened the factory, however the extent to which this was advertised was also limited.

No policy was developed with regard to marketing for this product; this may be a direct result of the fragmented management structure that existed within Meadow Fresh Ltd at that time. Selected areas of Hot Rocks Ltd, such as finance and economics were controlled in Christchurch, with the actual production decisions etc occurring in Dunedin where the plant was based.

A significant reason for the lack of demand for Hot Rocks can be attributed to the high cost charged for the product, as seen in Section 10. The higher cost of Hot Rocks in comparison with wood and coal is due to a number of reasons:
- Manufactured fuel
- Low cost industries.

9.1 Manufactured Fuel

Hot Rocks are comprised essentially of free waste materials, excluding coal, which has transport costs associated with it. Yet these products require processing and manufacturing into the final product. This is an expensive process requiring cost inputs for heat, labour and transportation. Whereas, both wood and coal are naturally occurring fuel and are basically extracted in the form they will be sold. The only processing costs associated with wood and coal is transport and extraction.

9.2 Low Cost Industries

Industries such as wood and coal merchants are often low cost industries with very little infrastructure and daily operating costs. Whereas Hot Rocks Ltd has expensive infrastructure and high overhead costs. This contributes considerably to the higher cost of Hot Rocks.

10. Economic Comparison

Table 11, below, shows a comparison of cost between solid fuels including Hot Rocks, Pinus Radiata and Coal.

Fuel Type	Cost/kg (cents)	GCV (MJ/kg)	Cost/MJ (cents)	kWh/kg	Cost/kWh (cents)
Pinus Radiata	19.90	17.93	1.1	4.98	4.00
Hot Rocks	80.07	29.78	2.7	8.27	9.68
Coal	26.25	28.9	0.9	8.03	3.27

Table 11 – Economic Comparison

The cost of Hot Rocks is inclusive of transport costs, based on 15c/km tonne over 400km, (from Dunedin to Christchurch), giving $60/tonne or 6c/kg.

Costs obtained from the appropriate merchants were:

- Pinus Radiata $45/m^3
- Coal $10.50/40kg
- Hot Rocks $8.50/10.8kg

Comparing costs on a cents/kg basis, strongly indicates Hot Rocks are considerably more expensive than both coal and Pinus Radiata.

When contrasting solid fuels on a cost per kilowatt-hour basis Hot Rocks are much more expensive by three to four times than coal and Pinus Radiata. This is due to the fact that both wood and coal are naturally occurring products; therefore basically the only cost incurred is related to the removal and transportation. Whereas, although the raw products of Hot Rocks are essentially free, with the exception of coal, which has transport costs, associated with it, it is the manufacturing and processing costs, which are significant and expensive. These costs will always be associated with any manufactured fuel, however, must be minimised in order for manufactured fuels to be economically competitive in the market place.

Table 12, on the following page, indicates the difference in cost of both Pinus Radiata and Hot Rocks with appliance type.

Appliance	Fuel Type	Cost/kg (cents)	Appliance Efficiency (%)	Cost/kWh Produced cents)
Merlin	Pinus Radiata	19.9	54.9	7.3
	Hot Rocks	80.1	53.8	16.7
Woodsman Matai	Pinus Radiata	19.9	60.4	6.6
	Hot Rocks	80.1	67.1	13.3
Jayline Classic	Pinus Radiata	19.9	62.3	6.4
	Hot Rocks	80.1	69.0	13.0
Dante Freestander	Pinus Radiata	19.9	NA	NA
	Hot Rocks	80.1	NA	NA
Horizon 450	Pinus Radiata	19.9	67.7	5.9
	Hot Rocks	80.1	75.2	11.9
Horizon 600	Pinus Radiata	19.9	56.6	7.1
	Hot Rocks	80.1	62.5	14.3

Table 12 – Economic Comparison based on Appliance Type

Obviously, the most efficient appliance, being the Horizon 450, has the cheapest cost per kilowatt-hour of heat produced. However, Hot Rocks are double the price of Pinus Radiata. When specifically dealing with appliance that currently meet the regulations including the Woodsman Matai, Jayline Classic, Dante Freestander, Horizon 450 and Horizon 600, efficiencies vary by approximately 10%. Along with the efficiencies varying by 10%, the cost per kilowatt-hour of heat produced varies by just fewer than 2c. This seems to be a small amount, but when considering this cost variation due to efficiency over a year, it sums to a significant amount. This indicates the most efficient appliances also have the lowest running costs.

Table 13, below, taken from the Consumer Magazine shows both coal and wood at a much higher cost per kilowatt-hour. This may be attributed to the calculations being based on varying burner efficiencies.

Heat Source	**Cost Per kWh (Christchurch, 1998)**
Coal	28c
Woodburner	25c
Electricity	12c
Gas	12c
Modern Woodburner	5c
Heat Pump	5c

Table 13 - Estimated Current Home Heating Costs (Consumer, 1998)

Table 13 shows that older woodburners and coal burnt on open fires are the two most expensive fuels or sources of heating. Whereas gas and electricity are in the mid range, with a modern woodburner and heat pump being the most cost effective method of heating.

When considering the outcome in Tables 11 and 12 with Hot Rocks being significantly more expensive than both wood and coal, it may be directly assumed that if Hot Rocks were to be placed on Table 13, they would be considerably more costly than all of the other heating sources. Consequently, these findings may have an adverse effect on the demand for Hot Rocks at their current price; hence measures must be taken to reduce costs of production.

11. What Next!!

After establishing, from the desktop correlation and other information gathered that the Hot Rocks could quite possibly meet the regulations proposed by the Canterbury Regional Council, the following issues need to be addressed to ensure successful production, implementation and demand of Hot Rocks:

- Communication
- Fuel certification
- Cost of manufacture
- Marketing

11.1 Communication with Canterbury Regional Council

Since the present point in time is a transitional period for regulations regarding air quality and domestic burner emissions, continuing communication would be required with the Canterbury Regional Council. This would include communication regarding the implications of the proposed requirements and Natural Resources Regional Plan, Part A: Air, along with any amendments that may occur. Public opinion, with regard to issues addressed in the proposed plan to manufactured fuels may also be gained through reviewing the submissions entered.

Communication is a vital link to ensure Hot Rocks can be manufactured, sold and burnt effectively.

11.2 Fuel Certification

As regulated via the Clean Air Zone (Christchurch) Order, 1977, and its subsequent amendments, the Canterbury Regional Council must authorise fuels that are burnt within this zone on enclosed burners. These regulations are outlined in Section 3 and Appendix C.

From this, Hot Rocks must have a sulphur content less than 1% within its emissions, due to them containing coal. This allows for the utilisation of a lower quality of coal within the fuel, as the measurement is taken as a percentage of the weight. Due to the fact that coal is only a small proportion of the Hot Rocks as a whole, the actual sulphur level of the coal used can be higher.

The major problem of fuel certification with Hot Rocks is as a result of the product containing plastic. Regardless of the fact that through tests carried out by Coal Research Ltd, it has been proven that there are no adverse effects of combustion products, it may be difficult to obtain approval for the Hot Rocks. However, since there is currently, under the Transitional Regional Plan and Clean Air Zone Order, no standard regarding plastic products in fuels. Hot Rocks will need to be tested in an approved solid fuel burner that will meet the year 2000 requirements. Currently the test facility recommended by the Canterbury Regional Council is Applied Research Ltd in Nelson. Tests will be required to determine:

- PM_{10} and Propane especially,
- along with other gases emitted such as - Carbon Monoxide
  Carbon Dioxide
  Methane
  Ethane
  Dioxins

Furans

Since emissions tend to vary according to the type of solid fuel burner utilised, and for the best results, it would be ideal to test the Hot Rocks in a range of burners at the heat settings of high, medium and low.

Odour units will also have to be tested, as the sulphur dioxide produced as a result of the combustion process of coal can often produce an unpleasant odour. Ideally this value would need to below 1 odour unit, where the odour is detectable, but not offensive.

The cost of testing Hot Rocks is within the range of $3000 - $5000 per test, which is considerable, although accurate emission data will be obtained, from which management and marketing decisions can be inferred.

Companies where these tests can be carried out are:

- Coal Research Limited
- ESR
- Applied Research Limited.

11.3 Cost of Manufacture

Identified, as being the most expensive costs of the production of Hot Rocks is labour, coal and its associated transport costs and electricity. In order for Hot Rocks to be competitive within the market of solid fuels, these costs need to be minimised.

Employing more advanced methods of technology will be initially expensive, as the capital is purchased, but in the long term, will decrease labour costs, possibly only requiring one or two labourers to produce the Hot Rocks. Advancement in technology may slightly decreased electricity costs, also reducing the final cost of production.

However, it would seem there is very little that can be improved to reduce costs of coal and its transportation, besides the fact of utilising coal from a closer mine. This may result in having to use a lower grade coal, decreasing the combustion properties of the Hot Rocks. Further research would need to be carried out on the viability of this.

Costs of transporting the Hot Rocks to Christchurch are extremely high and from the calculations carried out raised the price of Hot Rocks to a level, which is unacceptable to consumers. Since a large opening in the market of manufactured fuels will possibly come about with the introduction of the proposed new regulations; it may be more economic to manufacture the Hot Rocks in Christchurch.

A temporary subsidy could possibly be obtained from the Christchurch City Council to manufacture Hot Rocks as they are produced from waste materials. This would be at no extra cost to the council and would benefit them, as it would be cheaper to transport the waste materials from collection to a manufacturing facility in Christchurch. This would save current recycling costs of sorting, baling and containerisation. These savings would form the basis of the subsidy, which would be allocated for a defined period of time until the manufacturing facility was well established.

11.4 Marketing Guide

Marketing of a product, especially something relatively new to the market such as Hot Rocks is required not only to create an awareness of the product to consumers, but also in order to establish a competitive advantage.

Basically, once the product has been developed, a marketing plan is employed to communicate the main benefits of that product, such as:

1. The product component
    - ensures that the product characteristics provide benefits to the consumer
2. The promotional component
    - Communicates the products ability to satisfy the customer through advertising, personal selling and sales promotions
3. The place component
    - Distributes the product to the right place at the right time to meet consumers needs
4. The price component
    - Ensures the product is priced at a level that reflects consumer value. (Assael, 1990)

In order to launch a new product, the following openings must be available in the potential market place:

- Good potential for growth,
- Few barriers to entry,
- Opportunity for competitive advantage,
- Stability in customer demand,
- No large capital investment required,
- Good prospects for increased market share,
- A high return on investment relative to other markets.

There are wide ranges of reasons why new products such as Hot Rocks have failed; they are usually based on poor marketing techniques such as:

- Misreading customers needs,
- Poor product positioning,
- Poor product performance,
- Inadequate marketing research,
- Inadequate competitive analysis.

In order to ensure a new product will succeed, the following must be known/occur:

- The degree to which the product matches customer needs,
- Use of existing company know-how,
- A superior product,
- An organisational environment that fosters entrepreneurship,
- An established new product development process. (Chisnall, 1985)

In order to develop a functional marketing plan, research within the market place must occur. The marketing research may be carried out through the following steps:

1. Define research objectives
   Ie, Is there a place for Hot Rocks in the market?
   What is the probable level of demand?
2. Determine if new research is required
   Ie, Has research for this purpose already been collected and collated?
3. Develop research design
   - survey – develop questionnaire
     - telephone/personal interview
     - mail surveys
   - experimentation - cause and effect
   - observation – either direct or indirect
4. Determine areas of information to be collected
   Ie, Consumer demands
   Retail outlets that will be prepared to sell the product
   Advertisers
5. Develop sampling plan
   Ie, Random
   Target some socio-economic sectors?
6. Implement research / carry out surveys etc.
7. Analyse data, report. (Assael, 1990)

Once this research has been carried out, it provides a basis on which a marketing schedule can be developed. The following issues need to be addressed within a marketing plan:

1. Identify marketing opportunities
   (Analysing customers needs, this has been covered in market research)
2. Develop marketing plans and strategies
   - Marketing plan - What Hot Rocks Ltd as a firm wants to accomplish (include specific objectives on the managements assessment of marketing opportunities)
     - How Hot Rocks Ltd plans to accomplish the objective defined by the marketing strategy
     - What resources are required to implement this marketing plan
     - How the management of Hot Rocks Ltd should implement specific strategies
     - Projected profit etc
3. Target the marketing effort
   - Segments of the market need to be identified based on consumer needs, demographic and lifestyle characteristics
   - Information from marketing research will be utilised to determine this
4. Implement marketing effort
   - Promotion of Hot Rocks
   - Develop a media plan that outlines how to reach the target market with a selected mix of vehicles such as TV, radio, circulars, newspapers, billboards and magazines
   - Distribution and pricing
5. Evaluate and control marketing effort
   - Record and track sales
   - Compare revenue and costs to those projected in the product marketing plan

(Assael, 1990)

The price of the product is based on a range of issues including:

- Establish pricing objectives	- return on investment
	- market share
	- competitive advantage
	- cost criteria
	- competitive actions
	- sales objective
	- customer demand
- Determine influences on price	- demand
	- cost (Chisnall, 1985)

A marketing step that is recommended is to sell Hot Rocks from Service Station Forecourts along-side expensive fuels such as packages wood and coal. Some consumers prefer to buy wood and coal from these suppliers and if Hot Rocks were along-side these, with the appropriate advertising, a niche may well develop in the marketing place for Hot Rocks. This market would be further developed with the lowering of the production costs, hence final costs of the Hot Rocks.

A marketing plan following the above approach will enable the initiation of a base from which the Hot Rocks can be sold. A foundational market will be set up with regular customers gained through the initial marketing effort, from which additional customers will be gained through continual advertising and word of mouth.

12. Conclusion

There are advantages to be gained through the burning of fuels manufactured from waste products on domestic solid fuel burners. A demand can be created for products that would otherwise be disposed of in a landfill, which is both expensive and environmentally degrading. As a manufactured fuel, Hot Rocks produce burning characteristics equal or superior to that of natural fuel alternatives.

Due to the problem Christchurch experiences annually related to smog, and the recent tightening of regulations enforced by the Canterbury Regional Council, there is a definite market for fuel alternatives to be burnt in domestic solid fuel burners.

The time to enter the manufactured fuels market with a product such as Hot Rocks is now, due to the following reasons:

1. Public awareness of environmental degradation and adverse health effects resulting from air pollution is high. Through education, the public will realise the benefits of burning Hot Rocks.
2. The desktop correlation carried out in this report strongly indicated Hot Rocks would easily meet the requirements proposed by the Canterbury Regional Council regarding PM_{10} emissions.
3. Proposed regulations enhance the market for a manufactured fuel such as Hot Rocks, as they are a consistent product with favourable combustion properties in line with the proposed requirements.
4. Technological advance will contribute to lowering the costs of production; hence making Hot Rocks a more economically competitive fuel.
5. Currently there are very few other competitors in the manufactured fuels market. If Hot Rocks can be manufactured and marketed economically and efficiently, they may quite possibly dominate the market for manufactured fuels.
6. With the introduction of kerbside recycling, more waste materials are available. Awareness of recycled products through this program has increased.

The issue of the market value of Hot Rocks must be addressed, as the cost of $8.50 per bag was unrealistic. Costs of production, including labour, electricity and transport need to be addressed to dramatically reduced this cost disadvantage.
To enhance the market that has already been created through the restriction placed on coal, a marketing plan should be employed; this will create an awareness and demand for Hot Rocks, ensuring viability of production.

13. Recommendations

Before production of Hot Rocks recommences, several steps need to be taken to ensure successful production and high levels of demand. These steps include:

1. Further contact with the Canterbury Regional Council regarding the combustion of manufactured fuels such as Hot Rocks, especially with regard to the proposed Natural Resources Plan, Part A: Air.
2. Tests need to be carried out on a variety of burners that are Clean Air Certified in order to obtain authorisation of Hot Rocks as a fuel. The correlation carried out in this report strongly indicates the fuel will easily meet the proposed requirements relating to PM_{10}, however, this needs to be verified through a testing process. Also, due to the inclusion of plastics within the Hot Rocks, tests on flue gas emissions for furans and dioxins need to be carried out to ensure no adverse pollutants are released into the atmosphere.
3. Production or transport costs need to be lowered, this may occur through two different approaches:
   - Decrease production costs – using more advanced technology to reduce electricity and labour costs.
   - Decrease transport costs – this could possibly occur by encouraging a potential manufacturer to move the production facility to Christchurch, which has a higher potential demand for Hot Rocks. Approaching the Christchurch City Council for a subsidy to produce the Hot Rocks will decrease production costs for a specified time period.
4. Employ a marketing strategy to create sufficient demand to ensure continued and successful production of Hot Rocks.

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16. Appendices

Appendix A Ambient Air Quality Guidelines

Ambient Air Quality Guidelines

	Averaging Period	Concentration
Particulate (PM_{10})	24 hour* Annual	120 μgm^{-3} 40 μgm^{-3}
Sulphur dioxide (SO_2)	10 min 1 hour 24 hour Annual	500 μgm^{-3} 350 μgm^{-3} 125 μgm^{-3} 50 μgm^{-3}
Carbon Monoxide (CO)	1 hour 8 hour	30 mgm^{-3} 10 mgm^{-3}
Ozone (O_3)	1 hour 8 hour	150 μgm^{-3} 100 μgm^{-3}
Nitrogen dioxide	1 hour 24 hour	300 μgm^{-3} 100 μgm^{-3}
Lead (Pb)	3 month	0.5 – 1.0 μgm^{-3}

Table 1 – Summary of Ministry for the Environment Guidelines for Ambient Air Quality

*In March 1996 the Canterbury Regional Council adopted a 24 hour monitoring and reporting guideline for PM_{10} of 50 μgm^{-3}. In May 1997, it also established 50 μgm^{-3} as the air quality management target for Christchurch.

It should be noted that guideline are minimum requirements for air quality. They are not maximum permissible concentrations of pollutants in air or limits that can be polluted "up to" safely. (Ministry for the environment, 1994) The Ministry for the Environment has recommended that ambient levels of gaseous pollutants should not exceed 66% of the applicable guideline. (Ministry for the Environment, 1996)

Appendix B Coal Research Update 1998

Analysis - As Sampled Basis

Name of Mine	Mine Ownership	Mine No.	1997 Output (000 T)	Moisture %	Ash %	Volatile Matter %	Fixed Carbon %	Gross Calorific Value MJ/kg	Gross Calorific Value Btu/lb	Sulphur %	Crucible Swelling No.	AFT Hemi °C
Waikato												
BBL	BBL Underground Mining Co. Ltd	(a)	20	19.9	4.5	34.1	41.5	23.63	10160	0.30	0	1200
Huntly East No. 1	Solid Energy	N56 M121	286	20.9	3.9	34.9	40.4	22.85	9830	0.20	0	1270
Huntly West No. 1	Solid Energy	N56 M120	20	22.2	2.9	34.9	40.0	22.72	9770	0.19	0	1260
Kopako	Glencoal Energy Limited	N52 M4	136	27.5	6.0	32.2	34.4	19.78	8510	0.21	0	1190
Kopako	Solid Energy	(a)	12	26.9	4.1	33.0	36.0	20.04	8620	0.15	0	1210
O'Reilly's	O'Reilly's Opencast Ltd	N56 M109	8	20.1	4.7	35.0	40.2	22.36	9620	0.25	0	1260
Pirongia	Glencoal Energy Limited	N74 (b)	37	27.6	10.0	32.8	29.7	18.31	7870	2.89	0	1080
Renown	Glencoal Energy Limited	(a)	86	22.0	5.0	32.9	40.2	22.21	9550	0.26	0	1230
Renown Washery	Glencoal Energy Limited	(a)	32	22.6	4.7	32.5	40.3	22.14	9520	0.28	0	1190
Rotowaro	Solid Energy	N56 (c)	888	19.7	3.4	36.1	40.8	23.33	10040	0.22	0	1250
Buller												
Cascade	Cascade Mining Ltd	S31 M28	(d)	9.3	1.5	36.0	53.2	30.13	12960	0.48	3	1320
Heaphy	Heaphy Mining Ltd	S31 M14	(d)	20.4	3.3	34.0	42.3	23.31	10030	1.96	0	1250
McLaughlin	McLaughlin Mine	S30 M23	(d)	28.3	3.8	34.6	33.4	19.62	8440	4.53	0	1290
New Creek	New Creek Mining	S31 M27	<1	18.3	1.5	37.5	42.8	24.36	10480	4.22	½	1100
Plateau	Neighbours & Groot	(a)	(d)	7.6	3.5	35.9	53.0	30.48	13110	2.63	7	1270
Stockton	Solid Energy	S24 (a)	1097	8.0	1.7	28.7	61.6	32.08	13800	1.32	9	1550
Reefton												
Echo	Francis Mining Co. Ltd	S38 M169	46	6.4	1.9	38.9	52.9	30.95	13310	0.52	4	1450
Fletcher Creek	Morris Mines Ltd	S31 M23	11	24.9	4.8	34.4	35.8	20.60	8860	3.85	0	1460
Giles Creek	Dunollie Coal Mines Ltd	S38 M187	24	28.2	3.2	32.4	36.2	19.28	8290	0.47	0	1270
Hart Creek	Francis Mining Co. Ltd	(a)	11	22.6	3.3	34.9	39.2	21.54	9270	0.88	½	1140
Hutt Creek	R.J. & R.J. Banks	S38 M183	4	8.8	1.5	38.4	51.4	30.10	12950	0.66	2	1180
Island Block	Solid Energy	S38 M168	29	6.7	2.1	39.4	51.9	30.63	13170	1.32	4	1280
Peerless	Waitahu Coal Party	S38 (a)	0	14.2	5.2	36.1	44.5	25.11	10800	0.58	½	1420
Pyramid No.2	Francis Mining Co. Ltd	S38 M127	7	12.4	1.7	41.8	44.0	26.68	11470	4.54	1	1250
Radiant	Newstar Minerals Ltd	S38 M134	6	8.9	2.8	37.6	50.6	28.88	12420	0.61	3	1440
Surprise	Francis Mining Co. Ltd	S38 M81	3	14.4	3.1	40.7	41.8	25.63	11020	4.51	1	1240
Terrace	Solid Energy	S38 M181	26	19.1	1.8	34.9	44.2	24.56	10560	1.08	½	1180
Topline	Francis Mining Co. Ltd	S38 M170	8	8.8	5.5	36.1	49.6	28.89	12420	0.85	5	1450
Waitahu No.2	Waitahu Coal Party	S38 M76	0	10.4	1.9	42.0	45.7	27.21	11700	4.67	1	1150
Waitahu No.4	Waitahu Coal Party	S38 (a)	0	11.9	3.2	37.7	47.2	26.31	11310	2.43	½	1250
Welcome	Francis Mining Co. Ltd	S38 M161	16	15.3	2.1	37.4	45.1	26.08	11220	0.44	½	1180
Greymouth												
Harrison	Harrison & Party	S44 M124	(d)	9.5	3.6	38.9	47.9	29.68	12760	0.23	4	1230
Kiwi	Kiwi Collieries Ltd	S44 M132	(d)	13.2	4.9	35.8	46.1	27.43	11790	0.30	1	1230
Moody Creek (e)	Viking Coal Ltd	S44 M131	47	9.9	3.4	36.5	50.2	29.61	12730	0.29	4	1170
Roa	Francis Mining Co. Ltd	S44 (a)	0	7.1	6.9	19.3	66.7	31.65	13610	0.30	9+	1360
Snowline	Snowline Co-op Party	S44 M127	(d)	11.8	4.1	36.4	47.8	28.26	12160	0.38	1	1440
Strongman No.2	Solid Energy	S44 (a)	301	8.0	3.1	39.2	49.6	30.57	13150	0.21	5	1240
United	United Coal Party	S44 M126	(d)	6.5	3.9	39.2	50.4	31.46	13530	0.28	4½	1500
Canterbury												
Mt Somers	Mt Somers Mines Ltd	S81 M14	2	27.0	12.4	29.2	31.4	17.72	7620	2.24	0	1360
Otago												
Harliwich	Harliwich Carrying Co.	S152 M3	5	28.9	5.4	38.8	26.9	18.72	8050	0.37	0	1290
Kai Point	Kai Point Coal Co. Ltd	S179 M60	45	30.7	4.8	31.1	33.3	19.59	8430	1.58	0	1320
Southland												
Goodwin	New Vale Coal Co. Ltd	S169 M28	43	41.0	3.7	30.3	25.0	15.07	6480	0.50	0	1310
Moss Bank	Southern Mining Ltd	(a)	2	22.0	6.8	30.4	40.8	21.62	9300	0.25	0	1230
New Vale	New Vale Coal Co. Ltd	S169 M24	136	40.5	3.0	30.8	25.8	15.24	6550	0.35	0	1340
Nightcaps	Southern Mining Ltd	S168 M162	4	27.1	7.2	29.6	36.1	19.10	8220	0.26	0	1170
Mataura	Solid Energy	S178 M23	18	44.7	4.7	26.8	23.9	13.87	5970	0.49	0	1310
Wairaki, Ohai	Solid Energy	S168 M164	158	17.2	3.3	34.1	45.5	25.18	10830	0.17	0	1190
Waituna	G. Chalmers	S182 M7	(d)	39.1	5.7	31.5	23.8	14.51	6240	0.61	0	1190

Notes To The Table

(a) Mine number(s) not available

(b) The Pirongia production was from two mines - (N74 M6) and (N74 M8)

(c) Rotowaro production was a blend of coals

(d) Output figures not available

(e) Washed Product

Appendix C Transitional Regional Plan

9.. Clean Air Provisions

(a) Clean Air Act Section 24(2) - The Christchurch City Clean Air (Licensing of Part C Processes) Bylaw 1990.

Activities requiring licensing as Part C processes are a **discretionary activity** in Christchurch City (not applicable in other parts of the Canterbury Region).

(b) Clean Air Act 1972, Section 55A - Christchurch City Fires Bylaw 1991

(i) Only Clauses 1, 2, 3, and 4 of this bylaw and clauses 5 and 9 insofar as they relate to fires in the open-air during the months of May to August inclusive, were made under the Clean Air Act 1972. The balance of the bylaw is administered by the Christchurch City Council under the Local Government Act 1974.

(ii) The setting on fire in the open air of any vegetation or other combustible material (excluding any barbecue or hangi) is for

The occupier of

(a) any premises in or upon which any agricultural, commercial or industrial process or operation is being carried on which necessitates the use of fire in the open air; or

(b) any premises licensed under the Clean Air Act 1972; or

The organiser of any special occasion or event

- **a discretionary activity** during the months of May to August (inclusive).

Any activity outside the scope of the above is a **non-complying activity**.

(c) The Clean Air Zone (Christchurch) Order 1977 and the Clean Air Zones (Canterbury Region) Order and specified sections of the Clean Air Act 1972 insofar as they apply to the zones specified in those orders. These zones include the urban area of Christchurch City and the urban areas of the previous Rangiora Borough, Kaiapoi Borough and adjoining urban area of Eyre County and are more specifically defined in the above Clean Air Zone Orders as they relate to the previous boundaries of Christchurch City and other respective local authorities prior to local government reorganisation.

- **Non-complying activities** (as specified below). Without prejudice to the specific requirements of these Orders, the purpose of these orders (now regional rules) is to prohibit (in the areas specified in the Orders) subject to the exemption below:

  (i) The use as a fuel of wood having a moisture content exceeding 25 percent (on wet weight).

  (ii) The use of any fuel having a sulphur content exceeding 1 percent (by weight).

(iii) The use of any fuel burning equipment not installed at the time of commencement of the orders (or the Orders as amended) of a kind not specifically approved for installation in accordance with the Orders.

(iv) The use of fuels in approved fuel burning equipment, as specified above, which have not been approved for use in that equipment.

(v) The acquisition and sale of fuel for use within the areas specified as Clean Air Zones which does not comply with (i) above.

The above restrictions apply principally to solid fuel burning appliances in dwellings and do not apply to industrial premises subject to the 'discharge permit' requirements of the Resource Management Act.

Appendix D Clean Air Zone (Christchurch 1977) Order

THE CHRISTCHURCH CITY CLEAN AIR (LICENSING OF PART C PROCESSES) BYLAW 1990

Pursuant to the powers vested in it by the Clean Air Act 1972, the Clean Air (Licensing) Regulations 1973, the Local Government Act 1974, and all other powers thereunder enabling the Christchurch City Council makes this Bylaw.

1. SHORT TITLE

This Bylaw may be cited as the Christchurch City Clean Air (Licensing of Part C Processes) Bylaw 1990.

2. COMMENCEMENT

This Bylaw shall come into force on the 5th day of December 1990.

3. OBJECT OF BYLAW

The object of this Bylaw is:

(a) to give effect to Section 24(2) of the Clean Air Act 1972 by requiring certain processes which are described in Part C of the second schedule to that Act to be licenced pursuant to that Act; and

(b) to prescribe the fees payable in respect of those processes for the purposes of Regulations 10B(1) and 11(1)(c) of the Clean Air (Licensing) Regulations 1973.

4. INTERPRETATION

In this Bylaw, unless the context otherwise requires, -

"Act" means the Clean Air Act 1972:
"Council" means the Christchurch City Council:
"Part C process" means, subject to Section 2 of the Act, a scheduled process specified or described in Part C of the Second Schedule to the Act:
Words defined in the Act shall, when used herein, have the same meaning.

5. PART C PROCESSES TO BE LICENCED

(1) No person shall on or after the commencement of this Bylaw carry on any Part C process in or on any premises unless that person is for the time being licenced under the Act to carry on that process in or on those premises.

(2) Subclause (1) of this clause shall not apply to any Part C process which is -

(a) that of deep frying, curing by smoking or the roasting of berries or grain; or

(b) a combustion process fired by gas

where the premises in or on which that process is carried out are registered under the provisions of the Health (Registration of Premises) Regulations 1966.

THE CLEAN AIR ZONE (CHRISTCHURCH) ORDER 1977, AMENDMENT NO. 4

PAUL REEVES, Governor-General

ORDER IN COUNCIL

At Wellington this 16th day of May 1988

Present:

HIS EXCELLENCY THE GOVERNOR-GENERAL IN COUNCIL

PURSUANT to sections 12 and 13 of the Clean Air Act 1972, His Excellency the Governor-General, acting by and with the advice and consent of the Executive Council, hereby makes the following order

ANALYSIS

1. Title and commencement
2. New clauses substituted
5. Authorised fuels
5A. Prohibited fuels
5B. Authorised fuel burning equipment
5C. Fuel burning equipment authorised until close of 31 October 1988
5D. Fuel burning equipment authorised until close of 30 April 1992
5E. Condition in relation to use of fuel burning equipment
5F. Prohibited fuel burning equipment
5G. Power of Minister to authorise or prohibit use of fuel or fuel burning equipment
3. Further exemptions from sections 15 and 16 (1) of the Act
4. Order not to apply to scheduled process
5. New First, Second, and Third Schedules substituted
6. Revocations
Schedule

Price Code: 9—C

ORDER

1. Title and commencement—(1) This order may be cited as the Clean Air Zone (Christchurch) Order 1977, Amendment No. 4, and shall be read together with and deemed part of the Clean Air Zone (Christchurch) Order 1977* (hereinafter referred to as the principal order).

(2) This order shall come into force on the 1st day of June 1988.

2. New clauses substituted—The principal order is hereby amended by revoking clause 5, and substituting the following clauses:

"5. **Authorised fuels**—(1) The use in the clean air zone of any of the following fuels, namely,—

"(a) Any fuel (being wood or fuel derived from wood) having a moisture content not exceeding 25 percent (on wet weight):

"(b) Any fuel (being coal or fuel derived from coal) having a sulphur content not exceeding 1 percent (by weight):

"(c) Any fuel (being natural gas, liquefied petroleum gas, or any other fuel derived from oil) having a sulphur content not exceeding 1 percent (by weight),—

is hereby authorised.

"(2) Subject to the conditions specified in subclause (3) of this clause, the use in the clean air zone of any fuel specified in the First Schedule or the Second Schedule or the Third Schedule to this order is hereby authorised.

"(3) Subclause (2) of this clause is subject to the following conditions, namely—

"(a) That the fuel be used only—

"(i) In fuel burning equipment of a kind or class specified in the First Schedule or the Second Schedule or the Third Schedule to this order in relation to that fuel; or

"(ii) In any fuel burning equipment installed before the 14th day of July 1977; or

"(iii) In any fuel burning equipment that has at any time been authorised for installation or use in the clean air zone; and

"(b) That, in the case of fuel used in any fuel burning equipment to which subparagraph (ii) or subparagraph (iii) of paragraph (a) of this subclause applies, the fuel is not—

"(i) A fuel (being wood or fuel derived from wood) having a moisture content exceeding 25 percent (on wet weight); or

"(ii) A fuel having a sulphur content exceeding 1 percent (by weight).

"(4) Nothing in this clause affects the use in the clean air zone of electricity or solar radiation.

"5A. **Prohibited fuels**—(1) The use in the clean air zone of any of the following fuels, namely,—

"(a) Any fuel (being wood or fuel derived from wood) having a moisture content exceeding 25 percent (on wet weight):

"(b) Any fuel having a sulphur content exceeding 1 percent (by weight),—

is hereby prohibited.

*S.R. 1977/172
Amendment No. 1: S.R. 1979/258
Amendment No. 2: S.R. 1981/17
Amendment No. 3: S.R. 1982/243

"(2) The use in the clean air zone in any fuel burning equipment of a kind or class specified in the First Schedule or the Second Schedule or the Third Schedule to this order of any fuel other than a fuel specified in the First Schedule or the Second Schedule or the Third Schedule to this order or in a notice under clause 5G of this order in relation to that kind or class of fuel burning equipment is hereby prohibited.

"(3) Nothing in subclause (2) of this clause affects the provisions of subclauses (2) and (3) of clause 5 of this order.

"(4) Nothing in this clause relates to the use in a clean air zone of electricity or solar radiation.

"5B. **Authorised fuel burning equipment**—Subject to the condition specified in clause 5E of this order, the installation and use in the clean air zone of any fuel burning equipment of a kind or class specified in the First Schedule to this order is hereby authorised.

"5C. **Fuel burning equipment authorised until close of 31 October 1988**—(1) Subject to the condition specified in clause 5E of this order, the installation and use in the clean air zone of any fuel burning equipment of a kind or class specified in the Second Schedule to this order is hereby authorised.

"(2) This clause and the Second Schedule to this order shall expire with the close of the 31st day of October 1988.

"5D. **Fuel burning equipment authorised until close of 30 April 1992**—(1) Subject to the condition specified in clause 5E of this order, the installation and use in the clean air zone of any fuel burning equipment of a kind or class specified in the Third Schedule to this order is hereby authorised.

"(2) This clause and the Third Schedule to this order shall expire with the close of the 30th day of April 1992.

"5E. **Condition in relation to use of fuel burning equipment**—Clauses 5B, 5C, and 5D of this order are each subject to the condition that the only fuel used in fuel burning equipment of a kind or class specified in the First Schedule or the Second Schedule or the Third Schedule to this order is fuel of a kind or class specified in the First Schedule or the Second Schedule or the Third Schedule to this order or in a notice under clause 5G of this order in relation to that kind or class of fuel burning equipment.

"5F. **Prohibited fuel burning equipment**—(1) The installation or use in the clean air zone of any fuel burning equipment (other than fuel burning equipment of a kind or class specified in the First Schedule or the Second Schedule or the Third Schedule to this order or of a class authorised for installation or use in the clean air zone by a notice under clause 5G of this order) is hereby prohibited.

"(2) Nothing in this clause prohibits the use in the clean air zone of—

"(a) Any fuel burning equipment installed before the 14th day of July 1977; or

"(b) Any fuel burning equipment that has at any time been authorised for installation or use in the clean air zone; or

"(c) Electricity or solar radiation.

"5G. **Power of Minister to authorise or prohibit use of fuel or fuel burning equipment**—(1) The Minister may, by notice in the *Gazette*, given after consultation with the City Council,—

"(a) Authorise or prohibit the use in the clean air zone of any class of fuel specified in the notice:

"(b) Authorise or prohibit the installation or use in the clean air zone of any class of fuel burning equipment specified in the notice.

"(2) The Minister may exercise in such manner as the Minister thinks fit the powers delegated to the Minister by this clause."

3. Further exemptions from sections 15 and 16 (1) of the Act—Clause 6 (1) of the principal order is hereby amended by repealing paragraph (a), and substituting the following paragraph:

"(a) To fuel burning equipment, of a kind specified, or belonging to a class described, in the First Schedule or the Second Schedule or the Third Schedule to this order or belonging to a class authorised for installation or use in the clean air zone by a notice under clause 5c of this order, for a period of 30 minutes while the equipment is being lit up from cold by the use, as kindling, of paper, dry wood, manufactured fire lighters, or gas; or".

4. Order not to apply to scheduled process—The principal order is hereby amended by inserting, after clause 6, the following clause:

"6A. This order shall not apply to a scheduled process on any scheduled premises."

5. New First, Second, and Third Schedules substituted—The principal order is hereby amended by revoking the Schedule, and substituting the First, Second, and Third Schedules set out in the Schedule to this order.

6. Revocations—The following regulations are hereby revoked:

(a) Regulation 3 of the Clean Air Zone (Christchurch) Order 1977, Amendment No. 1:

(b) The Clean Air Zone (Christchurch) Order 1977, Amendment No. 2:

(c) The Clean Air Zone (Christchurch) Order 1977, Amendment No. 3.

SCHEDULE

Cl. 5

NEW FIRST, SECOND, AND THIRD SCHEDULES TO PRINCIPAL ORDER

"FIRST SCHEDULE

Cls. 5, 5A, 5B

AUTHORISED FUEL BURNING EQUIPMENT AND FUEL

Authorised Fuel Burning Equipment	*Authorised Fuel*
(a) Gas fired fuel burning equipment	Natural gas or manufactured gas. Liquefied petroleum gas.
(b) Flueless kerosene fuel burning equipment (fixed or portable).	Kerosene.
(c) Oil fired fuel burning equipment, with a chimney to ensure adequate draught to enable the equipment to be operated on a continuous basis with a smoke emission not exceeding Bacharach No. 2, and being one of the following kinds:	
(i) Pot-type burner:	Kerosene or a blended home heating oil.
(ii) Gun-type burner.	Automotive gas oil (diesel oil).
(d) Alcohol fired fuel burning equipment.	Liquefied alcohol or solid alcohol fuels.
(e) Fuel burning equipment for open air cooking.	Coke, char, charcoal, dry wood, or liquefied petroleum gas.

SCHEDULES

Cl. 3

FIRST SCHEDULE

DESCRIPTION OF CLEAN AIR ZONES

District	Areas included in Zone
1. Eyre County	All that area of the county defined as the "Risely Ward" for electoral purposes in a technical description certified by the Chief Surveyor, the present subject being dated 19 September 1979.
2. Heathcote County	All those areas of the county zoned, as at the 3rd day of July 1982, Residential 1, Residential Hillslope, Special Development and Land Management Zones, Commercial 1, Commercial Service, Service Station, Industrial 1, or Industrial 2, in the No. 1 Review of the Heathcote County District Scheme.
3. Kaiapoi Borough	All those areas of the borough zoned, as at the 3rd day of July 1982, residential, commercial, or industrial in terms of the Kaiapoi Borough District Scheme.
4. Paparua County	All those areas of the county zoned, as at the 3rd day of July 1982, residential, commercial, or industrial in terms of the Paparua County District Scheme, but excluding the townships of Templeton, West Melton, Tai Tapu, and Prebbleton.
5. Rangiora Borough	All those areas of the borough zoned, as at the 3rd day of July 1982, residential, commercial, or industrial in terms of the Rangiora Borough District Scheme.
6. Riccarton Borough	All those areas of the borough zoned, as at the 3rd day of July 1982, residential, commercial, or industrial in terms of the Riccarton Borough District Scheme.
7. Waimairi District	The whole of the district, excluding all those areas zoned, as at the 3rd day of July 1982, Rural G, Rural H, or Rural P in terms of Change No. 27 to the Waimairi District Scheme.

Appendix E Rules from Proposed Natural Resources Regional Plan Part A: Air (Christchurch)

Activity-Industrial Fuel-burning Equipment	Rule	Standards/Terms	Classification	Conditions	Matters Reserved for Control/Discretion	Policy Reference
Excluding unflued gas-fired heaters and domestic heating devices subject to any other rule in Part A: Air, discharge of contaminants into air from: (i) external combustion equipment having a net combined heat generation capacity (within one property held in a single certificate of title) of 100 kilowatts or less; or (ii) internal combustion equipment used only for emergency electricity supply, having a net combined electricity generation capacity (within one property held in a single certificate of title) of 40 kilowatts or less; burning natural gas, liquefied petroleum gas, diesel oil or kerosene.	10		Permitted	1. The discharge into air from the fuel-burning equipment shall occur via a chimney stack at a height of at least seven metres above ground level and at least three metres above the ridge line of the roof of any building within a radius (from the stack) of five times the stack height. 2. The discharge shall be directed vertically into the air and shall not be impeded by any obstruction in or above the chimney stack, which may reduce the emission velocity. 3. Except for a period not exceeding two minutes in each hour of operation, the opacity of the discharge at the chimney exit shall not be darker than Ringelmann Shade No. 1, as described in New Zealand Standard 5201:1973. 4. The sulphur content of the fuel burned shall not exceed 0.35 percent by weight. 5. The fuel-burning equipment shall be maintained by a competent person at least once every year. This maintenance shall include: ash removal; adjustment if necessary of the fuel to air ratio and testing of the ratio of combustion gases (carbon monoxide, carbon dioxide and oxygen) discharged to ensure compliance with condition 3. A copy of each maintenance report shall be held and provided to the CRC before 31 March each year. 6. A record shall be kept of the type and quantity of fuel used each week in the fuel-burning equipment. This record shall be held and provided to the CRC before 31 March each year.		Policy 6

Activity-Industrial Fuel-burning Equipment	Rule	Standards/Terms/Notification	Classification	Conditions	Matters Reserved for Control/Discretion	Policy Reference
Discharge of contaminants into air from external combustion equipment burning natural gas, liquefied petroleum gas, diesel oil or kerosene having a net combined heat generation capacity (within one property held in a single certificate of title) of greater than 100 kilowatts and less than or equal to 2 megawatts.	11	1. The discharge into air from the fuel-burning equipment shall occur via a chimney stack at a height of at least three metres above the ridge line of the roof of any building within a radius (from the stack) of five times the stack height. 2. The discharge must be directed vertically into the air and must not be impeded by any obstruction in or above the chimney stack, which may reduce the emission velocity. 3. The sulphur content of the fuel burned may not exceed 0.35 percent by weight. Notification: May be non-notified without written approval of affected parties.	Controlled		For the purpose of imposing conditions, the CRC reserves control over the following matters: 1. The ability of the equipment to disperse contaminants, including chimney height, chimney design and emission velocity; 2. Maintenance of the fuel-burning equipment; 3. Monitoring of the discharge, including contaminant concentrations and opacity; 4. The concentration of the contaminants in the fuel burned; 5. The emission rate of contaminants, including amount of fuel burned and use of control equipment to reduce contaminant emissions; 6. Duration of consent; 7. Review of consent conditions.	Policy 6

Activity-Industrial Fuel-burning Equipment	Rule	Standards/Terms	Classification	Conditions	Matters Reserved for Control/Discretion	Policy Reference
Excluding unflued gas-fired heaters and domestic heating devices, discharge of contaminants into air from fuel-burning equipment burning gas or oil, which is not classified as a permitted or controlled activity by Part A: Air.	12		Discretionary		When considering the matters listed in Section 104 of the Act concerning assessment of an application for consent, the Council will have particular regard to the following matters: 1. The ability of the device to disperse contaminants, including chimney height, thermal insulation, chimney design and emission velocity; 2. How the device will be maintained; 3. How the discharge will be monitored; 4. The concentration of the contaminants in the fuel; 5. The emission rate of contaminants, including amount of fuel burned and use of control equipment to reduce contaminant emissions; 6. The cumulative effects of the proposed discharge in combination with other discharges.	Policy 6

Activity-Industrial Fuel-burning Equipment	Rule	Standards/Terms	Classification	Conditions	Control/Discretion	Policy Reference
Discharge of contaminants into air from fuel-burning equipment burning solid fuel, where the net combined heat generating capacity (within one property held in a single certificate of title) is greater than or equal to 10MW.	13	1. After 30 September 2001 the concentration of particulate matter in the emission stack(s) immediately prior to the point of discharge into air, measured according to the requirements described below, shall not exceed 50 milligrams per cubic metre of air adjusted to zero degrees Celsius, 101.3 kilopascals, 12 percent carbon dioxide on a dry gas basis. *Measurement requirements:* The concentration of particulate matter in the exhaust gas stream from devices described above shall be measured by a competent person at least once during every 6 month period when the device is operated. Measurement of the discharge from each device shall occur when that device is operating at greater than 50 percent of the normal maximum fuel-burning rate. The method of sampling and analysis shall comply with ISO 9096:1992(E), and may include methods ASTM D3685-78, BS 3405:1983(1989), US EPA Method 5 or US EPA Method 17. A description of the method used shall be provided to the CRC. Results shall be adjusted to zero degrees Celsius, 101.3 kilopascals, 12 percent carbon dioxide on a dry gas basis. The results of the analyses and description of method used shall be provided to the CRC within one month of the measurement.	Discretionary		**Existing Resource Consents Affected** This rule will affect existing resource consents for contaminant discharges into air from combustion of coal or wood. Resource consents for discharges from existing devices will be reviewed in accordance with section 128(b) of the Act to ensure compliance with the above standards and terms by 30 September 2001 (net combined heat output greater than 1MW) or 30 September 2008 (combined heat output less than 1MW).	Policy 6

Activity-Industrial Fuel-burning Equipment	Rule	Standards/Terms	Classification	Conditions	Comments	Policy Reference
Discharge of contaminants into air from fuel-burning equipment burning solid fuel, where the net combined heat generating capacity (within one property held in a single certificate of title) is greater than or equal to 1 MW.	14	1. After 30 September 2001 the concentration of particulate matter in the emission stack(s) immediately prior to the point of discharge into air, measured according to the requirements described below, shall not exceed 250 milligrams per cubic metre of air adjusted to zero degrees Celsius, 101.3 kilopascals, 12 percent carbon dioxide on a dry gas basis. *Measurement requirements:* The concentration of particulate matter in the exhaust gas stream from devices described above shall be measured by a competent person at least once during every six month period when the device is operated. Measurement of the discharge from each device shall occur when that device is operating at greater than 50 percent of the normal maximum fuel-burning rate. The method of sampling and analysis shall comply with ISO 9096:1992(E), and may include methods ASTM D3685-78, BS 3405:1983(1989), US EPA Method 5 or US EPA Method 17. A description of the method used shall be provided to the CRC. Results shall be adjusted to zero degrees Celsius, 101.3 kilopascals, 12 percent carbon dioxide on a dry gas basis. The results of the analyses and description of method used shall be provided to the CRC within one month of the measurement.	Discretionary		**Existing Resource Consents Affected** This rule will affect existing resource consents for contaminant discharges into air from combustion of coal or wood. Resource consents for discharges from existing devices will be reviewed in accordance with section 128(b) of the Act to ensure compliance with the above standards and terms by 30 September 2001 (net combined heat output greater than 1MW) or 30 September 2008 (combined heat output less than 1MW).	Policy 6

Activity-Industrial Fuel-burning Equipment	Rule	Standards/Terms	Classification	Conditions	Comments	Policy Reference
Excluding domestic heating devices, discharge of contaminants into air from fuel-burning equipment burning solid fuel, where the net combined heat generating capacity (within one property held in a single certificate of title) is less than 1 MW.	15	1. After 30 September 2008 the concentration of particulate matter in the emission stack(s) immediately prior to the point of discharge into air, measured according to the requirements described below, shall not exceed 250 milligrams per cubic metre of air adjusted to zero degrees Celsius, 101.3 kilopascals, 12 percent carbon dioxide on a dry gas basis. *Measurement requirements:* The concentration of particulate matter in the exhaust gas stream from devices described above shall be measured by a competent person at least once during every 12 month period when the device is operated. Measurement of the discharge from each device shall occur when that device is operating at greater than 50 percent of the normal maximum fuel-burning rate. The method of sampling and analysis shall comply with ISO 9096:1992(E), and may include methods ASTM D3685-78, BS 3405:1983(1989), US EPA Method 5 or US EPA Method 17. A description of the method used shall be provided to the CRC. Results shall be adjusted to zero degrees Celsius, 101.3 kilopascals, 12 percent carbon dioxide on a dry gas basis. The results of the analyses and description of method used shall be provided to the CRC within one month of the measurement.	Discretionary		**Existing Resource Consents Affected** This rule will affect existing resource consents for contaminant discharges into air from combustion of coal or wood. Resource consents for discharges from existing devices will be reviewed in accordance with section 128(b) of the Act to ensure compliance with the above standards and terms by 30 September 2001 (net combined heat output greater than 1MW) or 30 September 2008 (combined heat output less than 1MW).	Policy 6

Activity-Industrial Fuel-burning Equipment	Rule	Standards/Terms	Classification	Conditions	Comments	Policy Reference
After 30 September 2001, where the net combined heat generating capacity (within one property held in a single certificate of title) is greater than or equal to 10 MW, discharge of contaminants into air from fuel-burning equipment burning solid fuel where the concentration of particulate matter in the emission stack(s) immediately prior to the point of discharge into air exceeds 50 milligrams per cubic metre of air adjusted to 0 degrees Celsius, 101.3 kilopascals, 12 percent CO_2 on a dry gas basis.	16		Prohibited			Policy 6
After 30 September 2001, where the net combined heat generating capacity (within one property held in a single certificate of title) is greater than or equal to 1 MW, discharge of contaminants into air from fuel-burning equipment burning solid fuel where the concentration of particulate matter in the emission stack(s) immediately prior to the point of discharge into air exceeds 250 milligrams per cubic metre of air adjusted to 0 degrees Celsius, 101.3 kilopascals, 12 percent CO_2 on a dry gas basis.	17		Prohibited			Policy 6

Activity-Industrial Fuel-burning Equipment	Rule	Standards/Terms	Classification	Conditions	Comments	Policy Reference
After 30 September 2008, where the net combined heat generating capacity (within one property held in a single certificate of title) is less than 1 MW, discharge of contaminants into air from fuel-burning equipment burning solid fuel where the concentration of particulate matter in the emission stack(s) immediately prior to the point of discharge into air exceeds 250 milligrams per cubic metre of air adjusted to 0 degrees Celsius, 101.3 kilopascals, 12 percent CO_2 on a dry gas basis.	18		Prohibited			Policy 6
Discharge of contaminants into air from burning of timber treated with chemicals (other than manufactured fuel pellets), chip board and painted timber.	19		Prohibited			Issue 1, Objective 1, Policy 6

Appendix F NZS 7402: 1992 and NZS 7403: 1992

SECTION 2 APPARATUS

2.1 AMBIENT TEMPERATURE MEASUREMENT SYSTEM A system that measures ambient temperatures in the range 10°C to 40°C with an accuracy of ±3°C.

2.2 APPLIANCE TEMPERATURE MEASUREMENT SYSTEM Apparatus for measuring appliance temperatures shall consist of—

(a) a number of type J (iron constantan) or type K (chromel-alumel) thermocouples having a wire diameter of no greater than 0.6 mm; and

(b) a recording device capable of responding to the outputs of the thermocouples, as required in Clause 2.2(a) above.

2.3 WEIGHT DETERMINATION EQUIPMENT The following weighing scales are required:

(a) A balance capable of measuring a test fuel load with an accuracy of ±10 g.

(b) A balance capable of measuring the mass of the appliance and fuel load, as installed, with an accuracy of ±0.5% of the test fuel load mass.

2.4 MASS FLOW MEASUREMENT SYSTEM An instrument that measures the mass flow of the heat extraction medium with an accuracy of ±3% of the maximum measured flow.

NOTE: Assessment of accuracy will take into account density and instrument accuracy.

2.5 AMBIENT AIR PRESSURE MEASUREMENT SYSTEM An instrument that is capable of measuring ambient barometric pressure within ±3 hPa.

2.6 ANEMOMETER An instrument that measures the ambient air velocities in the vicinity of the appliance, in the range 0 to 2 m/s, with an accuracy of ±0.25 m/s.

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SECTION 3 TEST ENCLOSURE AND FLUE

3.1 GENERAL The testing shall be carried out in a calorimeter room with an internal volume of not less than 15 m^3, provided that the test facility performance criteria set out in Clauses 3.2 to 3.9 are met.

3.2 ROOM INSULATION The outer walls, ceiling and floor of the calorimeter room shall have a minimum thermal resistance of 2.5 m^2.kW.

3.3 LENGTH OF FLUE The flue pipe shall terminate at a height of 4.6 ±0.1 m above the lowermost part of the appliance.

Sections of flue outside the calorimeter room shall be surrounded by not less than 25 mm of high-temperature insulation to within one flue diameter of the flue exit.

3.4 EXPOSED FLUE WITHIN CALORIMETER ROOM

3.4.1 Freestanding appliances For freestanding appliances, the distance between the top of the exposed flue and the lowermost part of the appliance shall be 2000 ±20 mm, as shown in Figure 3.1. Flue sections within the calorimeter room above the 2 m height shall be wrapped with high-temperature insulation with minimum thickness of 25 mm.

If an appliance is designed to operate with a fully insulated flue or special flue nominated by the manufacturer, the flue specified in the appliance installation instructions shall be used.

3.4.2 Fireplace-insert appliances For fireplace-insert appliances, sections of flue pipe within the calorimeter room shall be surrounded by thermosiphon-vented flue casings, as shown in Figure 3.2. The air gap between casings shall be nominally 25 mm. The flue casings shall be wrapped with high-temperature insulation with a minimum thickness of 25 mm. All outer surfaces of the appliance not directly exposed to a living area in normal fireplace installations shall be wrapped with high-temperature insulation with a minimum thickness of 25 mm.

3.5 AIR TEMPERATURES Air entering the calorimeter shall be in the range 10°C to 25°C. The sum of the incoming and outgoing air temperatures shall not exceed 80°C at any time during a test.

3.6 AIR PRESSURE The air pressure within the calorimeter room shall be monitored regularly during testing and shall be maintained to within 1 Pa of the static pressure adjacent to the top of the flue. Flue draught pressure should not be influenced by wind-induced or fan-induced draughts by more than 1 Pa.

3.7 WALL TEMPERATURES The surface temperature at the centre of each of the innermost walls or wall shields of the calorimeter room shall be within the range 20°C to 45°C throughout the test.

3.8 AIR FLOW With the calorimeter room operating, air flows near the surface of the appliance under test shall be not greater than 1 m/s when measured at a distance of 100 mm from the appliance with the appliance not operating. In a ventilated calorimeter room, incoming air shall not be directed onto the appliance or flue.

3.9 CALIBRATION

3.9.1 General All instruments referred to in Clause 3.9 shall be calibrated before commissioning the test apparatus, and shall be recalibrated at the frequency prescribed. All calibrations shall be traceable to the relevant Australian, New Zealand or International calibration standards.

3.9.2 Calorimeter room The calorimeter room shall be calibrated using electrical resistance heating to simulate the heat output of a solid fuel burning appliance. The electrical heating calibration shall cover the entire power range over which the calorimeter room will be used, i.e. the calibration points shall not be extrapolated but may be interpolated.

The calibration shall be done for at least four power levels, spread evenly across the full range of powers. Each calibration shall allow for the thermal mass of the room. This may require a significant stabilization period at each power level. The time taken to reach 68% of steady-state conditions shall not exceed 30 min. The calibration factor shall be an average of calibration points for both increasing and decreasing power levels.

During calibration, power measurements shall be made at least every 2 min. Heat transfer medium flows, room pressure, room air temperature, and room wall temperature shall be recorded at sufficiently regular intervals to ensure that overall accuracy is not affected.

Calibration of the calorimeter room shall be carried out after any modification to the structure of the room or heat extraction system, and shall also be carried out at least annually.

NOTE: Calorimeter rooms using liquid heat transfer mediums are unlikely to meet this criterion.

3.9.3 Barometer The barometer shall be calibrated annually.

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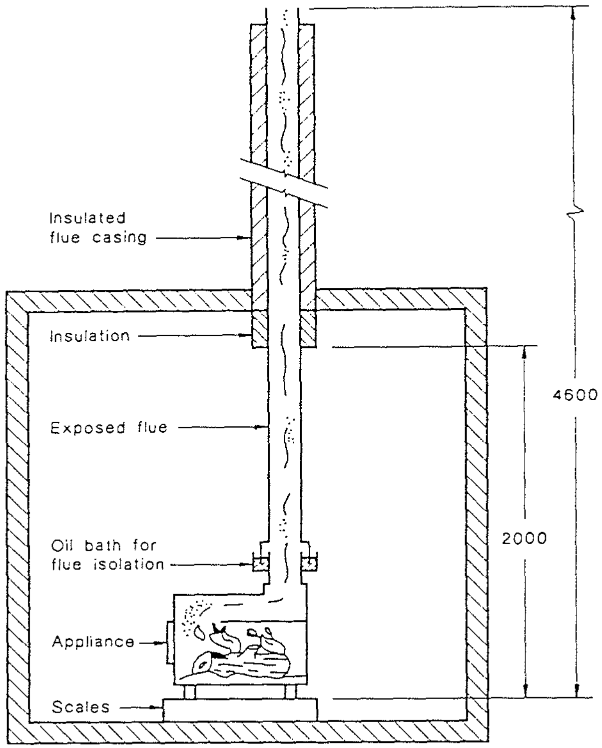
3.9.4 **Anemometer** The anemometer shall be calibrated annually.

3.9.5 **Weighing instruments** All weighing instruments (platform scales for the test fuel load and the combined mass of the appliance and fuel load) shall be calibrated annually. A multipoint calibration with at least five points spanning the operational range of each instrument shall be performed.



DIMENSIONS IN MILLIMETRES

FIGURE 3.1 TYPICAL INSTALLATION OF A FREESTANDING APPLIANCE IN A CALORIMETER ROOM

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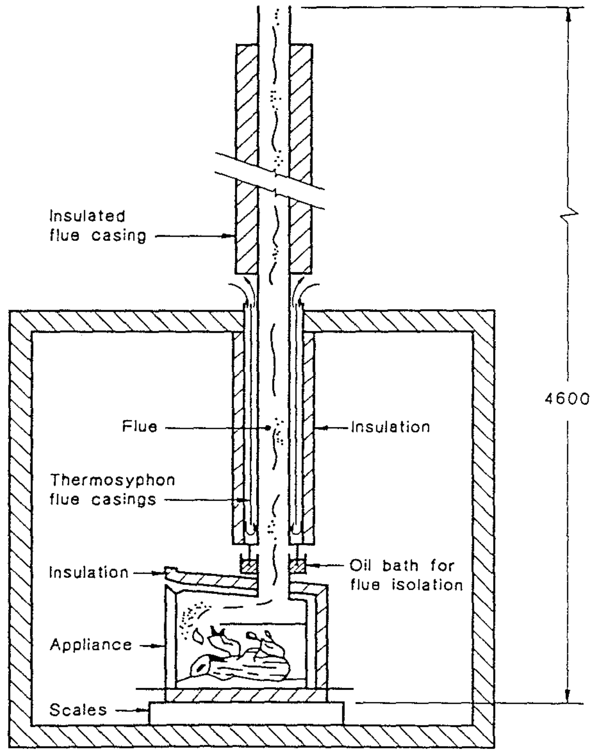

DIMENSIONS IN MILLIMETRES

FIGURE 3.2 TYPICAL INSTALLATION OF A FIREPLACE-INSERT APPLIANCE IN A CALORIMETER ROOM

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SECTION 4 MEASUREMENT ACCURACY

4.1 TEMPERATURE AND MASS FLOW To monitor power, it is necessary to measure the temperature change and mass flow of the heat extraction fluid. The required accuracy for these measurements will depend on the magnitude of the changes in temperatures and mass flows over the power range of the calorimeter room. Error calculations shall be performed to demonstrate that the combined mass flow and temperature measurements are sufficiently accurate to allow the calculation of instantaneous power to within 5%. The error calculation shall be performed assuming the power delivered by the appliance to the calorimeter room is 5 kW.

4.2 CALORIMETER ROOM SCALES The accuracy of the calorimeter room scales used for monitoring fuel consumption shall take into account any temperature change of the scales during a test. If scales are temperature-sensitive, then the temperature of the scales shall be monitored at suitable intervals throughout a test and the necessary corrections made.

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SECTION 5 TEST FUEL

5.1 GENERAL The test fuel shall comply with the requirements of this Standard and AS 4014/NZS 7404. If an appliance has a permanent label specifying the type of fuel or combination of fuel types that are to be used in that appliance, then it shall be tested to determine the power output and efficiency with *each* type of fuel and combination of fuels specified on that label. An appliance that does not have a label indicating fuel type shall be tested to determine the power output and efficiency with each type of fuel specified in AS 4014/NZS 7404.

NOTE: Unlabelled appliances need not be tested with fuel mixes.

5.2 FUEL CHAMBER USABLE VOLUME The fuel chamber usable volume (V) shall be determined by calculation. As heights, widths and lengths may vary in different places in the firebox, a summation of the volumes of all usable parts of the fuel chamber shall be performed, using the following factors to determine each element of usable volume.

The space above an ash lip next to a fuel loading door shall not be considered part of the usable volume provided that it is shallower than 25 mm unless the manufacturer's instructions state or infer that fuel may be placed in that location.

Spaces more than 50 mm above the peak of the fuel loading opening and all spaces into which a 125 mm cube, held with one plane horizontal, cannot enter shall be excluded from the calculation. Measurement shall be made with the appliance swept clean of ash but with any firebrick(s), grate(s), or baffle(s) which are intended for normal use in the appliance in place.

All other parts of the firebox shall constitute usable volume.

5.3 TEST FUEL LOAD

5.3.1 General The size of the test fuel load shall be determined by the volume of the firebox of the appliance under test as measured in Clause 5.2.

The test fuel load nominal volume (V_f) shall be 16.5% of the fuel chamber usable volume (V), i.e. $V_f = 0.165V$.

NOTE: A typical worked example for a firewood test fuel load is given in Appendix A.

5.3.2 Firewood test fuel load mass The test fuel load (wet mass) is calculated by the following formula:

$$L_f = \frac{P_D \times V_f}{1 - (M/100)}$$

where

L_f = test fuel load (wet mass)

P_D = midpoint of the allowable range of the dry density of fuel, in kilograms per litre

V_f = test fuel load nominal volume (see Clause 5.3.1)

M = midpoint of the allowable range of the moisture content of the fuel, measured as a percentage. The mass of each test fuel load shall be measured and recorded to an accuracy of ±10 g. The tolerance on the test fuel load shall be ±200 g.

Individual firewood pieces making up a test fuel load shall not vary by more than 10% in mass.

5.3.3 Coal test fuel load mass The test fuel load (wet mass) is calculated by the following equation:

$$L_c = P_D \times V_f$$

where

L_c = coal test fuel load (wet mass)

P_D = midpoint nominal density of coal, fuel, in kg/litre

V_f = test fuel load volume in Clause 5.3.1

5.3.4 Combination firewood and coal fuels The mass of the fuel shall be the combination of the following two masses:

(a) The mass of the firewood fuel shall be half the firewood test fuel load mass as calculated by the formula in Clause 5.3.2.

(b) The mass of the coal fuel shall be half the coal fuel load mass as calculated by the formula in Clause 5.3.3.

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5.4 FIREWOOD PIECE DIMENSIONS

5.4.1 General The test fuel shall be cut to length and split to an approximate cylindrical shape.

5.4.2 Length range The lengths of the firewood pieces (L) used in the test shall be equal to within ±10 mm and shall be 70% to 80% of the longest (not diagonal) dimension of the firebox (F_b). If the manufacturer specifies, in written operating instructions supplied with the appliance, that firewood should only be placed parallel to the shorter firebox dimension, then this dimension shall be used for calculating firewood piece lengths.

The measurement shall be taken horizontally at the bottom of the fuel loading opening.

5.4.3 Cross-section The cross-section of the test fuel shall be such that each piece has a core diameter of solid wood not less than 75 mm at any point and each piece will pass through a circular hole of diameter 110 mm.

If the appliance is too small to allow pieces of this length and cross-section to be loaded, then the fuel pieces should be as large as possible for convenient loading, and their sizes shall be recorded and reported.

5.4.4 Calculation of number of fuel pieces in a test fuel load The number of firewood pieces (N_t) is calculated by the following formula:

$$N = \frac{V_t \times 182}{L}$$

where

N = theoretical number of pieces

V_t = test fuel load nominal volume (see Clause 5.3.1)

L = mean length of firewood pieces
= 0.75 × fire box dimension (see Clause 5.4.2), in millimetres

N_t = actual number of firewood pieces. N_t is calculated by rounding off the theoretical number of pieces (N) to the nearest whole number

5.4.5 Firewood piece length Firewood piece length (L_p) is calculated using the following equation:

$$L_p = \frac{L \times N}{N_t}$$

If the calculated firewood piece length is outside the range of 0.7 to 0.8 of the firebox dimension (Clause 5.4.2), firewood piece length is set to the appropriate limit of the range (i.e. 0.7 or 0.8).

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SECTION 6 TEST PROCEDURE

6.1 PREPARATION BEFORE TESTING

6.1.1 Appliance air flow test All adjustable openings allowing air ingress to the appliance shall be positioned so that they reduce air inflow to its lowest level. An extraction fan shall be applied to the flue gas outlet and the pressure shall be adjusted to −25 Pa if possible, without exceeding the flow rate of 1 m^3/min when corrected to 20°C and 101.3 kPa. The flow rate shall be measured and the value recorded. If the pressure at a corrected flow rate of 1 m^3/min is less than −25 Pa, then the value of the pressure at that flow rate shall be recorded. This test shall be carried out before and after the conditioning burn, with the appliance at ambient temperature.

6.1.2 Conditioning burn Conditioning burns shall be carried out using the same fuel type, flue length and flue diameter as will be used in the test program. Fuel piece size and number, loading geometry and loading frequency shall be similar to that used in the test program. If more than one fuel type is to be used, the conditioning burn need only be done once and any of the fuel types may be used.

For a non-catalytic appliance the conditioning burn shall be carried out at the maximum burn rate of which the appliance is capable for not less than two separate 8 h burn periods.

For an appliance equipped with a catalyst, conditioning burns shall be carried out at the highest burn rate at which the catalyst will operate for not less than three separate 8 h burn periods. If the catalyst is inoperative at the maximum burn rate of which the appliance is capable, two additional 8 h burn periods shall be carried out at the maximum burn rate.

A minimum of 4 h shall be allowed between consecutive burn periods.

6.1.3 Post-conditioning adjustment Maintenance adjustments specified in the manufacturer's operating instructions shall be carried out after the conditioning burn and prior to the post-conditioning air flow test.

6.1.4 Ash Before testing, appliances shall be swept clean of ash and charcoal. Appliances without grates or refractory based fireboxes shall have a layer of ash or sand approximately 10 mm thick spread over the base of the firebox. If a manufacturer recommends a different thickness of ash or sand in the user's written instructions, then this procedure shall be followed. The mass of ash or sand shall not be included as part of the mass of burning embers.

6.1.5 Fire lighting A fire shall be lit in the appliance using newspaper or firelighters and kindling. Firewood and/or wood charcoal shall then be added and the fire allowed to burn until a bed of embers is established which weighs 24% to 26% of the test fuel load.

NOTE: The intention is to establish a bed of carbonized wood.

6.1.6 Pretest burn cycle Each pretest burn cycle shall use the same fuel as the test cycles. The appliance shall be operated in a manner that ensures conditions at the beginning of a test cycle are similar to conditions at the end. This is achieved by establishing in the appliance a bed of burning embers of the same mass at the start as at the end of the test. The average power during the pretest burn cycle shall be within 20% of the mean of the average powers measured during the test cycles. The power at the end of the pretest burn cycle shall be within 20% of the average of the powers at the end of each test cycle.

In practice, therefore, more than one pretest burn cycle may be required to be able to achieve constant conditions at the beginning and end of each test burn cycle.

6.2 FUEL LOADING At the start of each test cycle, the test fuel load shall be added to the raked bed of embers. If the appliance operating instructions specify a particular loading geometry, this shall be used.

6.2.1 Firewood loading geometry Where no loading geometry is specified, the individual firewood pieces shall be placed and levelled so that there is a gap of approximately 25 mm between pieces and from the sides of the firebox. The fuel load shall be centred approximately relative to the base of the firebox.

Pieces shall be positioned to ensure a free flow of combustion air between them. Each subsequent layer shall be placed at the minimum angle necessary to prevent close stacking with the layer below. Firewood pieces shall not be in line contact with the sides, rear or front of the firebox.

For appliances without primary under-fire air, the bottom row of firewood pieces shall, where possible, be placed so that the incoming primary combustion air flow is along the length of the fuel pieces.

Where the firebox size and shape prevents the above loading geometry, the actual geometry should be as close as possible to it.

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6.2.2 Coal fuel-loading geometry Where no loading geometry is specified, the fuel shall be loaded and levelled.

6.2.3 Mixed firewood and coal fuel-loading geometry Where no loading geometry is specified the firewood shall be loaded first in accordance with Clause 6.2.1 and coal in accordance with Clause 6.2.2.

6.3 BURN RATES The three burn rates required for this test method are as follows:

(a) *High burn rate* The appliance shall be operated with combustion rate controls fully open and an average high burn rate power for the entire burn cycle shall be calculated.

NOTE: The high power is an average and not the instantaneous peak power during a cycle.

(b) *Low burn rate* The appliance shall be operated with all combustion rate controls adjusted to the minimum setting and an average low burn-rate power for the entire burn cycle shall be calculated. If the burn cycle is unable to be completed because combustion is not sustained then the test shall be deemed invalid.

(c) *Medium burn rate* The medium burn rate shall be conducted following the high and low burn-rate tests and an average medium burn-rate power for the entire burn cycle shall be calculated.

The appliance shall be operated with combustion rate controls adjusted such that the medium burn cycle time is within ±20% of the midpoint of the difference between the average high burn cycle times and the average of low burn cycle times with a maximum variation from the midpoint of 30 min.

If an appliance has only discrete control positions (e.g. a stepwise dial), then the low and medium burn rates specified in Clause 6.3(b) and (c) above should be achieved by selecting the position on the control nearest the appropriate burn rate.

6.4 BURN CYCLE The burn cycle is complete when the mass of the test fuel load, less its calculated ash content, is consumed to within ±0.5% of the mass of the test fuel load. The time shall be recorded to the nearest minute and the exact mass of the embers recorded to the limiting accuracy of the scales. Prior to refuelling, the embers shall be raked level. The appliance shall be refuelled as required.

6.5 NUMBER OF BURN CYCLES The minimum number of valid test cycles (excluding pre-test burn cycles) required for a full test at a particular burn rate is three.

6.6 DATA-RECORDING INTERVAL During tests, measurements required for power output shall be made at intervals of not more than 2 min. Other measurements shall be recorded at sufficiently regular intervals to ensure that overall accuracy is not affected.

Barometric pressure and relative humidity (RH) shall be recorded at the beginning of each burn cycle. Barometric pressure shall be recorded during each burn cycle and shall be within the range 995 to 1030 hPa during all burn cycles for the test results to be valid.

6.7 OPERATION OF THE APPLIANCE

6.7.1 Baffle bypass damper During tests, the appliance operating instructions for the baffle bypass damper shall be followed. If no instructions are provided, the baffle bypass damper, if fitted, shall be opened during refuelling and then closed as soon as the fuel mass drops by 10% of the test fuel load.

6.7.2 Burn-rate control For tests at medium and low burn rates, the burn-rate control or controls shall be left fully open after refuelling until the fuel mass drops by 20% of the test fuel load. The burn-rate control shall then be set to the appropriate position to provide the required burn rate. The burn-rate control shall *not* be adjusted again during the burn cycle.

If the appliance operating instructions specify a different operational sequence for controls, then the operating instructions shall be followed except that adjustment of the controls shall be made *once* only during a burn cycle.

6.7.3 Fans If the appliance is designed to be fitted with a fan, then the fan shall be in position and operating at its maximum rate, or at the fan setting specified in the appliance operating instructions, except that the fan controls shall *not* be changed during a particular burn cycle.

6.7.4 Other controls Appliances with fuel specific or multiple controls (e.g. more than one controllable air supply) shall be operated in accordance with the appliance operating instructions, except that adjustment of the controls shall be made *once* only during a burn cycle. If no instructions are provided, the appliance shall not be tested. The setting and adjustment of controls shall be noted and recorded in the report on the appliance.

6.7.5 Automatic controls Automatic controls such as thermostatic controllers, air supply and fans shall be allowed to operate in the normal mode during the burn cycle.

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6.8 APPLIANCES WITH A WATER-HEATING FACILITY If the appliance incorporates a water-heating facility, or if the manufacturer provides or offers instructions for installing an optional water-heating facility then the facility shall be in position during testing. Water shall be passed through the water-heating facility, such that the inlet water temperature shall be in the range of 25° to 30°C, and the temperature rise across the facility is in the range 25° to 30°C. The energy content of the heated water shall not be taken into account for the purposes of calculating heat output and efficiency.

An appliance may be fully retested without a water-heating facility in place and the heat output and efficiency calculated. These calculations may be reported in addition to the calculations made with the water heating facility in place provided the report notes the fact that the water heating facility was *not* fitted.

When the heat output and efficiency of an appliance is recorded during testing to determine the particulate emissions (see AS 4013/NZS 7403), the water heating facility shall be in place and operating correctly.

6.9 DUCTED APPLIANCES Appliances with auxiliary duct systems may be tested by simulating the required back-pressure in the duct.

6.10 POST-BURN APPLIANCE AIR-FLOW TEST If the air-flow test in Clause 6.1.1 results in a flow rate of less than one standard cubic metre per minute (corrected to 20°C and 101.3 kPa), then a post-burn air flow test shall be conducted as follows. Immediately after the conclusion of all the necessary burn cycles, and after the appliance has cooled to ambient laboratory temperature, an air-flow test shall be conducted on the appliance, as detailed in Clause 6.1.1, and the flow rate recorded. If the flow rate varies from that recorded in the post-conditioning air-flow test by more than 25%, the results of the performance tests shall be invalid.

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SECTION 7 CALCULATION AND REPORTING OF RESULTS

7.1 CALCULATIONS

7.1.1 Average power The average power for each burn cycle in a test shall be calculated by averaging the power measured at each recording interval (Clause 6.6). If the average power for a burn cycle in a test varies by more than 15% when expressed as a percentage of the average of all the burn cycles, the results of that burn cycle shall be invalid. The average power for a full test is the average for the total number of valid burn cycles at the same burn rate.

7.1.2 Heat output The heat output for a burn cycle shall be calculated by multiplying the average power for the burn cycle by the time taken for the burn cycle (recorded to the nearest minute) in accordance with the following equation:

$$\text{Heat output (MJ)} = \frac{\text{Average power (kW)} \times \text{time (min)} \times 3.6}{60}$$

7.1.3 Energy input The energy input, in the form of fuel, shall be calculated by multiplying the oven dry mass of test fuel added at the start of the burn cycle by the gross calorific value of the fuel (oven-dry basis).

7.1.4 Efficiency The efficiency of an appliance for a single burn cycle shall be calculated by dividing the heat output by the energy input and expressing this fraction as a percentage in accordance with the following equation:

$$\text{Efficiency (\%)} = \frac{\text{Heat output (MJ)}}{\text{Energy input (MJ)}} \times \frac{100}{1}$$

If the calculated efficiency for any burn cycle varies by more than 10% from the average efficiency of the rest of the burn cycles at the same burn rate in a test, the results of that burn cycle shall be invalid.

7.1.5 Fuel consumption rate The fuel consumption rate for a burn cycle shall be calculated by dividing the oven-dry mass of the test fuel by the burn cycle time and expressed in kilograms per hour (oven-dry).

7.2 REPORT The following shall be reported:

(a) Make, type and model of the appliance.

(b) Details of fuelling rates, type of fuel used, gross calorific value of the fuel, moisture content of the fuel, firewood piece dimensions and all operating conditions and settings recorded during tests. A photograph of the fuel load shall be included.

(c) For each of the high, medium, and low burn rates, the average power (kW) to the nearest 0.1 kW, the average peak power for high burn rates to the nearest 0.1 kW, average efficiency (percent) to the nearest percentage point, and the average fuel consumption rate (kg/h) to the nearest 0.1 kg/h.

(d) Confirmation that the accuracy of the test method is ±5%.

(e) The average burn time for each of the high, medium and low burn cycles.

(f) Name of the testing agency, date of test, and the name of the person responsible for the test.

(g) A reference to this test method, i.e. AS 4012/NZS 7402.

If results are publicly reported as being carried out in accordance with AS 4012/NZS 7402, then the fuel type and all the results in Clause 7.2(c) and (e) above shall be included.

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SECTION 8 MARKING

8.1 MARKING The following information shall be marked, in a permanent and legible manner, on one or more plates permanently attached to the appliance.

8.1.1 Compulsory permanent marking

(a) Name or trade mark of the manufacturer or distributor of the appliance.

(b) Type, unique model and serial number of the appliance or sufficient information to provide adequate identification for replacement parts and necessary servicing.

(c) If the appliance has a catalytic combustor fitted, the type model and serial number of the combustor, or sufficient information to provide adequate identification for replacement.

8.1.2 Fuel types If the appliance is to be used only with certain fuels or combinations of fuels the words 'BURN ONLY' followed by the specified fuels or combinations of fuels shall be marked in letters not less than 3 mm in height. This wording shall be visible to an operator when opening the fuel loading door.

8.1.3 Additional marking The following additional information (see Figure 8.1) shall be marked in letters not less than 3 mm in height:

(a) The words 'MAXIMUM AVERAGE HEAT OUTPUT BURNING', followed by,
  - (i) the fuel or fuels specified in AS 4014/NZS 7404, followed by,
  - (ii) the average power on high burn rate calculated in accordance with Clause 7.1.1 to the nearest kilowatt followed by,
  - (iii) the letters 'kW' (kilowatts).

(b) The words 'EFFICIENCY BURNING', followed by,
  - (i) the fuel or fuels specified in AS 4014/NZS 7404, followed by,
  - (ii) the value calculated in accordance with Clause 7.1.4, followed by,
  - (iii) the symbol '%' (percent).

This wording shall be repeated for each fuel for which the appliance has been tested using the method set out in this Standard.

Beneath this there shall be the words 'when tested in accordance with AS 4012/NZS 7402.

NOTE: Manufacturers making a statement of compliance with this Australian/New Zealand Standard on a product, or on packaging or promotional material related to that product, are advised to ensure that such compliance is capable of being verified.

In Australia:

Independent certification is available from Standards Australia under the StandardsMark Product Certification Scheme. The StandardsMark, shown below, is a registered certification trade mark owned by Standards Australia and granted under licence to manufacturers whose products comply with the requirements of suitable Australian Standards and who operate sound quality assurance programs to ensure consistent product quality.

Further information on product certification and the suitability of this Standard for certification is available from Standards Australia's Quality Assurance Services, 80 Arthur Street, North Sydney, N.S.W. 2060.

In New Zealand:

THE NEW ZEALAND STANDARD CERTIFICATION MARK SCHEME

As this Standard covers product safety, manufacturers are advised to apply for a licence to use the New Zealand Standard Certification Mark.

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Manufacturers may obtain particulars of the conditions of licensing from the Director, Standards Association of New Zealand, Private Bag, Wellington.

MAXIMUM AVERAGE HEAT OUTPUT BURNING HARDWOOD—8 kW SOFTWOOD—8 kW EFFICIENCY BURNING HARDWOOD—44% SOFTWOOD—43% WHEN TESTED IN ACCORDANCE WITH AS 4012/NZS 7402

FIGURE 8.1 SAMPLE MARKING

APPENDIX A
FIREWOOD DETERMINATION—WORKED EXAMPLE
(Informative)

A1 SCOPE This Appendix provides a typical worked example for determination of a firewood test fuel load, when testing applicances in accordance with this Standard.

A2 WORKED EXAMPLE FIREWOOD DETERMINATION:

(a) *The usable volume* (see Clause 5.2)

$V = 35.5$ litres

(b) *Test fuel nominal volume* (see Clause 5.3.1)

$V_f = 16.5\%$ of V

$= .165 \times 35.5$

$= 5.86$ litres

(c) *Firewood test fuel load mass* (see Clause 5.3.2)

$$L_f = \frac{P_D \times V_f}{1 - (M/100)}$$

(i) *Softwood*

$P_D = 0.470$

$M = 18\%$

Softwood

$$L_f = \frac{0.470 \times 5.86}{1 - (18/100)}$$

$= 3.36 \pm 0.20$ kg

(ii) *Hardwood*

$P_D = 0.850$

$M = 14\%$

Hardwood

$$L_f = \frac{0.850 \times 5.86}{1 - (14/100)}$$

$= 5.79 \pm 0.20$ kg

(d) *Firewood length range* (see Clause 5.4.2)

Firebox dimension (F_b) (as measured) = 391 mm

Calculated length range

(i) Maximum

$L = F_b \times 0.80$

$= 391 \times 0.80$

$= 313$ mm

(ii) Minimum

$L = F_b \times 0.70$

$= 391 \times 0.70$

$= 274$ mm

(e) *Number of firewood pieces*: (N) (see Clause 5.4.4)

$$N = \frac{V_f \times 182}{L}$$

$$= \frac{5.86 \times 182}{391 \times 0.75}$$

$= 3.64$

$\therefore = N_f = 4$ pieces

(f) *Firewood piece length* (see Clause 5.4.5)

$$L_p = \frac{L \times N}{N_f}$$

$$= \frac{391 \times .75 \times 3.64}{4}$$

$= 267$ mm

As this is outside the range calculated in *Step d* (Clause 5.4.2), then firewood piece length is set to the appropriate limit of the range, i.e. 274 mm.

(g) *Summary of calculated firewood load*

	Softwood	*Hardwood*
(i) Test fuel load mass (L_f)	3.36 ± 0.20 kg	5.79 ± 0.20 kg
(ii) Number of pieces (N_f)	4	4
(iii) Wet mass per piece (L_f/N_f)	$0.840 \pm 10\%$ kg	$1.448 \pm 10\%$ kg
(iv) Actual piece length (L_p)	274 mm	274 mm

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STANDARDS AUSTRALIA/STANDARDS ASSOCIATION OF NEW ZEALAND

Australian Standard/New Zealand Standard
Domestic solid fuel burning appliances—Method for determination of flue gas emission

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE This Standard specifies a test method for determining the rate of particulate emission from batch-fed domestic solid fuel burning appliances and the associated particulate emission acceptance criteria.

1.2 APPLICATION This Standard applies to domestic solid fuel burning appliances.

1.2.1 Included appliances Appliances within the scope of this Standard include—

(a) space-heating appliances; and

(b) space-heating appliances which include water-heating devices.

1.2.2 Excluded appliances Appliances excluded from this Standard are—

(a) site-built masonry appliances;

(b) central heating appliances;

(c) cooking appliances;

(d) appliances intended solely for water heating;

(e) appliances intended solely to distribute convective heat via ducting to locations remote from the appliance;

(f) appliances that when fired at the high burn rate prescribed in this Standard have a maximum carbon dioxide output from the combustion chamber of less than 5% by volume with any optional doors fitted and closed; and

(g) appliances with volumetric flow rates through the combustion chamber which are too high to allow for total smoke capture by the method described in this Standard.

1.3 REFERENCED DOCUMENTS The following documents are referred to in this Standard:

AS

2918 Domestic solid fuel burning appliances—Installation

4012 Domestic solid fuel burning appliances—Method for determination of power output and efficiency

4014 Domestic solid fuel burning appliances—Method for determination of test fuels

NZS

7402 Domestic solid fuel burning appliances—Method for determination of power output and efficiency

7404 Domestic solid fuel burning appliances—Method for determination of test fuels

1.4 DEFINITIONS For the purposes of this Standard, the definitions given in AS 2918, AS 4012/NZS 7402 and below apply.

1.4.1 Appliance particulate emission factor—the arithmetic mean of the average particulate emission factors at each of the high, medium and low burn rates.

1.4.2 Central heating appliance—a heating appliance which has a maximum heat output rate greater than 25 kW, or a combustion unit which is intended for installation outside the living area, and includes a means of transferring heat to the living area by hot air, hot water or other fluid.

1.4.3 Cooking stove appliance—a cooking appliance is a solid fuel burning appliance which incorporates at least one cooking hot plate and an oven with a volume of not less than 28 L. Gaseous combustion products are capable of being routed around the oven.

1.4.4 Informative appendix—describes material which does not form an integral part of the Standard but provides additional information and, for reasons of convenience, is placed after the body of the Standard.

1.4.5 Normative appendix—describes material which is an integral part of the Standard and, for reasons of convenience, is placed after the body of the Standard.

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1.4.6 Particulate emission factor—the calculated weight in grams of the total emission from the flue of an appliance during a specific burn rate divided by the mass of dry fuel in kilograms used in that burn cycle.

1.4.7 Shall—indicates that a statement is mandatory.

1.4.8 Should—indicates a recommendation.

1.4.9 Standard temperature—20°C.

1.4.10 Standard pressure—101.3 kPa.

1.5 PRINCIPLE The appliance is installed in a calorimeter room with the flue exhausting into a dilution tunnel. It is fired in a given manner, and particulate emissions are sampled from the dilution tunnel and measured over a number of different burn cycles. The emission rate for each burn cycle is calculated, and the results averaged to obtain the appliance particulate emission factor.

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SECTION 2 APPARATUS AND REAGENT

The following apparatus and reagent and those specified in AS 4012/NZS 7402 are required:

2.1 AMBIENT TEMPERATURE MEASUREMENT SYSTEM A system which measures ambient temperatures in the range 10°C to 40°C with an accuracy of ±3°C.

2.2 AMBIENT AIR PRESSURE MEASUREMENT SYSTEM An instrument capable of measuring ambient barometric pressure within ±3 hPa.

2.3 WEIGHT DETERMINATION SYSTEM A balance with an accuracy of ±0.1 mg which weighs filters and, if required, filter holders and sample probes.

2.4 SAMPLING TRAIN Apparatus for the collection of emissions (see Figure 2.1). This shall include the following components:

2.4.1 Sample probe A 450 mm long seamless stainless steel or glass probe of nominal internal diameter 9.5 mm with one end cut off at right angles, as shown in Figure 2.1.

2.4.2 Filter holders Two 50 mm nominal diameter filter holders.

2.4.3 Temperature measurement A system for measuring the sample gas temperature in the range 10°C to 40°C with an accuracy of ±3°C.

2.4.4 Drying system Equipment capable of reducing the moisture content of the sample gas to less than 1.5% moisture by volume.

2.4.5 Dry gas meter A suitable instrument for measuring dry gas volume of a sample with a calibrated accuracy of ±1% of the volume sampled.

2.4.6 Sampling gas temperature measurement A system for measuring the average temperature of the sampling gas passing through the dry gas meter over the range 10°C to 40°C to within ±3°C.

2.4.7 Filters Glass fibre filters of 50 mm nominal diameter to fit the filter holders, without organic binders and having at least 99.95% collection efficiency on 0.3 μm dioctyl phthalate smoke particles.

NOTE: The Gelman A/E 41631 filter has been found to be acceptable for this purpose.

2.4.8 Pump A pump that is capable of extracting the gas sample at the required rate against the resistance imposed by the sample probe, filters, dryer and connecting tubes.

2.4.9 Dilution tunnel Apparatus as shown in Figure 2.2, and including the following components:

(a) *A temperature system* for measuring the temperature in the dilution tunnel over the range 10°C to 200°C with an accuracy of ±3°C.

(b) *Pitot tube* A Type 'S' or standard Pitot tube of a known coefficient.

(c) *Differential pressure gauge* A pressure measuring device for measuring the Pitot tube velocity head to within ±1 Pa.

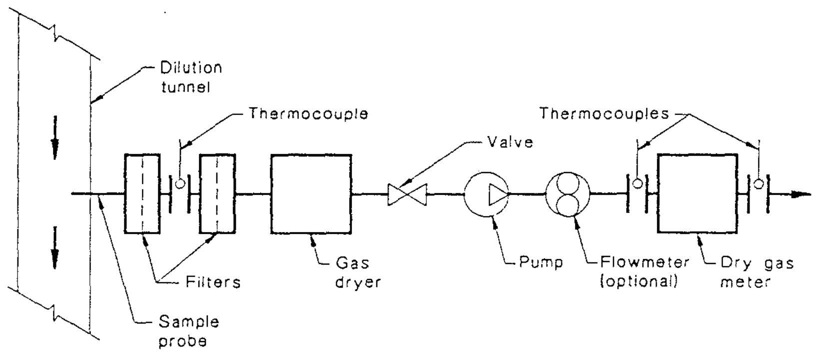

FIGURE 2.1 A TYPICAL SAMPLING TRAIN USED WITH THE DILUTION TUNNEL

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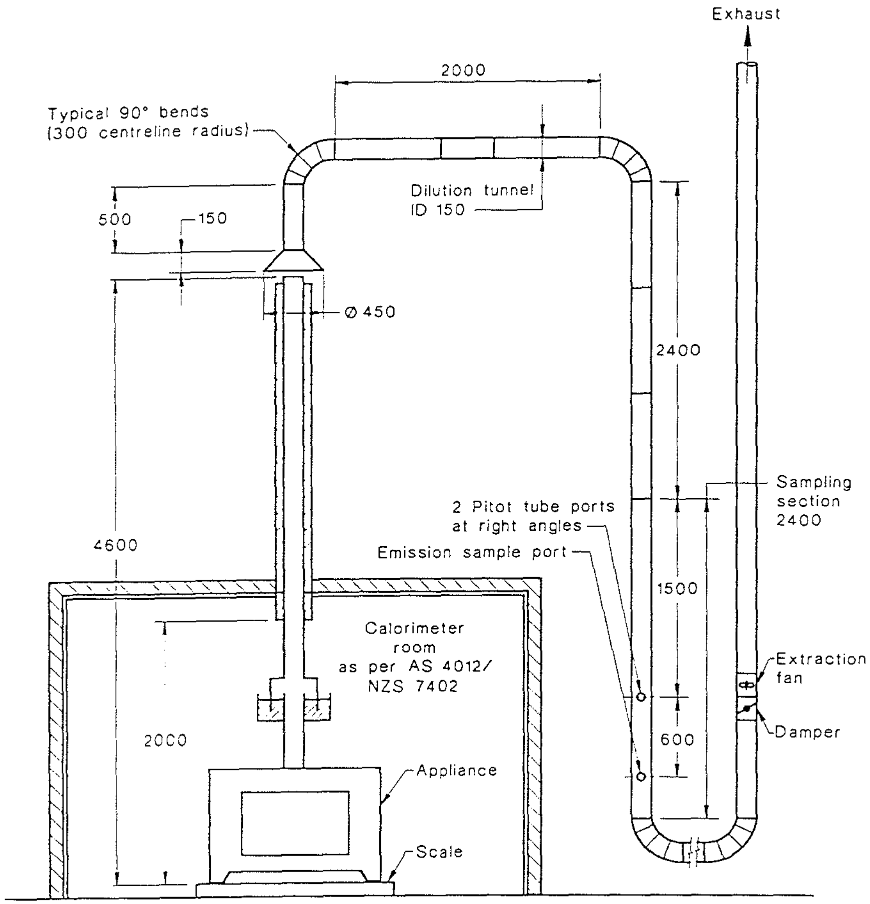

DIMENSIONS IN MILLIMETRES

FIGURE 2.2 TYPICAL DILUTION TUNNEL FACILITY

2.5 DRAUGHT GAUGE A suitable instrument for measuring a flue draught in the range of 0 to 2.0 Pa with an accuracy of ±0.25 Pa.

2.6 DESICCATORS One or more desiccators for drying filters and components.

2.7 ACETONE Analytical grade acetone for the cleaning of components.

2.8 DISHES Glass or plastic dishes suitable for containing and weighing filters.

2.9 CARBON DIOXIDE ANALYZER (OPTIONAL) Of nominal 2% FS (full scale) accuracy.

SECTION 3 CONFIGURATION OF TEST EQUIPMENT

3.1 GENERAL The testing shall be carried out in a calorimeter room as specified in AS 4012/NZS 7402 with the sampling train and dilution tunnel arranged as shown in Figures 2.1 and 2.2.

3.2 DILUTION TUNNEL

3.2.1 Hood The hood shall be of corrosion-resistant steel, with its large end having a minimum entry opening diameter of 450 mm, and a nominal exit diameter of 150 mm. The hood shall be placed axially above the appliance outlet.

3.2.2 Connectors All connectors shall be made of seamless or longitudinally seamed stainless or corrosion-resistant steel with a nominal inside diameter of 150 mm. The connector nearest the hood shall be 500 ± 100 mm long, the connector between the bends shall be 2000 mm ± 10 mm long and the connector between the downstream bend and the sampling section shall be 2400 mm ± 10 mm long.

NOTE: Connectors may be constructed from more than one length of duct.

3.2.3 Bends The two 90° bends upstream from the sampling location shall be of stainless or corrosion resistant steel and shall have a nominal inside diameter of 150 mm with a nominal centreline radius of 300 mm.

NOTE: Segmental (lobster back) bends are permitted.

3.2.4 Sampling section The sampling section shall be joined to the connector after the downstream bend and shall be one continuous length of either stainless or corrosion-resistant seamless or longitudinally seamed steel tube not less than 2400 mm long with a nominal inside diameter of 150 mm. The distance from the upstream end to the Pitot tube position shall be 1500 ± 10 mm and the distance from the upstream end to the sample port location shall be 2100 ± 10 mm.

3.2.5 Extraction fan An extraction fan shall be fitted after the sampling section, and shall carry exhaust products clear of the test area. The system shall incorporate a means of adjusting the flow rate through the dilution tunnel, and be capable of maintaining a flow rate of at least six standard cubic metres per minute (corrected to 20°C and 101.3 kPa).

3.2.6 Component assembly The elbows, connectors and sampling section shall be fitted so that they can be removed easily for cleaning.

3.2.7 Pitot tube location The Pitot tube shall be installed within 2 mm of the centre of the velocity traverse section, and shall point directly upstream within 2° of the axis of the dilution tunnel.

3.3 SAMPLING TRAIN The sampling train apparatus shall be arranged as shown in Figure 2.1.

3.3.1 Probe The ends of the probe shall be cut at 90° to its axis, and there shall be means for positioning the probe end in the centre of the sampling section of the dilution tunnel to within 2 mm.

3.3.2 Filter coupling The first filter shall be coupled as close as is practicable to the end of the sample probe. The second filter assembly shall be coupled as close as is practicable to the first filter assembly so that the filter membranes are not more than 100 mm apart.

3.3.3 Temperature probes A probe for measuring sample gas temperature shall be inserted between the first and second filter with the sensing tip in contact with the sample gas.

Additional temperature probes shall be placed at the entrance and exit sides of the dry gas meter, with the sensing tips in contact with the sample gas. The output from the probes shall be arranged to give an average temperature for both locations which shall be taken to be the average temperature of the gas passing through the dry gas meter.

3.3.4 Dryer coupling The second filter shall be connected to the dryer, which shall connect to the pump and flow rate mechanism.

3.3.5 Exhaust pump The pump shall exhaust the sample gases to atmosphere through the dry gas meter.

3.3.6 Joint seals All joints shall be airtight during test runs. The probe and filter assemblies shall be readily detachable in such a manner that no weight variation occurs during disassembly.

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SECTION 4 CALIBRATIONS

4.1 GENERAL All instruments referred to in this Section shall be calibrated before commissioning the test apparatus, and shall be recalibrated at the frequency prescribed below. All calibrations shall be traceable to the relevant Australian, New Zealand or International calibration Standards.

4.2 DRY GAS METER The dry gas meter shall be calibrated annually. Appendix A provides a suitable method.

4.3 DILUTION TUNNEL The dilution tunnel shall be calibrated annually in accordance with Appendix B to establish the calibration factor.

4.4 WEIGHING INSTRUMENTS The balance for determining the weight of the filters shall be calibrated annually. A multipoint calibration with at least five points spanning the operational range of the instrument shall be performed.

4.5 TEMPERATURE MEASUREMENT All temperature measurement systems shall be calibrated annually.

4.6 DIFFERENTIAL PRESSURE MANOMETER AND DRAUGHT GAUGE Liquid manometers do not require calibration, however the fluids require periodic replacement. Other types of gauge shall be calibrated annually.

4.7 CARBON DIOXIDE ANALYZER The optional carbon dioxide analyzer instrument shall be calibrated in accordance with Appendix C.

SECTION 5 TEST FUEL

5.1 GENERAL The fuel or fuels shall comply with the requirements of AS 4012/NZS 7402 and AS 4014/NZS 7404. An appliance shall be tested to determine the particulate emission with *each* type of fuel and combination of fuels to be specified on the appliance. An appliance tested with more than one fuel need not be tested with a mixture of those fuels.

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SECTION 6 TEST PROCEDURE

6.1 GENERAL The appliance shall be installed in the calorimeter room in accordance with the requirements of AS 4012/NZS 7402.

6.2 DILUTION HOOD AND TUNNEL The dilution hood and tunnel shall be installed over the appliance flue outlet in a manner which ensures that all the flue gases from the appliance enter the dilution tunnel.

6.3 DILUTION TUNNEL The dilution tunnel shall be clean at the commencement of operation of the calorimeter room and dilution tunnel. The dilution tunnel shall be maintained at a flow rate at 6.0 ±0.5 standard cubic metres per minute (corrected to 20°C and 101.3 kPa).

6.3.1 Flue pipe draft The draft induced into the appliance flue pipe by the dilution tunnel shall be measured. It shall be less than 1 Pa. The setting of the controls and the draught induced into the appliance flue pipe shall be noted and recorded.

6.3.2 Ambient air velocity The ambient air velocity in the vicinity of the appliance before firing shall be measured. This shall be less than 1 m/s within 100 mm of the appliance and flue.

6.4 TEST PREPARATION

6.4.1 Appliance preparation The appliance shall be installed in the calorimeter room in accordance with AS 4012/NZS 7402.

6.4.2 Sample collection system All components shall be thoroughly cleaned. The filters, filter dishes and all other components (which shall be weighed for the purpose of calculating emission) shall be placed in a desiccator for at least 24 h at ambient laboratory temperature and pressure, such that successive measurements at not less than hourly intervals show no change or a gain in weight. The weights of each component shall be recorded. Each component in the collection system shall be readily identifiable by a number which is still readable following testing of the appliance.

6.5 TEST FUEL LOAD

6.5.1 Preparation All fuel loads shall be prepared in accordance with AS 4012/NZS 7402 and AS 4014/NZS 7404.

6.5.2 Fuel-loading geometry Fuel-loading geometry shall be in accordance with AS 4012/NZS 7402.

6.6 BURN CYCLES The appliance shall be conditioned in accordance with AS 4012/NZS 7402. A series of burn cycles shall be conducted in accordance with AS 4012/NZS 7402. The emission results from each cycle shall be measured and recorded. Emission results from any burn cycle not conducted in accordance with the requirements of AS 4012/NZS 7402 shall be invalid.

Emissions shall be measured on high, medium and low burn cycles, as described in AS 4012/NZS 7402.

The dilution tunnel shall be started at least 10 min prior to a burn cycle (i.e. during the pre-burn cycle). It shall not collect the combustion products during the fire-lighting stage.

6.7 SAMPLING TRAIN OPERATION

(a) The emission sampling train shall be tested for leakage before each burn cycle. Leakage must not be more than 4% of the sampling train flow rate.

(b) The dry gas meter reading shall be recorded before the sampling pump is started.

(c) The emission sampling train shall be started after the embers have been raked level and the scales indicate that the previous fuel load has been fully consumed.

(d) The test-fuel load shall be added to the appliance within 1 min of starting the sampling train pump.

(e) With the emission sampling train operating at 5.5×10^{-3} standard cubic metres per minute ±10% (corrected to 20°C and 101.3 kPa) the temperature of the gas between the filters shall be in the range 15°C to 32°C at all times throughout the burn cycle.

(f) The dilution tunnel flow-rate temperature and sampling rate shall be recorded at intervals not exceeding 10 min. Dilution tunnel temperature shall be not less than 25°C at all times throughout the burn cycle.

(g) Filters may be changed once if it is impossible to maintain the sample flow rate. The replacement filter assembly shall be leak tested prior to use. The total interruption to sample collection shall not exceed 30 s.

(h) The sampling-train pump shall be shut off when the scales indicate that all but 50 g of the test fuel load excluding calculated ash has been consumed.

(i) The dry gas meter reading shall be recorded after the sampling-train pump has been shut off.

(j) Steps (a) to (i) shall be repeated as required.

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6.8 SAMPLE TREATMENT The filters shall be removed and handled carefully to ensure that no sample is contaminated or lost.

6.9 SAMPLE MEASUREMENT Filters, filter dishes and all other components which need to be weighed for the purpose of calculating the mass of emission shall be desiccated separately for at least 24 h at ambient laboratory temperature and pressure. When successive measurements made at not less than hourly intervals show no change or gain in weight, each component shall be separately weighed and the weight recorded. Each component shall be identified so that its location in the collection system can be identified. The probe and filter holders shall be weighed directly or cleaned using acetone into a desiccated pre-weighed beaker. The washings shall be desiccated at ambient pressure and at a temperature of not more than 30°C. If acetone is used, an acetone blank of similar volume to acetone used for washing shall be prepared in a desiccated, pre-weighed beaker. The weight change in the blank shall be used to correct the weight of each beaker used for the samples.

6.10 CALCULATIONS

6.10.1 Sample weight The sample weight shall be calculated by adding the post-burn test and pre-burn test weight differences for each component in the sampling train.

6.10.2 Sample flow volume The total volume of the sample flow shall be calculated by summing the standard volumes collected for each interval. Relative humidity shall be assumed to be zero.

6.10.3 Dilution tunnel flow volume The dilution tunnel total flow volume shall be calculated by summing the standard volumes passing through the tunnel for all intervals. The moisture content shall be assumed to be 4% (100% RH at 30°C).

6.10.4 Volume ratio The ratio of dilution tunnel flow volume to sample flow volume shall be calculated.

6.10.5 Particulate emission weight The particulate emission weight in grams for each burn cycle shall be calculated by multiplying the sample weight by the ratio given in Clause 6.10.4.

6.10.6 Particulate emission factor The particulate emission factor for each burn cycle shall be calculated by dividing the particulate emission weight in grams by the oven-dry fuel mass in kilograms.

6.10.7 Burn-rate emission factors The particulate emission factor for high, medium and low burn rates shall be calculated separately by averaging the values for each valid burn cycle.

6.10.8 Appliance particulate emission factor The appliance particulate emission factor shall be calculated by averaging the particulate emission factors for high, medium and low burn rates.

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SECTION 7 MAXIMUM ALLOWABLE APPLIANCE PARTICULATE EMISSION FACTOR

7.1 APPLIANCES WITHOUT CATALYTIC COMBUSTORS For compliance with this Standard, an appliance without a catalytic combustor shall have an appliance particulate emission factor not greater than 5.5 g/kg.

7.2 APPLIANCES WITH CATALYTIC COMBUSTORS For compliance with this Standard, an appliance with a catalytic combustor shall have an appliance particulate emission factor not greater than 3.0 g/kg.

7.3 VALID TESTS After the commencement of a series of tests to determine compliance with this Standard, all subsequent valid test results shall be used to determine compliance.

SECTION 8 TESTING DOCUMENTATION AND TEST REPORTS

8.1 GENERAL Tests referred to in this Standard apply to a sample from a product line tested to demonstrate compliance of that product with this Standard. An appliance shall be submitted for test in the same condition as it would be if offered for sale.

8.2 DOCUMENTATION An appliance submitted for test shall be provided with the following documentation:

(a) The name and address of the manufacturer.

(b) A description, including the model name and design identification.

(c) A copy of the operation and installation manuals.

(d) Design plans of the appliance, which shall include—

 (i) overall dimensions;

 (ii) firebox dimensions;

 (iii) dimensions of the airways, including the cross-sectional area of restrictive inlets and outlets, and the dimension and location of the methods of control of gas movement through the appliance;

 (iv) dimensions and location of baffle systems;

 (v) dimensions and location of refractory and insulation materials and details of their heat capacity and thermal resistance;

 (vi) the dimensions and location of the flue gas outlet;

 (vii) the dimensions, type, fit and location of all gasket materials;

 (viii) details of the outer shielding and coverings, including dimensions and location;

 (ix) the dimensions, location, type and manufacturer of the combustor, if the appliance is fitted with a catalytic combustor;

 (x) the location, dimensions, cross-sectional area and gap tolerances of any bypass dampers;

 (xi) the position, type and specification of any air circulation fan; and

 (xii) the position, type and specification of any water heating device.

All dimensions shall be in millimetres and tolerances shall be stated.

8.3 TEST REPORT The following shall be reported:

(a) The name and address of the testing agency and the name of the person responsible for the test.

(b) A chronological listing of the dates, time commenced and duration of each burn cycle used in calculating the results, together with the particulate emission factor for each burn.

(c) All information required in Section 8.2, together with a photograph of the appliance under test.

(d) The post conditioning and the post burn air flow test flow rates, in cubic metres per minute (corrected to 20°C and 101.3 kPa).

(e) The calculated appliance particulate emission factor, in grams per kilogram.

(f) One of the following statements as appropriate:

 (i) This appliance complies with AS 4013/NZS 7403.

 (ii) This appliance does not comply with AS 4013/NZS 7403.

8.4 PUBLISHED RESULTS If results are publicly reported as being carried out in accordance with AS 4013/NZS 7403, the fuel type and all the results reported in Clauses 8.3(e) and (f) shall be included in the publication.

SECTION 9 VARIATION FROM TESTED APPLIANCE

9.1 GENERAL Except as provided in Clause 9.2, an appliance shall be retested whenever any change from the tested appliance is made in the design or method of construction affecting any of the items referred to in Clause 8.2(d). If components of an appliance are changed, retesting is not required if the specifications of the replacement components are the same as the components used during initial testing.

9.2 RETESTING EXEMPTION If, in the opinion of the testing agency, changes in the test fuel or changes to the appliance design or construction changes or a combination of these will not change or will lower the particulate emission rate, the appliance may not need retesting. Any such opinion should be made by the original testing agency and be given in writing and provide—

(a) details of the changes made to the appliance; and

(b) detailed opinions as to why such changes or alternatives would not be expected to result in a increase in the original emission results.

SECTION 10 MARKING

10.1 MARKING If the appliance meets the requirements of Section 7 of this Standard, the following information shall be marked, in a permanent and legible manner, on one or more plates permanently attached to the appliance:

(a) Name or trade mark of the manufacturer or distributor of the appliance.

(b) Type, unique model and serial number of the appliance and emissions report number or sufficient information to provide adequate identification for replacement parts, traceability of testing and necessary servicing.

(c) If the appliance has a catalytic combustor fitted, the type model and serial number of the combustor, or sufficient information to provide adequate identification for replacement.

(d) The words 'COMPLIES WITH AS 4013/NZS 7403'. This information shall be in letters not less than 3 mm in height.

(e) Fuel types (where applicable) and additional marking in accordance with marking requirements for AS 4012/NZS 7402.

NOTE: The information on this plate may be combined with other data.

NOTE: Manufacturers making a statement of compliance with this Australian Standard on a product, or on packaging or promotional material related to that product, are advised to ensure that such compliance is capable of being verified.

In Australia:

Independent certification is available from Standards Australia under the StandardsMark Product Certification Scheme. The StandardsMark, shown below, is a registered certification trade mark owned by Standards Australia and granted under licence to manufacturers whose products comply with the requirements of suitable Australian Standards and who operate sound quality assurance programs to ensure consistent product quality.

Further information on product certification and the suitability of this Standard for certification is available from Standards Australia's Quality Assurance Services, 80 Arthur Street, North Sydney, N.S.W. 2060.

In New Zealand:

THE NEW ZEALAND STANDARD CERTIFICATION MARK SCHEME

As this Standard covers product safety, manufacturers are advised to apply for a licence to use the New Zealand Standard Certification Mark.

APPROVED TO NEW ZEALAND STANDARD

The 'S' Mark appearing on a product, container or label is an assurance that the goods are manufactured under a system of supervision, control, and testing (including periodical inspection at the manufacturer's works by SANZ Certification Officers) designed to ensure compliance of the commodity, process, or practice with the relevant New Zealand Standard. The New Zealand Standard Certification Mark, registered as a certification trade mark under the Trade Marks Act 1953, may be used only in terms of a licence issued by SANZ, and must be accompanied by the licence number and the NZS number.

Used correctly in conjunction with advertising the 'S' Mark can provide a strong assurance of product quality for manufacturers when selling their goods and thus becomes a powerful marketing tool.

Manufacturers may obtain particulars of the conditions of licensing from the Director, Standards Association of New Zealand, Private Bag, Wellington.

Appendix G Correlation Data

Correlation between Merlin and Woodsman Matai

	Burn Time (min)	Fuel Consumption (kg/hr)	Avg Power Output (kW)	Efficiency (%)	Particulate Emission (g/kg)	Average
Merlin						
Hot Rocks (high)	129	1.4	6.2	51.2	3.68	
Pinus Radiata (high)	67	2.5	7.8	51.4	3.59	
Multiplier	1.93	0.56	0.79	1.00	1.03	1.06
Woodsman Matai						
Run 1						
Pinus Radiata (high)	57.7	3.3	7.8	59.0	0.6	
Est. Hot Rocks (high)	61.2	3.5	8.3	62.6	0.6	
Run 2						
Pinus Radiata (high)	57.7	3.3	7.8	52	0.6	
Est. Hot Rocks (high)	61.2	3.5	8.3	55.1	0.6	
Run 3						
Pinus Radiata (high)	57.9	3.3	7.9	60.0	0.7	
Est. Hot Rocks (high)	61.4	3.5	8.4	63.6	0.7	
Average						
Est. Hot Rocks (high)	61.2	3.5	8.3	60.4	0.7	
Pinus Radiata (high)	57.8	3.3	7.8	57.0	0.6	
Merlin						
Hot Rocks (low)	378	0.5	2.7	62.3	5.25	
Pinus Radiata (low)	170	1	3.5	58.5	3.7	
Multiplier	2.22	0.50	0.77	1.06	1.42	1.20
Woodsman Matai						
Run 4						
Pinus Radiata (low)	99.6	1.9	5.6	71	1.5	
Est. Hot Rocks (low)	119.1	2.3	6.7	84.9	1.8	
Run 5						
Pinus Radiata (low)	99.7	1.9	5.4	68	0.6	
Est. Hot Rocks (low)	119.2	2.3	6.5	81.3	0.7	
Run 6						
Pinus Radiata (low)	93.2	2	4.9	63	0.9	
Est. Hot Rocks (low)	111.4	2.4	5.9	75.3	1.1	
Average						
Est. Hot Rocks (low)	116.6	2.3	6.3	80.5	1.2	
Pinus Radiata (low)	97.5	1.9	5.3	67.3	1.0	
Merlin						
Est. Hot Rocks	101.3	2.0	6.4	53.8	3.6	
Est. Pinus Radiata	212.0	1.1	5.0	54.9	4.2	
Woodsman Matai						
Final Est. Hot Rocks	**79.70**	**3.10**	**7.65**	**67.13**	**0.85**	
Est. Pinus Radiata	**71.01**	**2.84**	**6.99**	**60.44**	**0.76**	

Note Standard method: the particulate emissions are calculated as the mean of the three tests at high, meduim and low burnrate hence, it is only possible to estimate the particulate emissions using: (1/3)*((2*High)+Low)

Correlation between Merlin and Jayline Classic

	Burn Time	Fuel Consumption	Avg Power Output	Efficiency	Particulate Emission	Average
	(min)	(kg/hr)	(kW)	(%)	(g/kg)	
Merlin						
Hot Rocks (high)	129	1.4	6.2	51.2	3.68	
Pinus Radiata (high)	67	2.5	7.8	51.4	3.59	
Multiplier	1.9	0.6	0.8	1.0	1.0	1.1
Jayline Classic						
Run 1						
Pinus Radiata (high)	86.3	2.6	5.8	63	1.1	
Est. Hot Rocks (high)	91.5	2.8	6.1	66.8	1.2	
Run 2						
Pinus Radiata (high)	76.3	2.9	6	56	0.5	
Est. Hot Rocks (high)	80.9	3.1	6.4	59.4	0.5	
Run 3						
Pinus Radiata (high)	79.9	2.8	6.3	65	0.8	
Est. Hot Rocks (high)	84.7	3.0	6.7	68.9	0.8	
Average						
Est. Hot Rocks (high)	85.7	2.9	6.4	65.0	0.8	
Pinus Radiata (high)	80.8	2.8	6.0	61.3	0.8	
Merlin						
Hot Rocks (low)	378	0.5	2.7	62.3	5.25	
Pinus Radiata (low)	170	1	3.5	58.5	3.7	
Multiplier	2.2	0.5	0.8	1.1	1.4	1.2
Jayline Classic						
Run 4						
Pinus Radiata (low)	103.8	2.2	5.5	67	0.8	
Est. Hot Rocks (low)	124.1	2.6	6.6	80.1	1.0	
Run 5						
Pinus Radiata (low)	103.2	2.2	5.2	65	1.4	
Est. Hot Rocks (low)	123.4	2.6	6.2	77.7	1.7	
Run 6						
Pinus Radiata (low)	88.6	2.6	5.6	61	1.3	
Est. Hot Rocks (low)	105.9	3.1	6.7	72.9	1.6	
Average						
Est. Hot Rocks (low)	117.8	2.8	6.5	76.9	1.4	
Pinus Radiata (low)	98.5	2.3	5.4	64.3	1.2	
Merlin						
Est. Hot Rocks	101.3	2.0	6.4	53.8	3.6	
Est. Pinus Radiata	212.0	1.1	5.0	54.9	4.2	
Jayline Classic						
Final Est. Hot Rocks	96.41	2.89	6.43	69.00	1.03	
Est. Pinus Radiata	86.73	2.62	5.83	62.33	0.92	

Note Standard method: the particulate emissions are calculated as the mean of the three tests at high, meduim and low burnrates, hence, it is only possible to estimate the particulate emissions using: (1/3)*((2*High)+Low)

Correlation between Merlin and Dante Freestander

	Burn Time (min)	Fuel Consumption (kg/hr)	Avg Power Output (kW)	Efficiency (%)	Particulate Emission (g/kg)	Average
Merlin						
Hot Rocks (high)	129	1.4	6.2	51.2	3.68	
Pinus Radiata (high)	67	2.5	7.8	51.4	3.59	
Multiplier	1.93	0.56	0.79	1.00	1.03	1.06
Dante Freestander						
Average						
Pinus Radiata (high)	NA	NA	NA	NA	0.6	
Est. Hot Rocks (high)	NA	NA	NA	NA	0.6	
Merlin						
Hot Rocks (low)	378	0.5	2.7	62.3	5.25	
Pinus Radiata (low)	170	1	3.5	58.5	3.7	
Multiplier	2.22	0.50	0.77	1.06	1.42	1.20
Dante Freestander						
Average						
Pinus Radiata (low)	NA	NA	NA	NA	1.1	
Est. Hot Rocks (low)	NA	NA	NA	NA	1.3	
Merlin						
Est. Hot Rocks	101.3	2.0	6.4	53.8	3.6	
Est. Pinus Radiata	212.0	1.1	5.0	54.9	4.2	
Dante Freestander						
Final Est. Hot Rocks	**NA**	**NA**	**NA**	**NA**	**0.86**	
Est. Pinus Radiata	**NA**	**NA**	**NA**	**NA**	**0.77**	

Note Standard method: the particulate emissions are calculated as the mean of the three tests at high, meduim and low burnrate hence, it is only possible to estimate the particulate emissions using: (1/3)*((2*High)+Low)

Correlation between Merlin and Horizon 450

This fire currently meets the 1.5 - 3.0g/kg standard and can be installed until 30 Septemer 2002, but its clean air license only las

	Burn Time (min)	Fuel Consumption (kg/hr)	Avg Power Output (kW)	Efficiency (%)	Particulate Emission (g/kg)	Average
Merlin						
Hot Rocks (high)	129	1.4	6.2	51.2	3.68	
Pinus Radiata (high)	67	2.5	7.8	51.4	3.59	
Multiplier	1.93	0.56	0.79	1.00	1.03	1.06
Horizon 450						
Run 1						
Pinus Radiata (high)	59.2	3.6	9.9	58.0	0.7	
Est. Hot Rocks (high)	62.8	3.8	10.5	61.5	0.7	
Run 2						
Pinus Radiata (high)	65.1	3.4	10.3	66	0.8	
Est. Hot Rocks (high)	69.0	3.6	10.9	70.0	0.8	
Run 3						
Pinus Radiata (high)	62.0	3.5	10.6	65.0	3.4	
Est. Hot Rocks (high)	65.7	3.7	11.2	68.9	3.6	
Average						
Est. Hot Rocks (high)	65.8	3.7	10.9	66.8	1.7	
Pinus Radiata (high)	62.1	3.5	10.3	63.0	1.6	
Merlin						
Hot Rocks (low)	378	0.5	2.7	62.3	5.25	
Pinus Radiata (low)	170	1	3.5	58.5	3.7	
Multiplier	2.22	0.50	0.77	1.06	1.42	1.20
Horizon 450						
Run 4						
Pinus Radiata (low)	115.5	1.9	6.8	79	6.7	
Est. Hot Rocks (low)	138.1	2.3	8.1	94.5	8.0	
Run 5						
Pinus Radiata (low)	114.4	1.9	7.1	78	2.7	
Est. Hot Rocks (low)	136.8	2.3	8.5	93.3	3.2	
Run 6						
Pinus Radiata (low)	108.7	2	6.9	74	5.2	
Est. Hot Rocks (low)	130.0	2.4	8.3	88.5	6.2	
Average						
Est. Hot Rocks (low)	135.0	2.3	8.3	92.1	5.8	
Pinus Radiata (low)	112.9	1.9	6.9	77.0	4.9	
Merlin						
Est. Hot Rocks					3.6	
Est. Pinus Radiata					4.2	
Horizon 450						
Final Est. Hot Rocks	**88.88**	**3.24**	**10.02**	**75.22**	**3.09**	
Est. Pinus Radiata	**79.02**	**2.98**	**9.16**	**67.67**	**2.71**	

Note Standard method: the particulate emissions are calculated as the mean of the three tests at high, meduim and low burnrat
hence, it is only possible to estimate the particulate emissions using: (1/3)*((2*High)+Low)

Correlation between Merlin and Horizon 600

This fire currently meets the 3.0 - 5.5g/kg standard and can be installed until 31 March 1999

	Burn Time (min)	Fuel Consumption (kg/hr)	Avg Power Output (kW)	Efficiency (%)	Particulate Emission (g/kg)	Average
Merlin						
Hot Rocks (high)	129	1.4	6.2	51.2	3.68	
Pinus Radiata (high)	67	2.5	7.8	51.4	3.59	
Multiplier	1.93	0.56	0.79	1.00	1.03	1.06
Horizon 600						
Run 1						
Pinus Radiata (high)	58.4	5.2	13.0	54.0	2.1	
Est. Hot Rocks (high)	61.9	5.5	13.8	57.3	2.2	
Run 2						
Pinus Radiata (high)	63.4	4.8	12.7	58	1.4	
Est. Hot Rocks (high)	67.2	5.1	13.5	61.5	1.5	
Run 3						
Pinus Radiata (high)	68.8	4.4	11.7	57.0	1.3	
Est. Hot Rocks (high)	72.9	4.7	12.4	60.4	1.4	
Average						
Est. Hot Rocks (high)	67.4	5.1	13.2	59.7	1.7	
Pinus Radiata (high)	63.5	4.8	12.5	56.3	1.6	
Merlin						
Hot Rocks (low)	378	0.5	2.7	62.3	5.25	
Pinus Radiata (low)	170	1	3.5	58.5	3.7	
Multiplier	2.22	0.50	0.77	1.06	1.42	1.20
Horizon 600						
Run 4						
Pinus Radiata (low)	93.7	3.2	8.1	55	5.4	
Est. Hot Rocks (low)	112.0	3.8	9.7	65.8	6.5	
Run 5						
Pinus Radiata (low)	106.2	2.8	7.1	55	6.7	
Est. Hot Rocks (low)	127.0	3.3	8.5	65.8	8.0	
Run 6						
Pinus Radiata (low)	115.5	2.6	7.1	61	7.9	
Est. Hot Rocks (low)	138.1	3.1	8.5	72.9	9.4	
Average						
Est. Hot Rocks (low)	125.7	3.4	8.9	68.2	8.0	
Pinus Radiata (low)	105.1	2.9	7.4	57.0	6.7	
Merlin						
Est. Hot Rocks					3.6	
Est. Pinus Radiata					4.2	
Horizon 600						
Final Est. Hot Rocks	**86.81**	**4.54**	**11.77**	**62.54**	**3.79**	
Est. Pinus Radiata	**77.40**	**4.16**	**10.79**	**56.56**	**3.29**	

Note Standard method: the particulate emissions are calculated as the mean of the three tests at high, meduim and low burnrat
hence, it is only possible to estimate the particulate emissions using: (1/3)*((2*High)+Low)

Appendix H Raw Materials of Hot Rocks

	Raw Material			
	Waste Newsprint	Sub-bituminous Coal (Ohai)	Bituminous Coal (Strongman)	Waste HDPE (Milk Bottles)
Moisture (%)	11 - 13	16.9	10.3	Very low
Ash (%)	0.5 – 1.0	2.8	2.9	Very low
Volatile Matter (%)		34.3	37.4	
Fixed Carbon (%)		46.0	49.4	
Sulphur (%)	0.1 – 0.2	0.17	0.19	0.06
GCV (MJ/kg)	18.15	25.38	29.39	46.22

Table 1 – Proximate Analyses and Heat Contents of Raw Materials, (Richards & Storm, 1989)

Appendix I Combustion Processes – Wood and Coal

1.0 Coal

Coal occurs naturally as a fossil fuel that originates from peat. It is an extremely heterogenous substance. As a result of this, the mineral matter distributed throughout the coal is in various forms and compositions. This leads to a large variety of coal grades and consequently combustion efficiencies and by-products. The quality of any sample of coal is dependent on the following factors:

- Moisture (generally ranges from 1 – 11%),
- Ash Content (generally ranges from 2 – 9%),
- Ultimate analysis in terms of
  - Carbon (usually ranges from 70 – 90%)
  - Hydrogen (usually ranges from 3 – 5 %)
  - Nitrogen (usually ranges from 1 – 2%)
  - Sulphur (up to 2 – 5%)
  - Oxygen and other impurities.

1.1 Combustion Process

Since coal is a solid fuel, it can not burn in its original solid form. The combustion process is required to break down the solid into individual molecules through the addition of heat. When the coal burns within an enclosed burner on a grate, either the burning fuel or ash heats incoming air through the grate. As the air temperature within the fire chamber increases, the heat begins to vaporise and scrub off volatile and carbonaceous material from the coal particles. (Smith & Gruber, 1966) It is in the vaporous state that the combustible material is oxidised via the following equations:

$$C + O_2 \rightarrow CO_2 \qquad \textit{Equation 1}$$
$$4H + O_2 \rightarrow 2H_2O \qquad \textit{Equation 2}$$
$$2N + O_2 \rightarrow 2NO \qquad \textit{Equation 3}$$
$$S + O_2 \rightarrow SO_2 \qquad \textit{Equation 4}$$

Because air, (comprised approximately 21% oxygen and 79% nitrogen) travels through the fuel bed and oxygen is consumed by the combustion process, the concentration of oxygen is reduced, and the chance of oxygen contacting the fuel decreases. Due to the consequent apparent lack of oxygen, the gases leaving the fuel bed have high concentrations of carbon monoxide and other combustible matter.

Above the fuel bed, for more complete combustion to occur, secondary air should be introduced in order to oxidise all of the combustible material. If this occurs, nitrogen from this air may dilute the gases, and consequently prevent the contact between oxygen and combustibles. In order to overcome this, within a specified period of time, there must be an excess of air over and above the stoichiometric amount. This amount of excess varies according to furnace type.

In order to increase the amount of contact of oxygen with the combustible material, a high degree of turbulence is required and must be maintained. This turbulence reduces the amount of excess air necessary for complete combustion. (Smith & Gruber, 1966)

1.2 Products of Combustion

The gas produces from coal combustion contain particulate matter:

- Smoke – Sulphur is present in coal in two different forms:
  1. Organic – which is part of the organic coal substance,
  2. Inorganic – this originates from the mineral matter, especially as sulphides – pyrites. Approximately 15% of the sulphur produced is retained within coal ash and almost all of the remainder sulphur is emitted as sulphur dioxide in the gases of combustion.
- Nitrogen oxides – Nitric Oxide (NO) is approximately 95% by volume of nitrogen oxide emissions and nitrogen dioxide.
  - Also, trace amounts of nitrous oxide (N_2O) are produced during the combustion of coal.
- Carbon Dioxide – Although carbon dioxide can not really be regarded as a pollutant, it is of some concern, due to the link it has with the global climate.
- Trace Species - Trace Elements
  - Major Elements - These are the main constituents of the organic coal substance: carbon, hydrogen and oxygen.
  - Minor Elements – Minor elements of organic coal substances are sulphur and nitrogen. The main inorganic elements in the mineral matter are silicon, aluminium, iron, calcium, sodium, potassium and magnesium.
  - Trace Gases – During the combustion process, the major and minor organic elements in coal are usually released as carbon dioxide, steam, nitric oxide and sulphur dioxide. However, there may be other gases produced in trace quantities such as: methane, ethylene, higher hydrocarbons, carbon monoxide, nitrous oxide, hydrogen cyanide, hydrogen sulphide, carbonyl sulphide and carbon disulphide.
  - Poly Aromatic Hyrodcarbons (PAH) – These are organic compounds that are contained in the volatile matter evolved from coal at temperatures greater than 450°C. PAH's are of concern due to their known carcinogenic properties. Smoke produced by burning bituminous coal on open and enclosed fires contains PAH.
  - Solid Residues – Ash comprised mainly of silicates, oxides and sulphates.

1.3 Analysis of Locally used Coal

The coal consumed within Christchurch is generally sourced from the West Coast, which has a large number of mines and hence variety of coal qualities. (See Appendix B)

For the purpose of this report, it will be assumed the majority of coal utilised in Christchurch is sourced from Greymouth. This coal has the following combustion properties, shown in Table 1:

Moisture (%)	Ash (%)	Volatile Matter (%)	Fixed Carbon (%)	GCV (MJ/kg)	Sulphur (%)
9.4	4.3	35	51.2	28.9	0.3

Table 1 – Combustion Properties of Coal (Coal Research, 1998)

2.0 Wood

Wood is difficult to burn efficiently. Approximately 80% of the energy in wood is in the form of volatile, combustible gas that is never completely burnt in an open fire. The other 20% of the energy is in the form of char residue. (Carle & Brown, 1977)

Wood consists almost entirely of combustible material; it usually produces only 0.5% ash. Because it has no sulphur and need not be burnt at high temperatures, noxious gases are not produced in its combustion process. Its composition by weight is 50% carbon, 44% oxygen and 6% hydrogen. (Cave, 1976)

The moisture content of wood affects its combustion temperature significantly and, unless the heat of vaporisation of the water is recovered by condensation, also influences heat yield. The greatest effect of moisture is to make complete combustion more difficult, and incomplete combustion drastically reduces heat yield.

Burning occurs in essentially two phases: gas and solid. Volatilisation begins at low temperatures (approximately 100°C) with the production of water, carbon dioxide and carbon monoxide. As the temperature increases the production of hydrocarbons and hydrogen increases, and carbon dioxide and carbon monoxide decrease. The rate of volatilisation increases rapidly above 275°C. Ignition from a flame takes place between 260 and 290°C, but above 450°C the gas ignites readily, and the combustion rate rises. (Cave, 1976)

Above 500°C the hydrocarbons dissociate and at temperatures greater than 900°C, tars are completely broken down. (Cave, 1976)

The charcoal (solid component) ignites more easily than the gases. At a later stage, when a deep bed of char has been developed, the charcoal may strip they oxygen from the air entering through the grate to such an extent that the volatiles are not completely burnt.

2.1 Primary Combustion

Upon the heating of the raw fuel, the gases such as carbon dioxide, carbon monoxide and water, together with smoke and volatile hydrocarbons are produced and heat is emitted.

The main heat producing reactions are:

$$2C + O_2 \rightarrow 2CO + 10.4\text{MJ/kg Carbon} \qquad \textit{Equation 5}$$

$$C + O_2 \rightarrow CO_2 + 33.9\text{MJ/kg Carbon} \qquad \textit{Equation 6}$$

A smaller but significant contribution is made by the combustion of the hydrogen in the fuel:

$$4H + O_2 \rightarrow 2H_20 + 142\text{MJ/kg Hydrogen} \qquad \textit{Equation 7}$$

(NZ Energy Research and Development, 1984)

The carbon monoxide fraction is capable of further oxidation to carbon dioxide with the emission of further heat. This further oxidation can only occur if the carbon monoxide is mixed with an adequate supply of oxygen at a temperature of approximately 600°C, before it leaves the fire box of the burner and escapes up the flue. (NZ Energy Research & Development, 1984)

In an open fire, the burning of the volatiles does not happen to the extent originally assumed it takes very high temperature and good mixing with oxygen to get these gases to burn efficiently. The unregulated supply of air passing up through the hot char on the grate becomes depleted in oxygen and lifts the unburnt volatiles away from the heat and up the chimney – the volatiles do not get a good chance to burn. (Volatiles constitute up to 80% of wood by mass).

Damping down a fire overnight by building it up and restricting the air supply leads to poor combustion and excessive emissions of unburnt flue gases.

2.2 Products of Combustion

Emissions from wood fired systems usually consist of three components:

- Ash or unburnable material carried out in flue gas
- Fly carbon or partially burnt particles of wood fuel
- Surplus air (air supplied that is above and beyond the amount required for good combustion.) (Cave, 1976)

If the temperature of the flame is high enough and continues long enough, complete combustion occurs, the products are carbon dioxide and water. Whenever the vaporous products are cooled, both in pockets in the burning pile or in diffusion currents around the fire, condensation of vapours will occur and any intermolecular reactions will be reduced. Since unburnt carbon particles are everywhere except in zones of complete combustion, these form the nuclei for adsorption of condensed organic gases and if the zone is cooled enough, water.

The main constituents of wood burner emissions are suspended particles (soot), a variety of polycyclic organic matter and carbon monoxide. Wood smoke consist almost entirely of fine particulate matter of less than 10μm, with approximately 80%

less than 2.5μm; these particles can be retained in the lungs for long periods, either months or years. (Gilmour & Walker, 1995)

Condensable polycyclic aromatic hydrocarbons in the smoke have some mutagenic potency; activity is complicated by the interaction with sunlight and other chemicals in the smog (Photochemical Smog).

2.3 Analysis of locally used Wood

After surveying several local wood yards, it was found that Pinus Radiata is the most common firewood sold. Below are its combustion properties, in Table 2:

Moisture (%)	Ash (%)	Volatile Matter (%)	Fixed Carbon (%)	CGV (MJ/kg)	Sulphur (%)
30	0.6	58.4	11	17.93	0.01

Table 2 – Combustion Properties of Pinus Radiata, (Cosgrove, 1998)

Appendix J Technological Advances in Domestic Solid Fuel Burners

There is a large range of solid fuel stoves. As technology increases, the particulate emissions decrease and efficiency increases. In order of technological advance, from low to high, are solid fuel stoves below:

- Open fireplaces
- Enclosed non-airtight heaters – freestanding or inbuilt
- Controlled combustion heaters
- Improved controlled combustion heaters.

1.0 Open fireplaces

These are all based on the same principal, that the air supply drawn from the room is far greater than that required for combustion of the fuel. (CAE, 1996) All open fires lose large amounts of heat and energy up the flue. The only heat they create is radiant heat from the flames and hot coals. Efficiencies of open fireplaces are extremely low, ranging from zero (radiant heat does not compensate for warm air loss) to approximately 20%, due to the loss of room air and lack or air warming.

2.0 Enclosed Non-airtight Heaters

These are generally freestanding and made of steel or cast iron, they are often shaped as boxed or are potbelly stoves.

Within these solid fuel heaters, air is able to enter through small gaps between the doors, grates, etc, also through controllable air inlets. These heaters tend to radiate heat into the room from their hot outer surfaces. They are ideal for heating in draughty, uninsulated conditions. (See Figure 1)

Potbelly type stoves also heat interior air via convection and conduction from surfaces, which may also include the exposed flue.

The combination of air heating, decreased excess air and significant radiant output means these stoves can obtain heating efficiencies of 30 – 50%

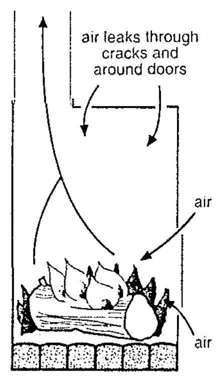


Figure 1 – Non-airtight Heaters

3.0 Controlled-combustion Heaters

Within these, the rate at which fuel is burnt is controlled by the amount of combustion air entering through a regulated air inlet. When the air inlet is fully open, the fuel will burn vigorously and as it is closed, the combustion rate slows.

These heaters operate most efficiently at medium to high settings. This is the case as when the fire is hot and there is sufficient air to burn, all of the combustible gases are released from the fuel. Of course, at lower settings, there is a release of some smoke.

Most designs have within them a baffle box. This contributes to mixing the flue gases, leading to higher efficiencies ranging from 30 – 60%.

4.0 Improved Controlled-combustion Heaters

These solid fuel stoves consist of modern appliances. They can burn more efficiently at low burn settings than any other of the previous mentioned stoves.

Generally, these stoves are reliant on convective heat technology; however, some do have a fan forced capability. All of these stoves are designed with baffles and secondary combustion chambers, which ensure high efficiencies with low emission levels.

Within the fireboxes, a choice of either ash grate or ash bed models constructed of cast steel or rolled welded steel materials. All fires are lined with fire bricks for extra heat mass, durability and protection for the high temperatures achieved. The firebox is encased by cast or rolled/welded steel, this allows convective heat transfer to all parts of the room. These add to the efficiency through convection.

These stoves produce less radiant heat output but more air heating that a PotBelly or any of the earlier designs. (See Figure 2)

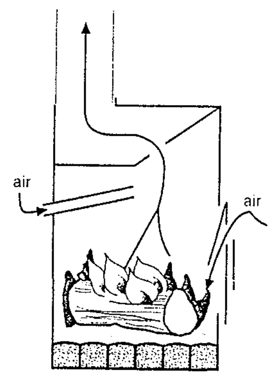


Figure 2 – Two Chamber with Preheated Secondary Air

Appendix K Test Reports – Solid Fuel Burners

APPLIED RESEARCH SERVICES LTD

P.O. Box 687, Nelson, New Zealand Phone (03) 547 7347 Fax (03) 547 2909

W. H. HARRIS LTD.
P.O. Box 4043, CHRISTCHURCH
NEW ZEALAND

Emissions testing of the Woodsman Matai Wood Burning Heater

For W.H. Harris Ltd.
PO Box 4043
CHRISTCHURCH

Report 97/292

November 1997

P.O. Box 687, Nelson, New Zealand Phone (03) 547 7347 Fax (03) 547 2909

Customer: W.H. Harris Ltd
PO Box 4043
Christchurch.

Emissions Testing of the W.H. Harris Matai Wood Burning Heater

1.0 Introduction

A sample of the Matai free standing heater supplied by W.H. Harris Ltd was tested for compliance of its flue gas emissions to the requirements of New Zealand Standard 7403:1992 (Australian Standard 4013:1992). The test was carried out in conjunction with a measurement of power output and efficiency using the methods set out in New Zealand Standard 7402:1992 (Australian Standard 4012:1992).

Accreditation

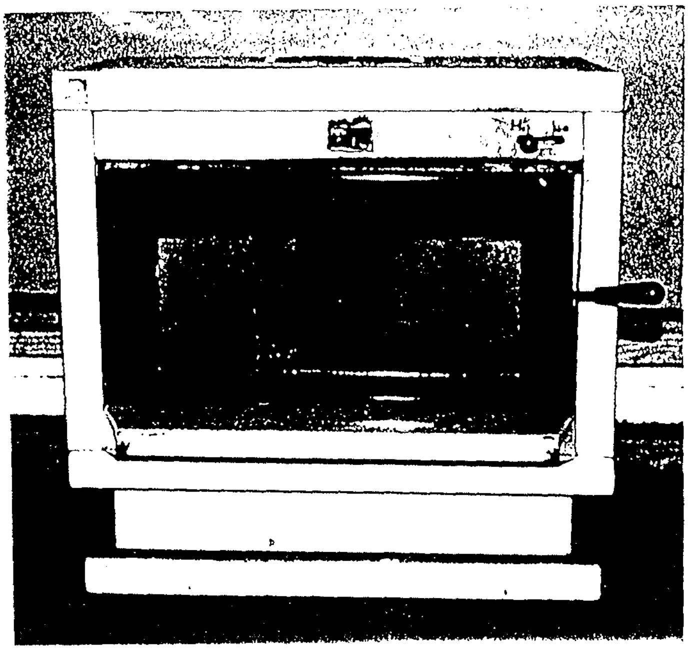
This laboratory is accredited by International Accreditation New Zealand (formerly Telarc). The tests reported herein have been performed in accordance with the terms of our accreditation. This accreditation does not extend to any opinions or any interpretations of test results contained in this report.

new zealand accredited laboratory

Laboratory Registration 395

The tests were carried out at our Beatty St. laboratory during October and November of 1997 by G.R. Catchpole.

A photograph of the assembled heater is given below.



2.0 Details of the Heater

The Matai has a rectangular firebox fitted with Promat panels on each side and also at the rear of the firebox. The longest axis of the firebox is across its width, which measures 482 mm between the Promat refractory panels. The firebox door is fitted with a 393 x 183 mm glass viewing window. The unit has a steel baffle plate.

Primary air is controlled by a metal slide which covers air holes in the heater and is connected to an arm that protrudes through the upper right corner of the unit. There are three such holes. The openings vary with the position of the control and were set as given in the table below for the tests reported here.

	height (mm)	width (mm)		
control setting	all	high	medium	low
hole measurement	20	33	20	9

There is a secondary air supply which enters the heater through a grill in the rear of the unit inside the outer shield of sheet steel. This air is then ducted into the hollow baffle plate from where it vents into the firebox via seventeen holes of 6.5 mm (approx.) diameter and twenty holes of 4.5 mm (approx.) diameter in the underside of the baffle. The secondary air supply is not controlled.

A wetback was fitted during testing. The wetback heat exchange area consisted of hollow rectangular steel box which had the following outside dimension; 177 mm high, 120 mm from left to right and 22 mm deep. The inlet tube entered at the bottom of the 177 mm x 120 mm face while the outlet exited at the top of the same face. The inlet and outlet tubes had an inside diameter of 26 mm. The heat exchange box was protected by a steel guard plate measuring 177 mm x 120 mm offset from the box by 10 mm. Fifty 8 mm holes had been punched in the steel guard plate.

The heater has a 150 mm diameter flue.

Design information supplied by the manufacturer is given in Appendix 1 of this report.

3.0 Test Procedures

Tests were carried out using equipment and procedures specified in New Zealand standards 7402:1992 and 7403:1992.

During the tests the heater is stabilised with the air controls at a chosen position. A test load of wood is then burnt and emissions, output, efficiency and other data are collected during the time it takes to burn the test fuel.

3.1 Details of Test Runs

The heater was conditioned with the control set on high and using *Pinus radiata* as fuel.

A test load of *Pinus radiata* logs was prepared for each test. Details of the test load complying with the requirements of NZS 7402 are given in Table 1. This consists of five test pieces. The test pieces were stacked in accordance with Woodsman Woodstoves operating instructions. The ashes are first leveled and then firewood is loaded so that it lays front to back rather than left to right. A photograph of a typical test load is shown in Figure 1.

The test fuel was added to a bed of embers weighing between 24% and 26% of the total fuel weight. For tests on medium and low bum rates the air control was left fully open until 20 minutes had elapsed. The air control was then set to the appropriate position for the required burn rate.

4.0 Results

A summary of the data obtained from these tests is given in Table 2 and an estimate of the uncertainties in individual measurements is given in Table 3.

4.1 Appliance Air Flow Test

The air flow was measured in the flue before and after the tests and the results were found to comply with the requirements of the standard. (Less than 25% change). The measured air flow in cubic metres per minute based on uniform flow through a 15 cm diameter (0.0177 sq. m) duct corrected to 20 C and 101.3 kPa was 0.5 before testing and 0.5 after testing.

4.2 Efficiency

Efficiency is estimated on the basis of a gross calorific value of 20.1 (MJ/kg dry weight) for the fuel burned during the test. This value was determined by measurements of samples of the wood used to prepare the test fuel.

Based on the test results the average efficiency of the heater is estimated to be 62.1%. The average is taken over all the tests reported.

Results for efficiency for each burn cycle and means for each burn rate are detailed in Table 2.

5.0 Compliance

New Zealand Standard 7403:1992 requires that the particulate emission factor calculated by averaging the results for the high, medium and low burns be not greater than 5.5 g/kg for an appliance without a catalytic converter.

The average particulate emission factor for the runs presented in this report is 0.86 g/kg. On the basis of this result the appliance tested complies with New Zealand Standard 7403:1992.

Any modifications to the equipment as tested may invalidate the compliance results.

Table 1 Firebox and Fuel Data

Usable volume of firebox: 33.26 litres

Longest dimension of firebox: 272 mm

Size of test fuel load: 5.4879 litres

Theoretical number of pieces per load: 4.896068

Actual number of pieces per load: 5

Theoretical length of fuel pieces: 200 mm

Actual length of fuel pieces: 200 mm (+/- 10 mm)

Theoretical mass of wood per load: 3.146 kg (+/- 200g)

Fuel: Pinus Radiata in conformity with NZS 7404.2

Gross calorific value of fuel: 20.1 MJ/kg

Average fuel moisture content: 16 - 20 % (wet weight)

Figure 1 Typical Test Fuel Load

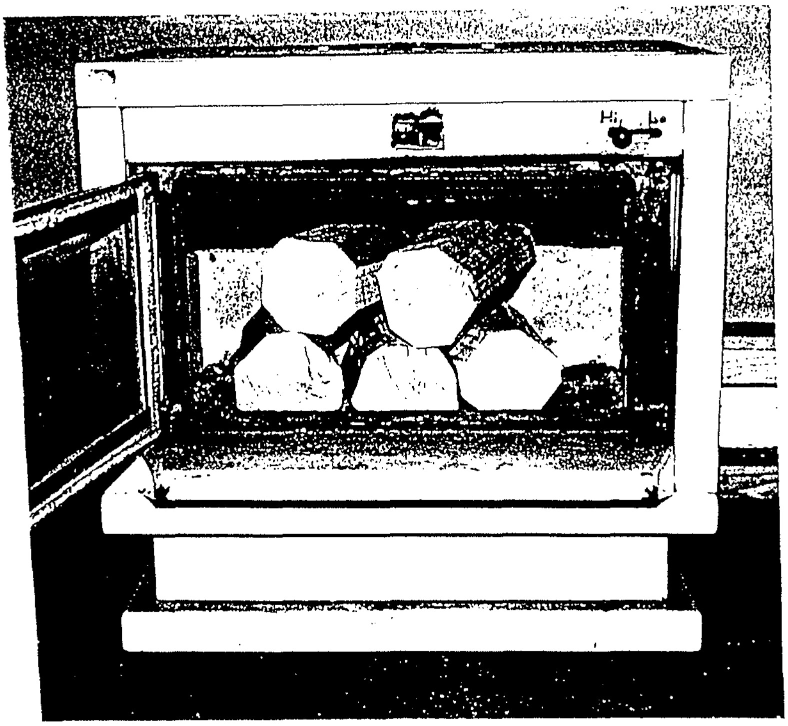


Table 2 Summary of Data From Test Runs

HIGH BURN RATE (October 23, 1997)

	1	2	3	MEANS
Time Commenced				
Burn Time (min)	57.7	57.7	57.9	57.8
Fuel Consumption (Kg/hr)	3.3	3.3	3.3	3.3
Flue Temperature, Mean (C)	379	377	385	380
Output to Air, Mean (kW)	7.8	7.8	7.9	7.8
Output to Wetback, Mean (kW)	1.0	0.9	1.1	1.0
Total Output, Mean (kW)	8.8	8.7	8.9	8.8
Peak Output to Air (kW)	9.0	9.2	9.0	9.1
Peak Output, Total (kW)	10.0	10.3	10.2	10.2
Efficiency (%)	59.0	52.0	60.0	57.0
Emission rate (g/kg)	0.6	0.6	0.7	0.6

LOW BURN RATE (October 24, 1997)

	4	5	6	MEANS
Time Commenced				
Burn Time (min)	99.6	99.7	93.2	97.5
Fuel Consumption (Kg/hr)	1.9	1.9	2.0	1.9
Flue Temperature, Mean (C)	269	266	257	264
Output to Air, Mean (kW)	5.6	5.4	4.9	5.3
Output to Wetback, Mean (kW)	0.5	0.5	0.5	0.5
Total Output, Mean (kW)	6.1	5.9	5.8	5.9
Peak Output to Air (kW)	8.0	7.8	6.5	7.4
Peak Output, Total (kW)	8.6	8.5	7.9	8.3
Efficiency (%)	71	68	63	67.3
Emission rate (g/kg)	1.5	0.6	0.9	1.0

Table 2 Summary of Data From Test Runs (Continued)

MEDIUM BURN RATE (October 28, 1997)

	7	8	9	MEANS
Time Commenced				
Burn Time (min)	78.3	74.7	86.9	80.0
Fuel Consumption (Kg/hr)	2.4	2.5	2.2	2.4
Flue Temperature, Mean (C)	330	327	325	327
Output to Air, Mean (kW)	6.5	6.2	6.0	6.2
Output to Wetback, Mean (kW)	0.6	0.6	0.6	0.6
Total Output, Mean (kW)	6.8	6.7	6.7	6.7
Peak Output to Air (kW)	8.2	7.9	7.8	8.0
Peak Output, Total (kW)	8.6	8.6	8.6	8.6
Efficiency (%)	61.0	57.0	68.0	62.0
Emission rate (g/kg)	1.0	1.0	0.8	0.9

Table 3 Estimate of Uncertainties in Measurement

Note: Absolute uncertainties are given for actual measurements: Uncertainties in calculated data are based on results for runs on a typical heater with the air control at maximum and are expressed as percentages.

Fuel Data
- Charcoal Bed Weight: 0.02 kg
- Test Fuel Load Weight: 0.001 kg (wet weight)
- Fuel Consumed: 0.1 kg (wet weight)
- Burn Time: 0.1 mins
- Fuel Consumption Rate: 2%
- Fuel Moisture Content: 2% (wet weight basis)
- Moisture Released: 2%
- Fuel Consumed: 3% (dry weight)

Average Flue Gas Parameters:
- Temperature: 2 C
- Draught: 0.1 mm water
- Oxygen (%): 1 (dry)

Average Dilution Tunnel Parameters
- Pitot Differential Pressure (duct centre): 2.5 Pa
- Diln. Tunnel Temp: 1 C
- Mean Velocity: 2%
- Volumetric Flow Rate: 2%
- Mass Flow Rate: 2%

Output Data
- Heat Output Rate to air: 5%
- Heat Output Rate to wetback: 5%
- Total Heat Output Rate: 5%
- Run Time: 0.2%
- Total Power Out: 5%

Sample Collection/ Emissions Data:
- Total Mass captured: 0.4 mg (10%)
- Sample Gas Temp: 1 C
- Capture Time: 0.2%
- Sampling Rate: 0.7 l/min (4%)
- Total Mass Emitted: 16%
- Emission Rate, g/hr: 16%
  - g/kg fuel (dry basis): 19%
  - g/kWh: 21%

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APPLIED RESEARCH SERVICES LTD

P.O. Box 687, Nelson, New Zealand Phone (03) 547 7347 Fax (03) 547 2909

1998 Jayline Classic Wood Burning Heater With Hot Water Booster Fitted - Emissions Tests

For Jayline Heating Ltd.
PO Box 20070,
Glen Eden,
Auckland, NZ

Reports 98/324 March 1998

APPLIED RESEARCH SERVICES LTD

P.O. Box 687, Nelson, New Zealand Phone (03) 547 7347 Fax (03) 547 2909

Customer: Jayline Heating Ltd.
PO Box 20070,
Glen Eden,
Auckland, NZ.

Attention: Ross Sneddon.

1998 Jayline Classic Wood Burning Heater With Hot Water Booster Fitted - Emissions Tests

1.0 Introduction

A sample of the 1998 Jayline Classic free standing heater was tested for compliance of its flue gas emissions to the requirements of New Zealand Standard 7403:1992 (Australian Standard 4013:1992). The test was carried out in conjunction with a measurement of power output and efficiency using the methods set out in New Zealand Standard 7402:1992 (Australian Standard 4012:1992). The tests were carried out at our Beatty St. laboratory during March of 1998 by Ben Brookes and Russell Millington.

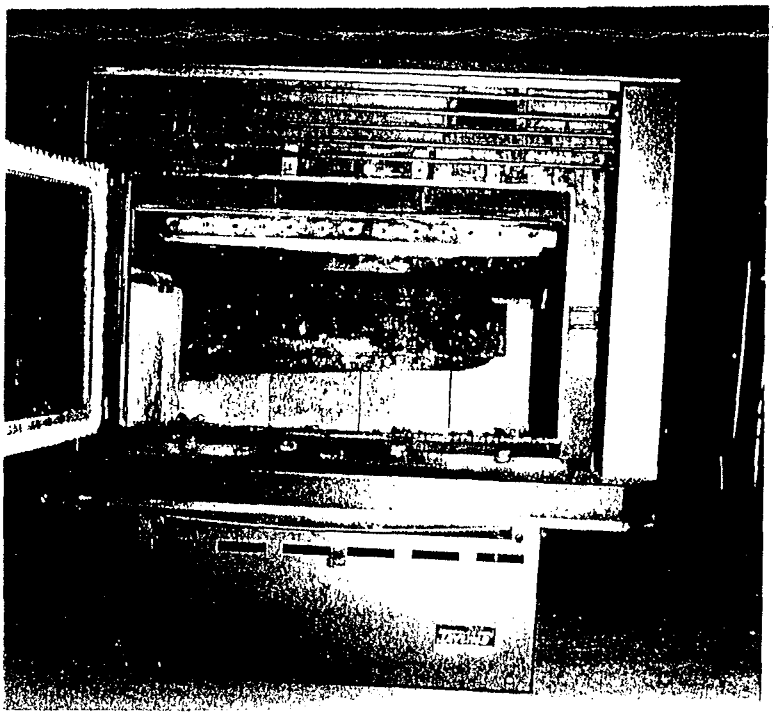
A photograph of the assembled heater is given below.

Accreditation

This laboratory is accredited by International Accreditation New Zealand (formerly Telarc). The tests reported herein have been performed in accordance with the terms of our accreditation. This accreditation does not extend to any opinions or any interpretations of test results contained in this report.

Laboratory Registration Number 395

Figure 1 Photograph of the heater tested



2.0 Details of the Heater

The 1998 Jayline Classic has a rectangular firebox. The longest axis of the firebox is across its width, which measures 450 mm with the firebricks in place. The fire bricks were arranged around the rear and side walls of the firebox. The firebricks were of a thickness of 30 mm and extended 230 mm above the floor of the firebox.

The firebox door is fitted with a 400 x 210 mm glass viewing window. The heater has a 20 mm thick Promat baffle plate. The heater requires a 150 mm diameter flue.

Primary air is regulated by an air control slide located on the front of the heater at the upper left corner. Primary air enters the heater via three slots set above the door glass. The primary air enters the firebox above the door and is deflected down the inside surface of the glass. The openings vary with the position of the control and were set as given in the table below for the tests reported here.

	height (mm)	width (mm)		
control setting	all	high	medium	low
hole measurement	16	23	18	14

There are two secondary air tubes each of approximately 26 mm outside diameter. Both tubes are placed horizontally below the baffle plate one across the rear of the firebox and the other near the front of the baffle. Secondary air enters these tubes at each end and exits through holes of between 4.5 and 5.0 mm diameter. In both tubes the air exits through thirteen holes facing slightly below horizontally toward the front of the firebox and seven holes which point slightly below horizontally toward the rear of the firebox. The secondary air supply is not controlled.

The heater was fitted with a hot water booster consisting of approximately 800 mm of 25 mm id copper tubing set inside a steel heat shield. This was fitted to the rear of the firebox inside the firebricks. (A small section of firebricks was removed to allow the tubing to pass through the rear wall of the firebox).

Design drawings supplied by the manufacturer are given in Appendix 1 of this report.

3.0 Test Procedures

Tests were carried out using equipment and procedures specified in New Zealand standards 7402:1992 and 7403:1992.

During the tests the heater is stabilised with the air controls at a chosen position. A test load of wood is then burnt and emissions, output, efficiency and other data are collected during the time it takes to burn the test fuel.

3.1 Details of Test Runs

The heater was conditioned with the control set on high and using *Pinus radiata* as fuel.

A test load of *Pinus radiata* logs was prepared for each test. Details of the test load complying with the requirements of NZS 7402 are given in Table 1. This consists of six test pieces. The test pieces were stacked in accordance with NZS 7402. A photograph of a typical test load is shown in Figure 2.

The test fuel was added to a bed of embers weighing between 24% and 26% of the total fuel weight. For tests on medium and low burn rates the air control was left fully open until 20% (by weight) of the fuel load had been consumed. The air control was then set to the appropriate position for the required burn rate as given in the table above.

4.0 Results

A summary of the data obtained from these tests is given in Table 2 and an estimate of the uncertainties in individual measurements is given in Table 3.

4.1 Appliance Air Flow Test

The air flow was measured in the flue before and after the tests and the results were found to comply with the requirements of the standard. (Less than 25% change). The measured air flow in cubic metres per minute based on uniform flow through a 15 cm diameter (0.0177 sq. m) duct corrected to 20 C and 101.3 kPa was 0.43 before testing and 0.48 after testing. These measurements were taken with the primary air control fully closed.

4.2 Efficiency

Efficiency is estimated on the basis of a gross calorific value of 20.1 (MJ/kg dry weight) for the fuel burned during the test. This value was determined by measurements of samples of the wood used to prepare the test fuel.

Based on the test results the average efficiency of the heater is estimated to be 63%. The average is taken over all the tests reported.

Results for efficiency for each burn cycle and means for each burn rate are detailed in Table 2.

5.0 Compliance

New Zealand Standard 7403:1992 requires that the particulate emission factor calculated by averaging the results for the high, medium and low burns be not greater than 5.5 g/kg for an appliance without a catalytic converter.

The average particulate emission factor for the runs presented in this report is 0.8 g/kg. On the basis of this result the appliance tested complies with New Zealand Standard 7403:1992.

Any modifications to the equipment as tested may invalidate the compliance results.

(Continued...)

Table 1 Firebox and Fuel Data

Usable volume of firebox: 39.4 litres

Length of fuel loading axis: 270 mm

Size of test fuel load: 6.50 litres

Theoretical number of pieces per load: 5.84

Actual number of pieces per load: 6

Theoretical length of fuel pieces: 197 mm

Actual length of fuel pieces: 197 mm (+/- 10 mm)

Theoretical mass of wood per load: 3.72 kg (+/- 200g)

Fuel: Pinus Radiata in conformity with NZS 7404.2

Gross calorific value of fuel: 20.1 MJ/kg

Average fuel moisture content: 16 - 20 % (wet weight)

Figure 2 Typical Test Fuel Load

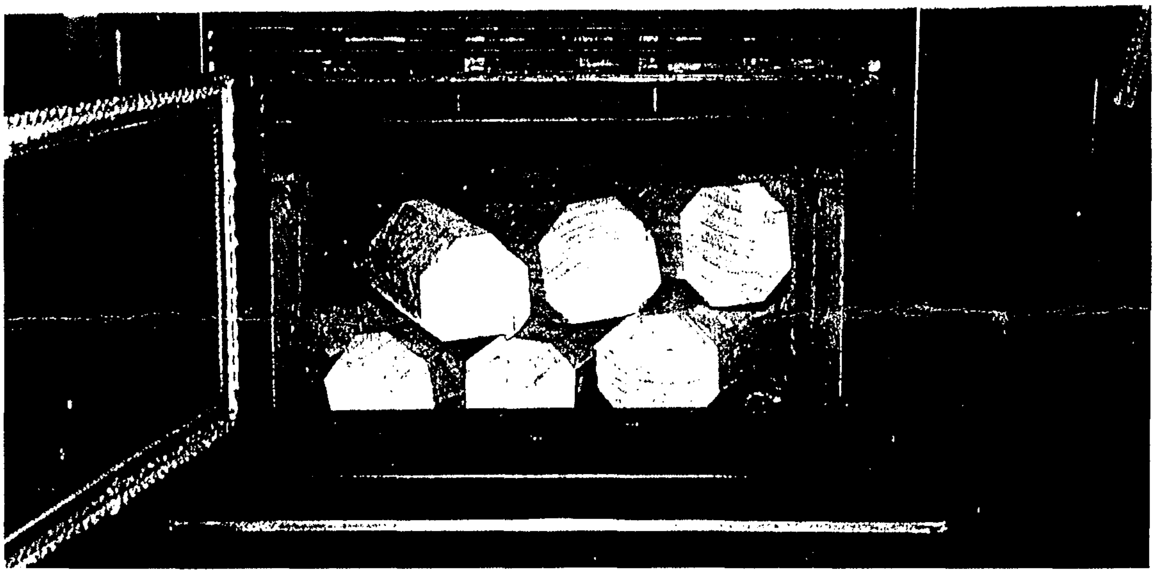


Table 2 Summary of Data From Test Runs

HIGH BURN RATE (March 13 and 16, 1998)

	1	2	3	MEANS
Time Commenced	14:48	17:54	17:48	
Burn Time (min)	86.3	76.3	79.9	80.8
Fuel Consumption (Kg/hr)	2.6	2.9	2.8	2.8
Flue Temperature, Mean (C)	193	203	199	198
Output to Air, Mean (kW)	5.8	6.0	6.3	6.0
Output to Wetback, Mean (kW)	1.8	1.6	2.1	1.8
Total Output, Mean (kW)	7.6	7.7	8.4	7.9
Peak Output to Air (kW)	7.1	7.0	7.6	7.2
Peak Output, Total (kW)	9.2	8.8	11.3	9.8
Efficiency (%)	63	56	65	61
Emission rate (g/kg)	1.1	0.5	0.8	0.8

LOW BURN RATE (March 15, 1998)

	4	5	6	MEANS
Time Commenced	12:58	14:46	16:32	
Burn Time (min)	103.8	103.2	88.6	98.5
Fuel Consumption (Kg/hr)	2.2	2.2	2.6	2.3
Flue Temperature, Mean (C)	178	171	184	178
Output to Air, Mean (kW)	5.5	5.2	5.6	5.4
Output to Wetback, Mean (kW)	1.2	1.4	1.7	1.4
Total Output, Mean (kW)	6.8	6.6	7.3	6.9
Peak Output to Air (kW)	6.8	6.3	6.5	6.5
Peak Output, Total (kW)	8.2	7.5	8.4	8.0
Efficiency (%)	67	65	61	64
Emission rate (g/kg)	0.8	1.4	1.3	1.2

Table 2 Summary of Data From Test Runs (Continued)

MEDIUM BURN RATE (March 16,17)

	7	8	9	MEANS
Time Commenced	23:17	00:50	02:27	
Burn Time (min)	90.0	93.8	99.9	94.6
Fuel Consumption (kg/hr)	2.5	2.4	2.2	2.4
Flue Temperature, Mean (C)	189	181	177	182
Output to Air, Mean (kW)	5.7	5.3	5.6	5.5
Output to Wetback, Mean (kW)	1.3	1.2	1.2	1.2
Total Output, Mean (kW)	7.0	6.5	6.9	6.8
Peak Output to Air (kW)	6.6	6.0	6.7	6.4
Peak Output, Total (kW)	8.3	6.0	7.9	7.4
Efficiency (%)	61	59	67	62
Emission rate (g/kg)	0.3	0.7	0.4	0.5

Table 3 Estimate of Uncertainties in Measurement

Note: Absolute uncertainties are given for actual measurements: Uncertainties in calculated data are based on results for runs on a typical heater with the air control at maximum and are expressed as percentages.

Fuel Data
- Charcoal Bed Weight: 0.02 kg
- Test Fuel Load Weight: 0.001 kg (wet weight)
- Fuel Consumed: 0.1 kg (wet weight)
- Burn Time: 0.1 min
- Fuel Consumption Rate: 2%
- Fuel Moisture Content: 2% (wet weight basis)
- Moisture Released: 2%
- Fuel Consumed: 3% (dry weight)

Average Flue Gas Parameters:
- Temperature: 2 C
- Draught: 0.1 mm water
- Oxygen (%): 1 (dry)

Average Dilution Tunnel Parameters
- Pitot Differential Pressure (duct centre): 2.5 Pa
- Diln. Tunnel Temp: 1 C
- Mean Velocity: 2%
- Volumetric Flow Rate: 2%
- Mass Flow Rate: 2%

Output Data
- Heat Output Rate to air: 5%
- Heat Output Rate to wetback: 5%
- Total Heat Output Rate: 5%
- Run Time: 0.2%
- Total Power Out: 5%

Sample Collection/ Emissions Data:
- Total Mass captured: 0.4 mg (10%)
- Sample Gas Temp: 1 C
- Capture Time: 0.2%
- Sampling Rate: 0.7 l/min (4%)
- Total Mass Emitted: 16%
- Emission Rate, g/hr: 16%
  - g/kg fuel (dry basis): 19%
  - g/kWh: 21%

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W A Y N E W E B L E Y

Customer: Tropicair Heating
P.O. Box 4220
CHRISTCHURCH

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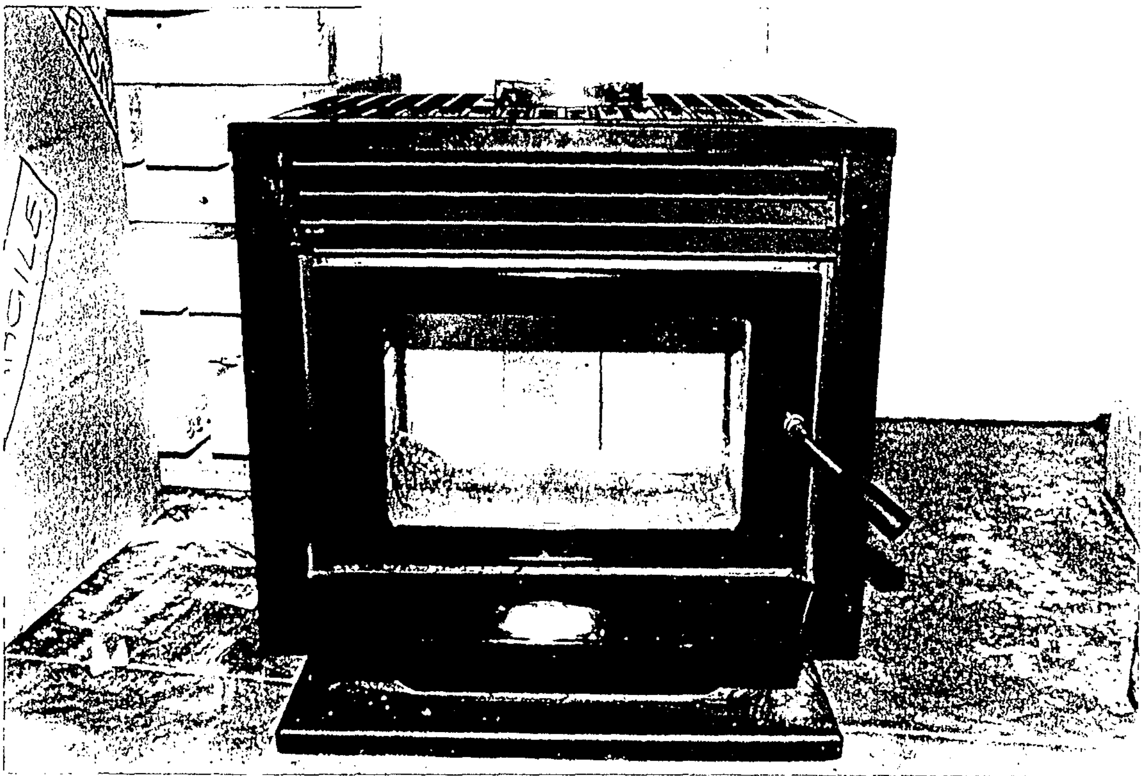
Emissions Testing of the Horizon 450 Woodstove

A sample of the Horizon 450 free standing heater produced by Tropicair Heating was tested for compliance of its flue gas emissions to the requirements of New Zealand Standard NZS7403:1992. The test was carried out in conjunction with a measurement of power output and efficiency using the methods set out in New Zealand Standard NZS 7402:1992.

The tests were carried out at the physical test unit during November and December 1993 by G.J. Hormann and W Webley.

A photograph of the heater is given in figure 1

Figure 1. Horizon 450 Heater



Test Procedures

Tests were carried out using equipment and procedures specified in New Zealand standards NZS 7402:1992 and NZS 7403:1992. The opacity of the flue gases was measured during the tests using an optical opacity meter.

During the tests the heater is stabilised with the air controls at a chosen position. A test load of wood is then burnt and emissions, opacity and other data are collected during the time it takes to burn the test fuel.

Details of the Heater

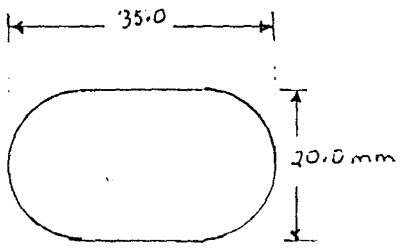
The heater has an approximately rectangular firebox. The rear and side walls are lined with ceramic tiles. The unit has a steel baffle plate.

Primary air enters the heater from two oblong holes behind a grille at the top front of the heater. The size of these holes is determined by the position of a slide controlled by the primary air control. The size of the holes at each test setting is shown in Figure 2.

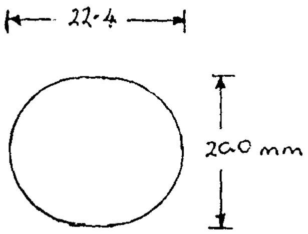
Figure 2 Details of Primary Air Opening (Scale 1:1)

The primary air intake consists of two identical apertures, of the dimensions shown below.

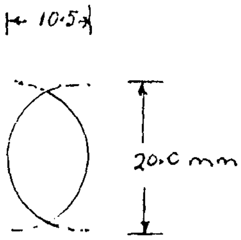
HIGH SETTING



MEDIUM SETTING



LOW SETTING



Secondary air enters the firebox through holes drilled in a tube placed at the front of the baffle. Additional air is supplied through holes from a duct in the firebox wall at the front and rear base of the heater. The secondary air supply is not controlled.

The heater is fitted with a 6 inch (150mm) diameter flue. A flue shield was not fitted.

The heater was supplied with a factory fitted wetback placed above the baffle plate, and connected through the rear of the firebox. In conformity with NZ Standard NZS7402:1992, this was supplied with water at a temperature between 25 and 30 C at a flow rate such that the water temperature increased by between 25 and 30 C during passage through the booster.

Details and drawings of the heater were provided by the manufacturer. A copy of these appear in appendix 2. Manufacturers Installation and Operation Instructions appear in appendix 3.

Test Runs

The heater was conditioned with two 8 hour burns using *pinus radiata*, with the control on the high setting prior to the collection of test data.

A test load of *Pinus radiata* logs was prepared for each test. Details of the test load are given in Table 1. The test pieces were stacked in accordance with NZS 7402. A photograph of a typical test load is shown in figure 3.

Table 1 Firebox and Fuel Data

Usable volume of firebox: 38.7 litres

Longest dimension of firebox: 400 mm

Size of test fuel load: 6.39 litres

Theoretical number of pieces per load: 3.87

Actual number of pieces per load: 4

Theoretical length of fuel pieces: 291 mm

Actual length of fuel pieces: 291 mm (+/- 10mm)

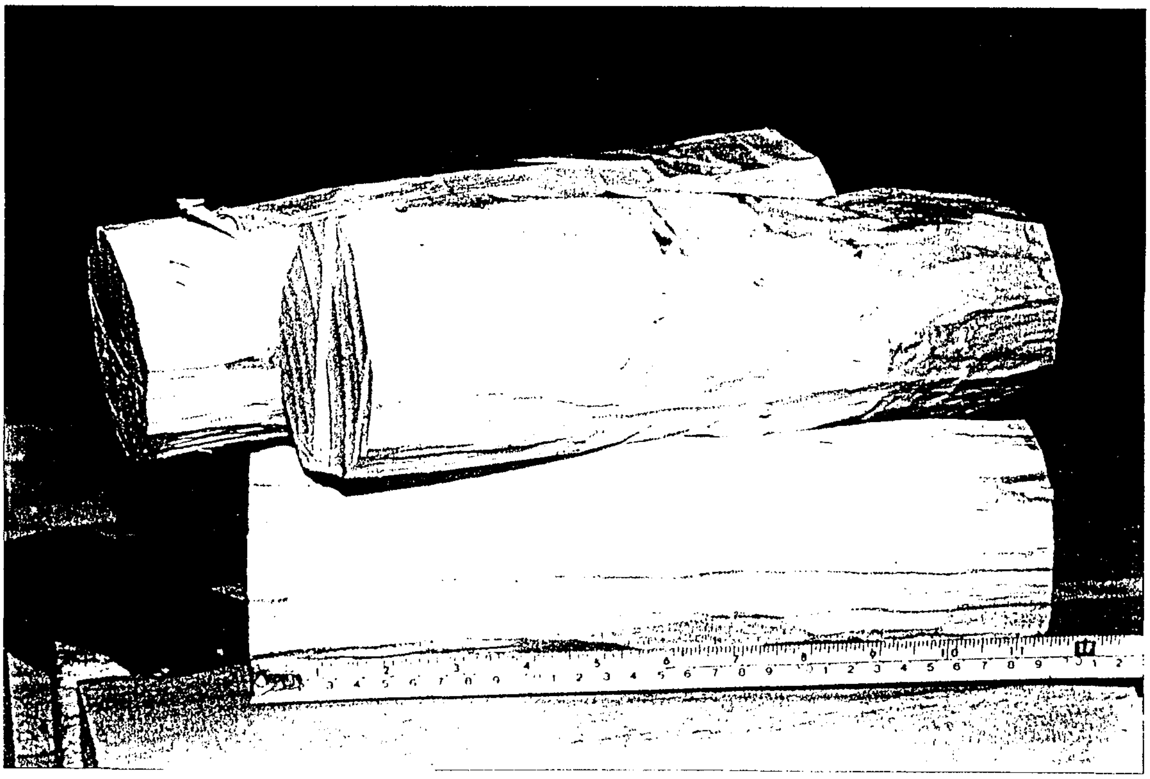
Theoretical mass of wood per load: 3.66 kg

Fuel: Pinus Radiata in conformity with NZS 7404.2

Gross calorific value of fuel: 20.1 MJ/kg

Average fuel moisture content: 16.9 % (wet weight)

Figure 3. Typical Test Fuel Load



The test fuel was added to a bed of embers weighing between 24 and 26% of the weight of the total fuel weight, the firebox door was then closed and the heater allowed to run on the high setting until 20% of the test fuel load (by weight) was consumed. The air control was then set to the appropriate position for the rest of the run.

To obtain representative data for the unit, tests were carried out with the air control at three positions representing high, medium and low output operation as shown in Figure 2.

A summary of the data obtained from these tests is given in Table 2. More detailed information appears in Appendix 1 while an estimate of the uncertainties in individual measurements is given in Table 4.

Table 2 Summary of Data From Test Runs

HIGH BURN RATE (November 28 - 29, 1993)

Run Identification	NOV28-1	NOV28-2	NOV28-3	MEANS
Time Commenced	22:42	23:52	01:04	
Burn Time (min)	59.2	65.1	62.0	62.1
Fuel Consumption (Kg/hr)	3.6	3.4	3.5	3.5
Output Total Mean (kW)	9.9	10.3	10.6	10.3
Peak Output Total (kW)	11.5	11.3	12.1	11.6
Efficiency (%)	58	66	65	63.0
Emission rate (g/kg)	0.7	0.8	3.4	1.6

LOW BURN RATE (December 1 and 3, 1993)

Run Identification	DEC01-3	DEC01-4	DEC03-3	MEANS
Time Commenced	15:25	17:28	20:31	
Burn Time (min)	115.5	114.1	108.7	112.8
Fuel Consumption (Kg/hr)	1.9	1.9	2.0	1.9
Output Total Mean (kW)	6.8	7.1	6.9	6.9
Peak Output Total (kW)	9.2	7.9	9.1	8.7
Efficiency (%)	79	78	74	77.0
Emission rate (g/kg)	6.7	2.7	5.2	4.9

MEDIUM BURN RATE (December 4, 1993)

Run Identification	DEC04-2	DEC04-3	DEC04-4	MEANS
Time Commenced	14:01	15:21	16:38	
Burn Time (min)	74.8	71.9	77.7	74.8
Fuel Consumption (Kg/hr)	2.9	3.0	2.8	2.9
Output Total Mean (kW)	8.4	9.0	7.9	8.4
Peak Output Total (kW)	10.8	10.0	8.6	9.8
Efficiency (%)	62	63	61	62.0
Emission rate (g/kg)	1.1	1.2	1.9	1.4

Appliance Air Flow Test

The air flow was measured in the flue before and after testing and found to comply with the requirements of the standard. (Less than 25% change) - See Table 3.

Table 3 Results of Appliance Air Flow Test

	Before Tests	After Tests	Estimated Uncertainty
Barometer (hPa)	1007	1020	1
Flue Pressure (Pa)	25	25	1
Temperature (C)	21	18	1
Velocity (fpm) (1)	160	180	5
Air Flow (cu m/min) (2)	0.85	0.98	0.03

(1) measured at duct centre
(2) based on uniform flow through a 15cm dia (0.0177 sq m) duct corrected to 20 C and 101.3 kPa

Efficiency

Efficiency is estimated on the basis of a gross calorific value of 20.1 (MJ/kg dry weight) for the fuel burned during the test. This value was determined by measurements of samples of the wood used to prepare the test fuel.

Based on the test results the average efficiency of the heater is estimated to be 67 % when the output to the wetback is included. The average is taken over all the tests.

Results for efficiency for each burn cycle and means for each burn rate are detailed in table 3.

Opacity

Although not required by NZS 7403, the opacity of the flue gases was measured during each of the test runs and is presented in graphical form in appendix 1.

Compliance

New Zealand Standard NZS 7403:1992 requires that the particulate emission factor calculated by averaging the results for the high, medium and low burns be not greater than 5.5 g/kg for an appliance without a catalytic convertor.

The average particulate emission factor for the runs presented in this report is 2.6 g/kg. On the basis of this result the appliance tested complies with NZS 7403:1992.

This Report ...

Prepared By: G.J. Hormann GJ Hormann

Approved By: W.S. Webley WS Webley

Release Date: 15/2/94

Table 4 Estimate of Uncertainties in Measurement

Note: Absolute uncertainties are given for actual measurements: Uncertainties in calculated data are based on results for runs on a typical heater with the air control at maximum and are expressed as percentages.

Fuel Data
- Charcoal Bed Weight: 0.02 kg
- Test Fuel Load Weight: 0.001 kg (wet weight)
- Fuel Consumed (70% Burn): 0.1 kg (wet weight)
- Burn Time (70% Burn): 0.1 mins
- Fuel Consumption Rate: 2%
- Fuel Moisture Content: 2% (wet weight basis)
- Moisture Released: 2%
  (Assumes moisture released from entire fuel load)
- Fuel Consumed: 3% (dry weight)

Average Flue Gas Parameters:
- Temperature: 2 C
- Draught: 0.1 mm water
- Oxygen (%): 1 (dry)

Average Dilution Tunnel Parameters
- Pitot Differential Pressure (duct centre): 2.5 Pa
- Diln. Tunnel Temp: 1 C
- Mean Velocity: 2%
- Volumetric Flow Rate: 2%
- Mass Flow Rate: 2%

Output Data
- Heat Output Rate to air: 5%
- Heat Output Rate to wetback: 5%
- Total Heat Output Rate: 5%
- Run Time: 0.2%
- Total Power Out: 5%

Sample Collection/ Emissions Data:
- Total Mass captured: 0.4 mg (10%)
- Sample Gas Temp: 1 C
- Capture Time: 0.2%
- Sampling Rate: 0.7 l/min (4%)
- Total Mass Emitted: 16%
- Emission Rate, g/hr: 16%
  g/kg fuel (dry basis): 19%
  g/kWh: 21%

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W A Y N E W E B L E Y

Customer: Tropicair Heating
P.O. Box 4220
CHRISTCHURCH

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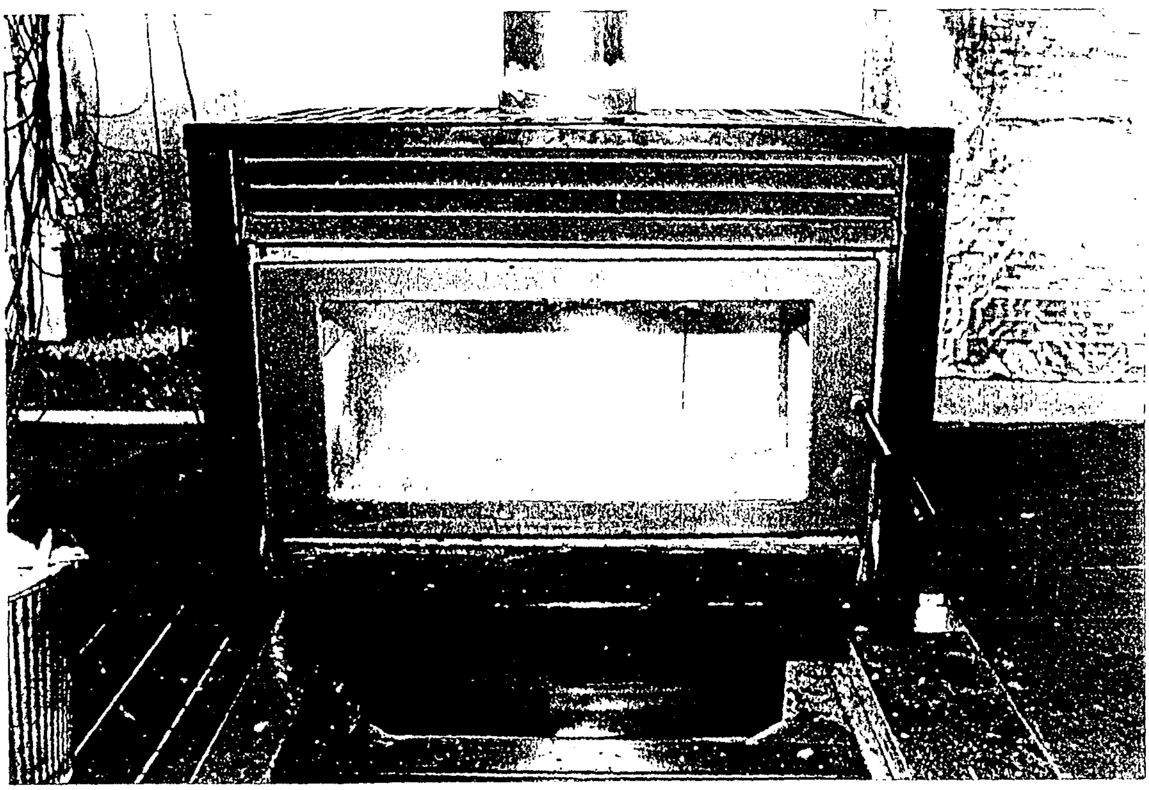
Emissions Testing of the Horizon 600 Woodstove

A sample of the Horizon 600 free standing heater produced by Tropicair Heating was tested for compliance of its flue gas emissions to the requirements of New Zealand Standard NZS7403:1992. The test was carried out in conjunction with a measurement of power output and efficiency using the methods set out in New Zealand Standard NZS 7402:1992.

The tests were carried out at the physical test unit during December 1993 by G.J. Hormann and W.S. Webley.

A photograph of the heater is given in figure 1.

Figure 1. Horizon 600 Heater



Test Procedures

Tests were carried out using equipment and procedures specified in New Zealand standards NZS 7402:1992 and NZS 7403:1992. The opacity of the flue gases was measured during the tests using an optical opacity meter.

During the tests the heater is stabilised with the air controls at a chosen position. A test load of wood is then burnt and emissions, opacity and other data are collected during the time it takes to burn the test fuel.

Details of the Heater

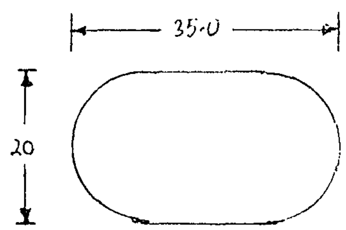
The heater has an approximately rectangular firebox. The rear and side walls are lined with ceramic tiles. The unit has a steel baffle plate.

Primary air enters the heater from three rectangular holes behind a grille at the top front of the heater. The size of these holes is determined by the position of a slide controlled by the primary air control. The size of the holes at each test setting is shown in Figure 2.

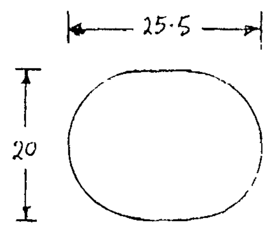
Figure 2 Details of Primary Air Opening (Scale 1:1)

The primary air intake consists of three identical apertures, of the dimensions (in millimeters) shown below.

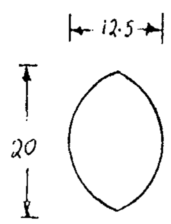
HIGH SETTING



MEDIUM SETTING



LOW SETTING



Secondary air enters the firebox through holes drilled in a tube placed at the front of the baffle. Additional air is supplied through holes from a duct in the firebox wall at the front and rear base of the heater. The secondary air supply is not controlled.

The heater is fitted with a 6 inch (150mm) diameter flue. A flue shield was not fitted.

The heater was supplied with a factory fitted wetback placed at the rear of the fire box. In conformity with NZ Standard NZS7402:1992, this was supplied with water at a temperature between 25 and 30 C at a flow rate such that the water temperature increased by between 25 and 30 C during passage through the booster.

Details and drawings of the heater were provided by the manufacturer. A copy of these appear in appendix 2. Manufacturers Installation and Operation Instructions appear in appendix 3.

Test Runs

The heater was conditioned with two 8 hour burns using *pinus radiata*, with the control on the high setting prior to the collection of test data.

A test load of *Pinus radiata* logs was prepared for each test. Details of the test load are given in Table 1. The test pieces were stacked in accordance with NZS 7402. A photograph of a typical test load is shown in figure 3.

Table 1 Firebox and Fuel Data

Usable volume of firebox: 53.2 litres

Longest dimension of firebox: 550 mm

Size of test fuel load: 8.78 litres

Theoretical number of pieces per load: 3.87

Actual number of pieces per load: 4

Theoretical length of fuel pieces: 399 mm

Actual length of fuel pieces: 399 mm (+/- 10mm)

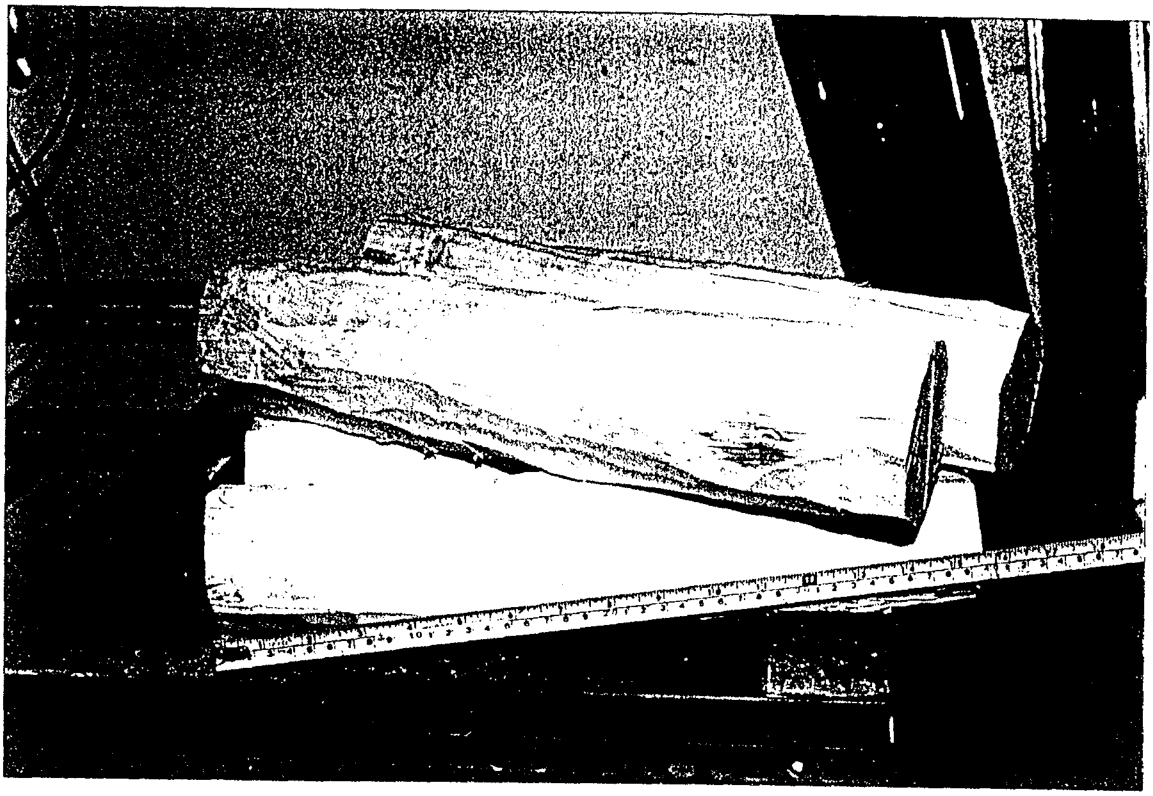
Theoretical mass of wood per load: 5.03 kg

Fuel: Pinus Radiata in conformity with NZS 7404.2

Gross calorific value of fuel: 20.1 MJ/kg

Average fuel moisture content: 18.2 % (wet weight)

Figure 3. Typical Test Fuel Load



The test fuel was added to a bed of embers weighing between 24 and 26% of the weight of the total fuel weight, the firebox door was then closed and the heater allowed to run on the high setting until 20% of the test fuel load (by weight) was consumed. The air control was then set to the appropriate position for the rest of the run.

To obtain representative data for the unit, tests were carried out with the air control at three positions representing high, medium and low output operation as shown in Figure 2.

A summary of the data obtained from these tests is given in Table 2. More detailed information appears in Appendix 1 while an estimate of the uncertainties in individual measurements is given in Table 4.

Table 2 Summary of Data From Test Runs

HIGH BURN RATE (December 7, 1993)

Run Identification	DEC07-2	DEC07-3	DEC07-4	MEANS
Time commenced	14:21	15:28	16:37	
Burn Time (min)	58.4	63.4	68.8	63.5
Fuel Consumption (Kg/hr)	5.2	4.8	4.4	4.8
Output Total Mean (kW)	13.0	12.7	11.7	12.5
Peak Output Total (kW)	15.0	15.9	12.9	14.6
Efficiency (%)	54.0	58.0	57.0	56.3
Emission rate (g/kg)	2.1	1.4	1.3	1.6

MEDIUM BURN RATE (Decenber 12, 1993)

Run Identification	DEC12-2	DEC12-3	DEC12-4	MEANS
Time commenced	14:58	16:35	18:03	
Burn Time (min)	90.5	80.8	87.1	86.1
Fuel Consumption (Kg/hr)	3.2	3.6	3.4	3.4
Output Total Mean (kW)	8.4	10.0	9.1	9.2
Peak Output Total (kW)	12.1	11.2	10.4	11.2
Efficiency (%)	57.0	61.0	59.0	59.0
Emission rate (g/kg)	2.0	2.2	3.1	2.4

LOW BURN RATE (December 15, 1993)

Run Identification	DEC15-1	DEC15-3	DEC15-4	MEANS
Time commenced	13:17	16:55	18:47	
Burn Time (min)	93.7	106.2	115.5	105.1
Fuel Consumption (Kg/hr)	3.2	2.8	2.6	2.9
Output Total Mean (kW)	8.1	7.1	7.1	7.4
Peak Output Total (kW)	8.9	12.1	7.8	9.6
Efficiency (%)	55.0	55.0	61.0	57.0
Emission rate (g/kg)	5.4	6.7	7.9	6.7

OVERALL MEANS: Efficiency (%) = 57, Emission rate (g/kg) = 3.6

Appliance Air Flow Test

The air flow was measured in the flue before and after testing and found to comply with the requirements of the standard. (Less than 25% change) - See Table 3.

Table 3 Results of Appliance Air Flow Test

	Before Tests	After Tests	Estimated Uncertainty
Barometer (hPa)	1014	1008	1
Flue Pressure (Pa)	25	25	1
Air Temperature (C)	14.3	19.3	1
Air Velocity (fpm) (1)	150	150	5
Air Flow (cu m/min) (2)	0.82	0.81	0.03

(1) measured at duct centre
(2) based on uniform flow through a 15cm dia (0.0177 sq m) duct corrected to 20 C and 101.3 kPa

Efficiency

Efficiency is estimated on the basis of a gross calorific value of 20.1 (MJ/kg dry weight) for the fuel burned during the test. This value was determined by measurements of samples of the wood used to prepare the test fuel.

Based on the test results the average efficiency of the heater is estimated to be 57 % when the output to the wetback is included. The average is taken over all the tests.

Results for efficiency for each burn cycle and means for each burn rate are detailed in table 3.

Opacity

Although not required by NZS 7403, the opacity of the flue gases was measured during each of the test runs and is presented in graphical form in appendix 1.

Compliance

New Zealand Standard NZS 7403:1992 requires that the particulate emission factor calculated by averaging the results for the high, medium and low burns be not greater than 5.5 g/kg for an appliance without a catalytic convertor.

The average particulate emission factor for the runs presented in this report is 3.6 g/kg. On the basis of this result the appliance tested complies with NZS 7403:1992.

This Report ...

Prepared By: G.J. Hormann G J Hormann

Approved By: W.S. Webley W.S. Webley

Release Date: 15/2/94

Table 4 Estimate of Uncertainties in Measurement

Note: Absolute uncertainties are given for actual measurements: Uncertainties in calculated data are based on results for runs on a typical heater with the air control at maximum and are expressed as percentages.

Fuel Data
- Charcoal Bed Weight: 0.02 kg
- Test Fuel Load Weight: 0.001 kg (wet weight)
- Fuel Consumed (70% Burn): 0.1 kg (wet weight)
- Burn Time (70% Burn): 0.1 mins
- Fuel Consumption Rate: 2%
- Fuel Moisture Content: 2% (wet weight basis)
- Moisture Released: 2%
- (Assumes moisture released from entire fuel load)
- Fuel Consumed: 3% (dry weight)

Average Flue Gas Parameters:
- Temperature: 2 C
- Draught: 0.1 mm water
- Oxygen (%): 1 (dry)

Average Dilution Tunnel Parameters
- Pitot Differential Pressure (duct centre): 2.5 Pa
- Diln. Tunnel Temp: 1 C
- Mean Velocity: 2%
- Volumetric Flow Rate: 2%
- Mass Flow Rate: 2%

Output Data
- Heat Output Rate to air: 5%
- Heat Output Rate to wetback: 5%
- Total Heat Output Rate: 5%
- Run Time: 0.2%
- Total Power Out: 5%

Sample Collection/ Emissions Data:
- Total Mass captured: 0.4 mg (10%)
- Sample Gas Temp: 1 C
- Capture Time: 0.2%
- Sampling Rate: 0.7 l/min (4%)
- Total Mass Emitted: 16%
- Emission Rate, g/hr: 16%
  - g/kg fuel (dry basis): 19%
  - g/kWh: 21%

Project 135b for Tropicair - large
Run: SEP14-1   Type: high

Fuel Data
    Charcoal Bed Weight, kg: 1.28
    Total Test Fuel Load Weight, kg: 5.11
    Weight Fuel Consmed, kg: 5.11
    Burn Time, min: 73.8
    Fuel Consumption Rate, g/min: 69
    Fuel Consumption Rate, kg/hr: 4.15
    Average Fuel Moisture, % wet weight: 18.6
    Weight Moisture Released, kg: .95
    Fuel Consumed Dry Weight Basis, kg: 4.16

Average Dilution Tunnel Parameters
    Pitot Differental Pressure: 44
    Temperature, C: 48.8
    Temperature, K: 322
    Velocity at Duct Centre, m/s: 7.4
    Mean Velocity, m/s: 7
    Cross sectional Area, sq. m: .01767
    Volumetric Flow Rate at Duct temp, cubic m/s: .124
    Volumetric Flow Rate at 0 C, cubic m/s: .105
    Mass Flow Rate, kg/s: .134
    Mass Flow Rate/ Fuel Consumption Rate: 116

Average Flue Gas Parameters
    Average Flue Temp, C: 298.4
    Average Oxygen, %: 11
    Draught, mm water: 1.5

Output Data
    Mean Cal Room exit duct velocity pressure, Pa: 125
    Volume of Water Through Wetback, l: 161.62
    Heat Output Rate to Air, kW: 8.2
    Heat Output Rate to Wetback, kW: 1.5
    Total Heat Output Rate, kW: 9.7
    Gross Calorific Value of Dry Fuel, MJ/kg: 20.1
    Total Power Out, MJ: 43
    Estimated Total Power In, MJ: 83.6
    Estimated Efficiency, %: 51

Emissions Data
    Length of Individual Events when Opacity > 20%, min...
        .4 6.8 37.1
    Total Time when Opacity > 20%, min: 44.3
    Total Mass Captured On Filter, mg: 9.4
    Sample Gas Temp at filter, C: 25.2
    Sample Gas Volume, l: 425.5
    Sampling Rate, l/min: 5.8
    Sample Gas Temp at meter, C: 16.1
    Sampling Rate, g/s: .117
    Ratio of (DT/ Sample) Mass Flow Rates: 1101
    Total Mass Emitted, g: 10.3
    Emission Rate, g/hr: 8.4
    Emission Rate, g/kg fuel (dry basis): 2.5
    Emission Rate, g/kWh: .87

Calculated With Program MPRCSS7

...icair - large
...low

...Weight, kg: 1.28
...uel Load Weight, kg: 5.37
...Consmed, kg: 5.37
..., min: 72
...umption Rate, g/min: 74
...sumption Rate, kg/hr: 4.47
...Fuel Moisture, % wet weight: 18.1
...Moisture Released, kg: .97
...Consumed Dry Weight Basis, kg: 4.4

...Dilution Tunnel Parameters
...tot Differental Pressure: 46
...emperature, C: 46
Temperature, K: 319.2
Velocity at Duct Centre, m/s: 7.5
Mean Velocity, m/s: 7.1
Cross sectional Area, sq. m: .01767
Volumetric Flow Rate at Duct temp, cubic m/s: .125
Volumetric Flow Rate at 0 C, cubic m/s: .107
Mass Flow Rate, kg/s: .137
Mass Flow Rate/ Fuel Consumption Rate: 110

Average Flue Gas Parameters
Average Flue Temp, C: 348.2
Average Oxygen, %: 5
Draught, mm water: 1.4

Output Data
Mean Cal Room exit duct velocity pressure, Pa: 130
Volume of Water Through Wetback, l: 183.6
Heat Output Rate to Air, kW: 10.8
Heat Output Rate to Wetback, kW: 2.9
Total Heat Output Rate, kW: 13.7
Gross Calorific Value of Dry Fuel, MJ/kg: 20.1
Total Power Out, MJ: 59.2
Estimated Total Power In, MJ: 88.4
Estimated Efficiency, %: 67

Emissions Data
Length of Individual Events when Opacity > 20%, min...
7.2 .4
Total Time when Opacity > 20%, min: 7.7
Total Mass Captured On Filter, mg: 15.5
Sample Gas Temp at filter, C: 25.7
Sample Gas Volume, l: 409.5
Sampling Rate, l/min: 5.7
Sample Gas Temp at meter, C: 15.9
Sampling Rate, g/s: .115
Ratio of (DT/ Sample) Mass Flow Rates: 1145
Total Mass Emitted, g: 17.7
Emission Rate, g/hr: 14.8
Emission Rate, g/kg fuel (dry basis): 4
Emission Rate, g/kWh: 1.08

Calculated With Program MPRCSS7

Appendix L Approved Woodburners

CANTERBURY REGIONAL COUNCIL
AUTHORISED SOLID FUEL BURNING EQUIPMENT AS AT 1 AUGUST 1998

Using dry wood as approved fuel unless noted otherwise. (2nd Edition)

Meets Canterbury Regional Council year 2000 emission standard

Appliance	Approval Holder	Average Emission Rate in g/kg.	Factory Fitted Water Booster Approval	Installation** Approved Until	Certification Number
Jayline Classic Freestanding	Jayline Heating Limited	0.8	Yes[6]	01/08/2003	98021
Jayline Classic Insert Wood Burner	Jayline Heating Limited	0.8	Yes[7]	01/08/2003	98020
Jayline Classic Insert Superclearance	Jayline Heating Limited	0.8	Yes[7]	01/08/2003	98019
Fisher Trojan Insert Wood Burner	Jayline Heating Limited	0.8	Yes[7]	01/08/2003	98018
Fisher Trojan Insert Superclearance	Jayline Heating Limited	0.8	Yes[7]	01/08/2003	98017
Woodsman Matai DLX, ECR and IBS *	W H Harris Limited	0.86	Yes	07/02/2003	98004
Eureka Emerald MkII Freestanding	Eureka Heating Pty Limited	0.9	No [1]	18/07/2003	98013
Masport LE7000 Series 2 *	Masport Limited	1.1	No	02/05/2003	98008
Dante Freestander *	Hewitsons Enviro-Heat Ltd	1.1	No [1]	23/02/2003	98011
Dante Inbuilt *	Hewtisons Enviro-Heat Ltd	1.1	No [1]	23/05/2003	98011
Jayline Spitfire FS10 freestanding *	Jayline Heating Ltd	1.2	Yes	30/04/2001	96004
Jayline Spitfire IB07 inbuilt *	Jayline Heating Ltd	1.2	Yes	30/04/2001	96004
Masport LE 3000 Series 2 *	Masport Limited	1.2	No	28/03/2003	98006
Masport LE 5000 Series 2 *	Masport Limited	1.2	No	28/03/2003	98005
Masport LE 3000 Provincial (Series 2) *	Masport Limited	1.2	No[4]	04/07/2003	98012
Masport LE 2000 *	Masport Limited	1.3	No	16/05/2003	98007
Yunca QEWB Standard *	Yunca Gas	1.3	No	16/05/2003	98010
Yunca Radiant QEWB *	Yunca Gas	1.3	No	16/05/2003	98010
Yunca Tenz *	Yunca Gas	1.3	No	16/05/2003	98010
Yunca Focus *	Yunca Gas	1.3	No	16/05/2003	98010
Yunca QEWB II *	Yunca Gas	1.3	No	16/05/2003	98010
Yunca QEWB Inbuilt *	Yunca Gas	1.3	No	16/05/2003	98010
Eureka Aztec *	Eureka Heating Pty Limited	1.3 [1]	No	06/06/2003	98009
Jayline Gem Freestanding Woodfire	Jayline Heating Ltd	1.32	Yes [5]	01/08/2003	98014
Jayline Gem Inbuilt Woodfire	Jayline Heating Ltd	1.32	Yes [5]	01/08/2003	98015
Jayline Gem Inbuilt Superclearance Model	Jayline Heating Ltd	1.32	Yes [5]	01/08/2003	98016
Fisher Blenheim II *	Nelson Reliance Engineering Co Ltd	1.47	Yes	08/11/2002	97011
Osburn 1000 freestanding *	West Glen Industries	1.5	No	31/08/2001	96007
Logaire Pegasus freestanding *	Metal Fab Industries Ltd	1.7 [2]	Yes	31/08/1999	96003
Pyroclassic II # *	Trentham Engineering Company	2.0 [2]	Yes	30/06/2001	96006

This list is subject to change. Please phone the Canterbury Regional Council Sevices unit for current approvals and information about air quality management in Christchurch (0800 CRC INFO, 0800 272 4636)

EF-III Bayi FS (freestanding) *	Pellet Heating New Zealand Limited	[illegible] [3]	[illegible]	28/0[illegible]03	98[illegible]
EF-III Bayi FPI (fireplace insert) *	Pellet Heating New Zealand Limited	1.47 [3]	No	28/01/2003	98001
EF-III Bayi BIH (built in heater) *	Pellet Heating New Zealand Limited	1.47 [3]	No	28/01/2003	98001
EF-IIi FS (freestanding) *	Pellet Heating New Zealand Limited	1.47 [3]	No	28/01/2003	98002
EF-IIi FPI (fireplace insert) *	Pellet Heating New Zealand Limited	1.47 [3]	No	28/01/2003	98002
EF-Iii BIH (built in heater) *	Pellet Heating New Zealand Limited	1.47 [3]	No	28/01/2003	98002

[1] Approved with a top exit flue.
[2] Emission rate on low burn <1.5 g/kg
[3] Approved Pelletised Wood Fuel as per Manufacturers Specifications
[4] Approved without heat recirculating fan.
[5] If wet back is fitted, it must be of the type; Reliance Group Number 112729 and Manufacturer Number SB007.
[6] If wet back is fitted, it must be of the type; Reliance Group Number 112936 and manufacturer Number SB007.
[7] If wet back is fitted, it must be of the type; Reliance Group Number 112687 and Manufacturer Number SB008.
PLEASE NOTE:
****A building consent for the installation of the appliance must be obtained from the Christchurch City Council or appropriate local authority.**
 # Christchurch City Council may have additional requirements for these models.
Appliances approved with hot water boosters are also approved without hot water boosters.

This list is subject to change. Please phone the Canterbury Regional Council Sevices unit for current approvals and information about air quality management in Christchurch (0800 CRC INFO, 0800 272 4636)

CANTERBURY REGIONAL COUNCIL
AUTHORISED SOLID FUEL BURNING EQUIPMENT AS AT 1 AUGUST 1998

Using dry wood as approved fuel unless noted otherwise. **(2nd Edition)**

Appliance	Approval Holder	Average Emission Rate in g/kg	Factory Fitted Water Booster Approval	Installation** Approved Until	Certification Number
ECOHEAT					
EF-III Bayi BIH (built in heater) *	Pellet Heating New Zealand Limited	1.47 [3]	No	28/01/2003	98001
EF-III Bayi FPI (fireplace insert) *	Pellet Heating New Zealand Limited	1.47 [3]	No	28/01/2003	98001
EF-III Bayi FS (freestanding) *	Pellet Heating New Zealand Limited	1.47 [3]	No	28/01/2003	98001
EF-Iii BIH (built in heater) *	Pellet Heating New Zealand Limited	1.47 [3]	No	28/01/2003	98002
EF-IIi FPI (fireplace insert) *	Pellet Heating New Zealand Limited	1.47 [3]	No	28/01/2003	98002
EF-IIi FS (freestanding) *	Pellet Heating New Zealand Limited	1.47 [3]	No	28/01/2003	98002
EUREKA					
Eureka Diamond Freestand & Inbuilt	Eureka Heating Pty Limited	3.1	No	23/08/1999	97007
Solitaire Freestanding #	Eureka Heating Pty Ltd	2.7	No	01/01/2001	97007
Eureka Aztec *	Eureka Heating Pty Limited	1.3	No [1]	06/06/2003	98009
Eureka Emerald Mk II Freestanding Woodfire	Eureka Heating Pty Limited	0.9	No [1]	18/07/2003	98013
FISHER					
Fisher Trojan Insert Wood Burner *	Jayline Heating Limited	0.8	Yes [7]	01/08/2003	98018
Fisher Trojan Insert Superclearance *	Jayline Heating Limited	0.8	Yes [7]	01/08/2003	98017
Fisher Blenheim II *	Nelson Reliance Engineering Co Ltd	1.47	Yes	08/11/2002	97011
GILLIES					
Gillies Condor	Gillies Manufacturing Co Ltd	4.8	Yes	31/03/2001	94018
HEWITSONS ENVIRO-HEAT					
Contessa III (top exit flue)	Hewitson Industries Ltd	3.6	Yes	31/07/2000	95006
Dante Freestander *	Hewitsons Enviro-Heat Ltd	1.1	No [1]	23/02/2003	98011
Dante Inbuilt *	Hewtisons Enviro-Heat Ltd	1.1	No [1]	23/05/2003	98011
JAYLINE					
Jayline Classic Freestanding *	Jayline Heating Limited	0.8	Yes [6]	01/08/2003	98021
Jayline Classic Insert Wood Burner *	Jayline Heating Limited	0.8	Yes [7]	01/08/2003	98020
Jayline Classic Insert Superclearance *	Jayline Heating Limited	0.8	Yes [7]	01/08/2003	98019
Jayline Ukal "12"	Jayline Heating Limited	4.6	Yes	31/03/1999	94002
Jayline Saffire WFS-04 freestanding	Jayline Heating Limited	3.1	Yes	31/01/2001	96001

This list is subject to change. Please phone Canterbury Regional Council Customer Services Unit for current approvals and information about air quality management in Christchurch (0800 CRC INFO, 0800 272 4636)

Jayline Spitfire FS10 freestanding *	Jayline Heating Limited	1.2	Yes	30/04/2001	96004
Jayline Spitfire IB07 (inbuilt) *	Jayline Heating Limited	1.2	Yes	30/04/2001	96004
Jayline Trojan IB06 (inbuilt)	Jayline Heating Limited	3.2	Yes	30/06/2001	96005
Jayline Gem Freestanding Woodfire *	Jayline Heating Limited	1.32	Yes [5]	01/08/2003	98014
Jayline Gem Inbuilt Woodfire *	Jayline Heating Limited	1.32	Yes [5]	01/08/2003	98015
Jayline Gem Inbuilt Seperclearance Model *	Jayline Heating Limited	1.32	Yes [5]	01/08/2003	98016
JETMASTER					
Jetmaster 700D	The Fireplace Ltd	5.4	No	30/09/1998	93016
Jetmaster 700S	The Fireplace Ltd	4.0	No	30/09/1998	93016
JOTUL					
Jøtul No. 3 TD Fireplace Stove	European Woodstoves Ltd	4.6	No	31/03/2000	95004
Jøtul No. 8 TD Fireplace Stove	European Woodstores Ltd	3.7	No	31/03/2000	95004
KENT					
Kent Fiamma (sloping or vertical door)	GLG NZ Ltd/Kent Heating Ltd	5.3	No	30/11/1998	93017
Kent Fiorenzi (sloping or vertical door)	GLG NZ Ltd/Kent Heating Ltd	5.3	No	30/11/1998	93017
Kent Spectra (sloping or vertical door)	GLG NZ Ltd/Kent Heating Ltd	5.5	No	30/11/1998	93017
Kent "Eurofire" (sloping or vertical door)	GLG NZ Ltd/Kent Heating Ltd	5.3	No	31/01/1999	94001
Kent Logfire CA (sloping or vertical door)	GLG NZ Ltd/Kent Heating Ltd	4.7	Yes	31/03/1999	94007
Kent Tilefire CA (sloping or vertical door)	GLG NZ Ltd/Kent Heating Ltd	4.7	Yes	31/03/1999	94008
Kent Sherwood CA	GLG NZ Ltd/Kent Heating Ltd	4.7	Yes	31/03/1999	94009
Kent Logger	GLG NZ Ltd/Kent Heating Ltd	5.5	No	31/03/1999	94011
LOGAIRE					
Logaire Atlanta (inbuilt and freestanding)	Logaire Ltd	4.5	Yes	31/03/2000	95003
Logaire Pegasus freestanding *	Metal Fab Industries Ltd	1.7 [2]	Yes	31/08/1999	96003
MAGNUM					
Magnum P200 (free standing)	Forlong & Maisey Limited	4.5	Yes	31/08/2000	95007/94010
Magnum P300 (free standing)	Forlong & Maisey Limited	4.5	Yes	31/03/1999	95007/94010
Magnum P300 (superseded model)	Forlong & Maisey Limited	4.5	Yes	31/08/2000	94010
MASPORT					
Masport Provincial LE/W	Masport Ltd	3.1	Yes	30/04/1999	94012
Masport Provincial LE/S	Masport Ltd	3.9	No	30/04/1999	94013
Masport LE 7000/W	Masport Ltd	4.3	Yes	31/05/1999	94016
Masport LE 7000/S	Masport Ltd	4.3	No	31/05/1999	94017
Masport LE 2000/S	Masport Ltd	2.4	No	31/03/2000	95005
Masport LE 2000/W	Masport Ltd	2.8	Yes	31/03/2000	95005
Masport Arcadia	Masport Ltd	4.5	No	31/08/2001	96008
Masport LE 3000/S Series 2	Masport Ltd	4.5	No	05/07/1999	97001
Masport LE 3000/W Series 2	Masport Ltd	4.2	Yes	05/07/1999	97001
Masport LE 5000/S Series 2	Masport Ltd	4.5	No	05/07/1999	97001

This list is subject to change. Please phone Canterbury Regional Council Customer Services Unit for current approvals and information about air quality management in Christchurch (0800 CRC INFO, 0800 272 4636)

Masport LE 5000/W Series 2	Masport Ltd	4.2	Yes	05/07/1999	97001
Masport LE 5000 Series 2 *	Masport Limited	1.2	No	28/03/2003	98005
Masport LE 3000 Series 2 *	Masport Limited	1.2	No	28/03/2003	98006
Masport LE 3000 Provincial (Series 2)	Masport Limited	1.2	No[4]	04/07/2003	98012
Masport LE 2000 *	Masport Limited	1.3	No	16/05/2003	98007
Masport LE7000 Series 2 *	Masport Limited	1.1	No	02/05/2003	98008
MERIDIAN					
Meridian Majestic Inbuilt	Forlong & Maisey Ltd	3.4	Yes	31/08/1998	93015
Merlin 3 (tested to USEPA standards)	Forlong & Maisey Ltd	3.5	No	31/12/1999	94022
MILAN					
Milan Piccolo (freestanding)	Milan Heating Systems Ltd	3.7	Yes[1]	30/04/2001	96002
OSBORN					
Osburn 1000 freestanding *	West Glen Industries	1.5	No	31/08/2001	96007
Osburn 1050 freestanding #	West Glen Industries	5.0	No	31/08/2001	96007
Osburn 1100 freestanding #	West Glen Industries	2.4	No	31/08/2001	96007
Osburn 1600 freestanding and insert	West Glen Industries	2.4	No	31/08/2001	96007
Osburn 2400 freestanding and insert	West Glen Industries	4.8	No	31/08/2001	96007
Osburn 1100 freestanding (wetback)#	West Glen Industries	1.8	Yes	01/01/2000	97003
Osburn 1600 freestanding and insert (wetback)	West Glen Industries	2.4	Yes	01/01/2000	97004
Osborn 2400 freestanding and insert (wetback)	West Glen Industries	4.8	Yes	05/07/1999	97005
PIONEER					
Pioneer Metro (freestanding)	Pioneer Manufacturing	2.3	Yes	31/03/2000	95006
Pioneer Metro (inbuilt)	Pioneer Manufacturing	2.3	Yes	31/03/2001	95006
Pioneer Metro Aspire	Pioneer Manufacturing	3.3	Yes	05/07/1999	97006
PYROCLASSIC					
Pyroclassic II # *	Trentham Engineering Company	2.0[2]	Yes	30/06/2001	96006
STACK					
Stack Combi 640/960	Stack Heating Ltd	3.6	No	31/08/1999	8908/94020
Stack Combi 640/960 (wetback)	Stack Heating Ltd	3.2	Yes	31/08/1999	9011/94020
Stack Ferra 830 #	Stack Heating Ltd	3.2	Yes	31/08/1999	94020
Stack Vista 640/960	Stack Heating Ltd	3.6	Yes	31/08/1999	8908/94020
Stack Vista 640/960 (rear flue)	Stack Heating Ltd	3.2	Yes	31/08/1999	9011/94020
Stack Vista 640/960 (wetback)	Stack Heating Ltd	3.2	Yes	31/08/1999	9011/94020
STUDIO PACIFIC					
Studio Stove	Warmington Industries '94 Ltd	3.4	No	30/04/1999	94015
TROPICAIR					
Tropicair Kowhai	Tropicair Heating Ltd	3.5	Yes	30/11/1999	9013
Tropicair Rimu	Tropicair Heating Ltd	3.5	Yes	30/11/1999	9013
Tropicair Tawa	Tropicair Heating Ltd	3.5	Yes	30/11/1999	9013

This list is subject to change. Please phone Canterbury Regional Council Customer Services Unit for current approvals and information about air quality management in Christchurch (0800 CRC INFO, 0800 272 4636)

Tropicair Horizon 450	Tropicair Heating Ltd	2.6	Yes	31/03/1999	94003
Tropicair Horizon 600	Tropicair Heating Ltd	3.6	Yes	31/03/1999	94004
WAGENER					
The Butler	Wagener Stoves "Lion" Ltd	2.1	Yes	30/06/1999	94019
WOODSMAN					
Woodsman Matai DLX, ECR and IBS *	W H Harris Limited	0.86	Yes	07/02/2003	98004
Woodsman Matai IBS	W H Harris Ltd	3.4	Yes	30/09/1998	93007
Woodsman Matai RMF, DMF, IMF	W H Harris Ltd	3.4	Yes	25/10/1999	97010
YUNCA					
Yunca Z50C Inbuilt Woodburner	Yunca Heating, A division of Terry YoungLtd	2.9	Yes	31/03/1999	94005
Yunca Flame Star (variation of the Radiant)	Yunca Heating, A division of Terry YoungLtd	3.9	Yes	31/05/1999	94006
Yunca Qewb / Radiant	Yunca Heating, A division of Terry YoungLtd	3.9	Yes	31/05/1999	94014
Yunca XCEL 18 Woodburner	Yunca Heating, A division of Terry YoungLtd	2.9	Yes	31/03/2000	95001
Yunca Wegj 2000 Woodburner	Yunca Heating, A division of Terry YoungLtd	5.4	Yes [1]	30/09/2001	96009
Yunca Wegj 2000 (modified)	Yunca Heating	2.3	No	30/09/2001	98003
Yunca Focus *	Yunca Gas	1.3	No	16/05/2003	98010
Yunca QEWB II *	Yunca Gas	1.3	No	16/05/2003	98010
Yunca QEWB Inbuilt *	Yunca Gas	1.3	No	16/05/2003	98010
Yunca QEWB Standard *	Yunca Gas	1.3	No	16/05/2003	98010
Yunca Radiant QEWB *	Yunca Gas	1.3	No	16/05/2003	98010
Yunca Tenz *	Yunca Gas	1.3	No	16/05/2003	98010
Yunca Wegj Wood Burning Heater	Yunca Heating, A division of Terry YoungLtd	5.4	Yes	31/03/2000	9010/95002

[1] Approved with a top exit flue.
[2] Emission rate on low burn <1.5 g/kg
[3] Approved Pelletised Wood Fuel as per Manufacturers Specifications
[4] Approved without heat recirculating fan
[5] If wet back is fitted, it must be of type; Reliance Group Number 112729 and Manufacturer Number SB007.
[6] If wet back is fitted, it must be of type; Reliance Group Number 112936 and Manufacturer Number SB007
[7] If wet back is fitted, it must be of type; Reliance Group Number 112687 and Manufacturer Number SB008
* Meets Canterbury Regional Council Year 2000 emission standard

PLEASE NOTE:

**A building consent for the installation of the appliance must be obtained from the Christchurch City Council or appropriate local authority.
Christchurch City Council may have additional requirements for these models.
Appliances approved with hot water boosters are also approved without hot water boosters.