SELECTING, INSTALLING AND OPERATING DOMESTIC SOLID FUEL HEATERS

Environmental Guidelines for Selecting, Installing and Operating Domestic Solid Fuel Heaters was prepared by the Air Policy Section, Environmental Policy Branch, NSW Environment Protection Authority.

For technical information on the matters discussed in this paper, contact: Air Policy Section, Environmental Policy Branch, Environment Protection Authority, phone (02) 9795 5000 (until end October 1999), (02) 9995 5000 (from November 1999).

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Environment Protection Authority
(Until end October 1999)
799 Pacific Highway
Chatswood
PO Box 1135
Chatswood 2057
Phone: (02) 9795 5000 (switchboard)
Phone: 131 555 (information & publications requests)
Fax: (02) 9325 5678
(From November 1999)
59–61 Goulburn Street
Sydney
PO Box A290
Sydney South 1232
Phone: (02) 9995 5000 (switchboard)
Phone: 131 555 (information & publications requests)
Fax: (02) 9995 5999

E-mail: info@epa.nsw.gov.au
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Minister's Foreword

Everyone has the right to breathe clean air and to be protected from pollution. That is why the Carr Government has put together its *Action for Air* plan, a comprehensive long-term blueprint to protect and improve air quality across NSW. In *Action for Air* the Government has committed itself to producing this guideline for selecting, installing and operating domestic solid fuel heaters.

The guideline is one of a range of actions to reduce pollution from solid fuel heaters. Overall, the Environment Protection Authority (EPA) estimates that solid fuel heaters contribute 40% of air particle pollution in winter. This is an important issue for the community. Smoke from solid fuel heaters contains a mix of pollutants, including carbon monoxide, fine particles and other chemical compounds. These pollutants can affect human health, especially the health of older people, children and people with respiratory illnesses.

Last year, the EPA consulted widely with the community on a draft of the guideline. Responses were received from local councils, environment groups, individuals, industry bodies and government agencies. The comments and the feedback that flowed from that consultation have helped improve this guideline, aimed at providing better solutions to air pollution from solid fuel home heaters across NSW.

This guideline offers practical solutions to assist councils and the community to reduce smoke emissions through the optimum selection, installation, operation and maintenance of solid fuel home heaters. It sets out some steps that all owners can take to improve air quality by selecting the right wood fuel and maintaining the most efficient fire for the least emissions. Although this guideline is primarily designed for local councils, we are making it available to the whole community.

I urge you to implement these guidelines to help make a difference to the quality of the air we all breathe.

Bob Debus

Minister for the Environment

Action for Air
An initiative of the NSW Government

Contents

SECTION

1 Introduction

Air quality is a priority issue for people in NSW. The NSW Government has developed an Air Quality Management Plan, *Action for Air*, to address all sources of air pollution, including motor vehicles, industry and domestic sources. In our own ways we all can and need to play a part in helping to improve air quality.

Domestic solid fuel heaters are a significant source of fine particle pollution in NSW in winter. Wood heaters, especially, are a popular form of heating. At the same time there has been an increase in the number of complaints about smoke and odour associated with wood heaters.

Emissions of fine particles contribute to the brown haze often seen on still winter mornings. Health authorities have recently drawn attention to a growing body of research that establishes a strong link between levels of fine particle pollution in the air and increases in respiratory and cardiovascular illnesses and deaths.

There are clearly environmental benefits in using a renewable fuel, such as wood, if it is being planted and harvested in an environmentally sensitive manner. However, if solid fuel heaters are not operated in a satisfactory way they can give rise to localised smoke and odour problems, and in winter can be a significant source of local and regional fine particle pollution.

Many of the air pollution problems associated with domestic fuel combustion can be prevented or minimised by using appropriately prepared fuel, burning fuel more efficiently, not burning overnight unless the heater is specifically designed for it and, in the case of installing a new heater, selecting a certified heater of a size appropriate for the purpose.

Since 1996 the wholesale and retail sale of new domestic solid fuel heaters has been prohibited in NSW, unless the model has been certified and carries a metal compliance plate in accordance with Australian standards for pollution emissions. The Environment Protection Authority (EPA) issues Certificates of Compliance for model lines when it is satisfied with emission test results in accordance with Australian Standard AS 4013:1992.

This document provides guidance on the selection, installation, operation and maintenance of domestic solid fuel heaters, as well as information on measures available to local government to address problems associated with smoke emissions from these types of heaters.

The NSW Government is addressing concerns about solid fuel heating in a number of ways:

- ▲ implementing a Regulation requiring new heaters to meet an appropriate particle emission limit, effective from March 1996
- ▲ increasing the use of community education programs that outline practical steps for heater owners to reduce emissions
- ▲ introducing a voluntary ‘Don’t Light Tonight—Unless your Heater’s Right’ campaign that encourages residents to use alternative forms of heating on the relatively few nights when poor dispersion of pollutants is forecast

- cooperating with a number of local councils in monitoring fine particle pollution
- facilitating the development, with relevant industries and local government, of an industry code of practice for heater installation
- preparing this environmental guideline as a background document for council officers in particular, but also for anyone interested in domestic solid fuel heating.

SECTION 2

Heaters and fuel types

Local councils will undoubtedly be called upon to manage issues associated with heaters of varying types and ages. This guideline provides information on various types of solid fuel heaters that may be found in homes. Some of the types of heaters described below are no longer available for sale in NSW because they do not meet Australian Standard AS 4013.

HEATERS

Slow-combustion heaters have sealed fireboxes with a control over the main combustion air supply. New models meeting AS 4013 have a secondary combustion air inlet. They may heat by radiation or convection. Many are made as either freestanding models or fireplace insert models. Examples of the internal design of some typical slow-combustion heaters are shown in Figures 1 and 2.

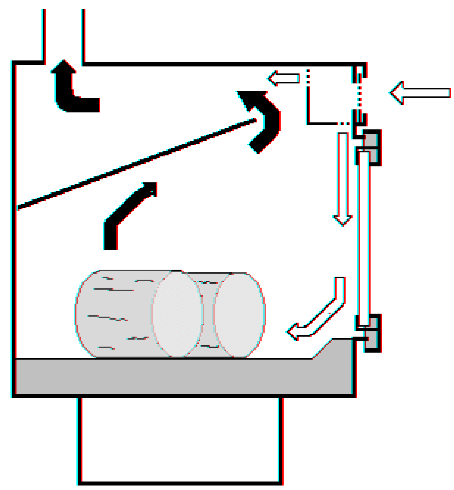
Pot-belly stoves generally do not have sealed fireboxes but do have combustion air control. There is usually no special provision for secondary combustion.

Slow-combustion cookers circulate combustion gas around the oven and under the hotplates before discharge to the atmosphere. They usually have good combustion air control for controlling cooking, and are often fitted with water-heating coils or panels. They are more common in rural areas.

Water heaters may be in-line, like the old chip heaters, or may supply into a hot-water storage system.

Central heating units rely entirely on heat exchangers to heat air for circulation around the house. They burn efficiently because there is no provision for radiating heat from the firebox. Consequently, there is no mixing of combustion products with the air inside the house. There are some types of heaters that can be placed inside building cavities, with distribution of the heated air from the cavity into surrounding rooms, giving an effect similar to that of a central heating unit.

Figure 1. Internal design of a typical wood-burning slow-combustion heater



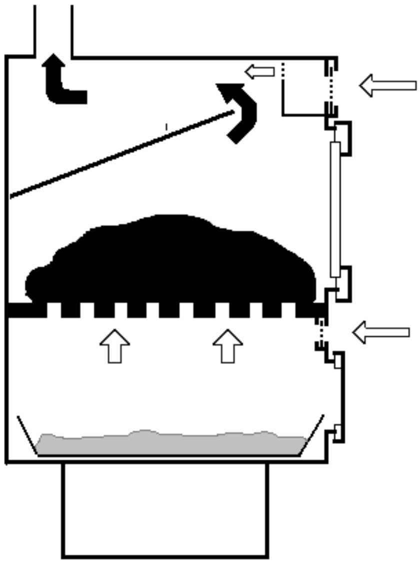


Figure 2. Internal design of a typical coal-burning slow-combustion heater

However, these are not central heating units within the meaning of the Australian Standards and the Regulation.

Open fireplaces are of two types:

- ▲ traditional, with a firebrick hearth or a grate and ashpan, and a brick chimney built above the hearth as part of the building structure
- ▲ central, with the chimney suspended from the roof, either resting fully or partly over the hearth and placed as a feature at the centre of the room.

Fireplace inserts are designed to be installed in existing traditional fireplaces or used in the construction of new fireplaces, and are far more efficient than open fireplaces. They have flue dampers for the control of combustion air, and heating panels to heat air for circulation around the house. Some may have doors, making them similar to slow combustion heaters.

Note: The terms 'insert' and 'inbuilt' are often used interchangeably for both the flue damper type and slow combustion type. Caution is needed in determining which model is being considered. In this document, the EPA uses 'insert' for the flue damper type and 'inbuilt' for the slow combustion type.

WOOD AS A FUEL

Wood was historically the major domestic fuel for cooking, water heating and space heating in Australia. Over time it has been replaced by fossil fuels such as coal, coal gas and natural gas, and by the generation and distribution of electricity. Since the energy crisis in the 1970s, however, there have been growing concerns in the community about the lifespan of fossil fuel resources and the environmental impacts associated with their use.

Wood is returning to favour for use in domestic heating appliances because it is a renewable resource (if, indeed, it is replaced through new plantings or other practices such as harvesting timber in a way that allows the tree to regenerate). Wood is also currently more practical than other sustainable energy forms such as wind power, micro-hydro-power or active solar power, although it is expected that research and development in these areas will change this in the future.

In order to reduce emissions and conserve resources there is a need to focus on improving the efficiencies of burning and heat recovery in relation to wood burning.

The first requirement for efficiency is that the wood must be burnt as completely as possible in the heater. The amount of smoke produced is a good indication of how efficient the fire is. (See the Appendix.) Smoke is the product of incompletely burnt wood; the more smoke generated, the less heat produced. The second requirement is that as much of the heat as possible should be transferred into the building, leaving just enough heat in the flue gas to provide the natural draught that keeps the fire going.

These two requirements are best met by a heater that loses as little heat as possible from the firebox and has a large heat-transfer area for transferring heat from the flue gas into the house. One of the best ways to improve a heater is to line the firebox with refractory bricks. This retains heat in the firebox, improving efficiency, although it takes longer to heat up initially. Better performance is also provided by operating a small heater at its design rate, rather than a large heater at a relatively low rate. Large glass areas in the firebox impair heater performance.

Any fire exhausting up a flue or chimney necessarily draws into the house a volume of cold outside air equal to that of the air going into the fire. A very inefficient fire, like an open fireplace, may heat an area immediately in front by radiation, but cool the rest of the house by drawing in cooler air. The difference has to be made up by some other form of heating.

Smoke consists of very fine particles that can be breathed in. About 80% by mass of smoke particles are less than 10 micrometres in diameter. Smoke particles larger than 10 micrometres may be trapped as they pass through the nose and throat, while smaller particles may pass deep into the lungs. Breathing in smoke particles may therefore be a serious health concern, as health authorities report links with respiratory and cardiovascular illnesses and deaths.

Poor heater selection, installation and operation are the principal causes of air pollution associated with domestic solid fuel burning.

See 'Practical considerations' in section 5 for information on selecting, storing and burning firewood.

OTHER SOLID FUELS

An independent survey carried out across NSW by Keys Young indicated that over 90% of solid fuel heater users choose wood as their main type of fuel. The remaining 10% use other solid fuels, such as black coal, coke, charcoal, lignite (brown coal) briquettes and compressed paper. The use of some of these is not recommended due to their sulfur content and the sulfur dioxide formed when they are burnt. To burn coal the heater must be fitted with a grate. (See Figure 2.) Coal should never be burnt in a heater not specifically designed for the purpose.

Black coals in NSW are generally bituminous or sub-bituminous; that is, they contain volatile hydrocarbons that decompose and vaporise as the coal is heated in a fire. If there is insufficient air, or if the fire is not hot enough, the vapours do not burn, and smoke is created. The sulfur content of black coals makes them unsuitable in many areas.

Anthracite is a black coal with a low level of volatile matter. Anthracite briquettes have lower sulfur levels due to the briquetting process.

Coke and charcoal are forms of coal and wood respectively that have been pyrolysed (heated without air) to reduce the amount of volatile matter. Higher temperatures are required to ignite them than for coal or wood, but they burn much more cleanly. Pyrolysis causes coke to have lower levels of sulfur than coal, but its use may still be restricted in some areas. Wood has a very low sulfur content and so does charcoal.

Lignite briquettes are dewatered and compacted brown coal. They have a low sulfur content and burn quite cleanly, producing little ash.

Compressed paper can be produced using devices that roll wet paper tightly into cylinders that burn like wood when dry. Only newsprint paper should be used. The gloss or semi-gloss papers used in magazines and advertising do not burn well because of the minerals used to produce the finish. There are some substances of concern in newspaper inks; however these will be destroyed or stay in the ash in a well-made roll. Crumpled newspaper burns too quickly to be useful, and tends to release the substances of concern into the flue gas.

SECTION

3 Selection of appliances

LEGAL CONSIDERATIONS

Under **Clause 6 of the Clean Air (Domestic Solid Fuel Heaters) Regulation 1997**, the wholesale and retail sale of domestic solid fuel heaters is prohibited in NSW unless the model has been certified and carries a metal compliance plate as described in AS 4012 and AS 4013.

The EPA issues Certificates of Compliance for model lines when it is satisfied with the emission test results in accordance with AS 4013:1992, and Certificates of Exemption for heaters that cannot be tested for the reasons given in the Standards. (This typically occurs with fireplace inserts.) Modification of the firebox design of a model line also requires a Certificate of Compliance or Exemption.

It is the responsibility of industry to have heaters tested for compliance by a recognised laboratory and then to apply to the NSW EPA for a Certificate of Compliance. Manufacturers can also apply for a National Certificate of Compliance from the South Australian Energy Information Centre. This certificate can be used to support the application to the NSW EPA for a Certificate of Compliance.

NSW EPA certificates remain in force until they are cancelled. Manufacturers or importers are required to supply copies of these certificates to dealers, and purchasers can ask to see an EPA certificate before buying a heater.

PRACTICAL CONSIDERATIONS

Home insulation

Home insulation is an important factor that should be taken into account before decisions are made about home heating appliances. Improved residential insulation can reduce the amount of space heating needed to maintain a comfortable temperature and therefore reduce the size of heater required. Housing design is also an important consideration, as appropriate design can maximise passive solar heating in winter.

Heaters should not be larger than necessary. A heater that is too large will be run at very low burn rates for most of the time. This leads to greater difficulties in maintaining temperatures and recovering heat into the house, and to relatively more air pollution than from a heater operating at its design rate. It is better to run a small heater close to its design rate, as this gives better combustion efficiency, more heat per kilogram of wood and far less pollution. On a few very cold nights extra clothing may be needed, but this is probably less expensive than operating a larger heater less efficiently.

Slow combustion heater

In its basic form the slow combustion heater incorporates combustion air controls to allow wood to burn more slowly than in an open fire, leading to more efficient operation. Newer models have been designed to promote secondary combustion, and they may achieve higher emission reductions for particles, carbon monoxide and polycyclic aromatic hydrocarbons than models without secondary combustion. As a result of secondary combustion more heat is available from a given quantity of wood.

In the past, catalytic reactors, similar in principle to those used in car exhausts, have been used in some heaters to promote secondary combustion at lower gas temperatures. With these, the manufacturer's instructions should be followed carefully to avoid thermal damage to the ceramic catalyst support, and the catalyst changed every few years, depending on the amount of use. Printed paper, coal and coke should not be burnt in these heaters, as substances in these materials can deactivate the catalyst and cause worse emissions than those from a non-catalyst heater. This occurs because these appliances have not been constructed to achieve high enough temperatures for uncatalysed secondary combustion.

Open fireplace

An open fireplace is much less efficient than an enclosed unit or open heat-circulating fire insert with combustion air control. Consequently, the fuel consumption of an open fireplace is higher for a given heating need. Because much of the inefficiency is due to incomplete combustion, the air pollution potential is also greater. However, as open fires are usually not left to smoulder overnight, the total mass of particles released may be smaller than that released from inefficiently operated, older, enclosed units.

Fireplace insert

Fireplace inserts include flue dampers and are designed to direct the combustion air supply so that secondary combustion is increased. These units are designed with open fronts to retain the ambience of an open fire but increase heat output by directing convected and radiant heat into the room. They are inserted into existing fireplaces or used in the construction of new fireplaces.

SECTION

4 Installation

LEGAL CONSIDERATIONS

Development consents under the Environmental Planning and Assessment Act 1979

On 1 July 1998, amendments were introduced to the Environmental Planning and Assessment Act (EP&A Act), administered by the Department of Urban Affairs and Planning (DUAP), and to the Local Government Act, administered by the Department of Local Government. Under the new legislation, councils are required to issue two approvals for solid fuel heaters:

- ▲ under Section 76A of the EP&A Act for the associated **building work** (the hole in the ceiling, etc), and
- ▲ under Part F4 of Section 68 of the Local Government Act for the actual **installation** of the solid fuel heater (placing the heater in the room).

To streamline the development consent process, a single application may be made to a council under the EP&A Act for consent to carry out the building work and to install the solid fuel heater. Alternatively, separate applications can be made for the building work (under the EP&A Act) and for the installation (under the Local Government Act). However, in either case, a council is still required to issue two approvals.

The new legislation also allows councils to include solid fuel heater building work in their Local Environmental Plans (LEPs) as either ‘complying’ or ‘exempt’ developments.

Complying developments require the work to be certified by an accredited certifier as complying with the council’s predetermined standards. Persons (individuals, not companies) are accredited as certifiers by an accreditation body, that is, a professional association that has been authorised as such by the Minister for Urban Affairs and Planning. A professional association gains this authority by applying to the Minister with a scheme giving details of how it will assess and accredit persons as accredited certifiers.

Exempt developments do not require consent and may be carried out by anyone, provided the council’s predetermined standards are met.

As mentioned above, solid fuel heater **installation** requires approval under Part F4 of Section 68 of the Local Government Act. As such, a mechanism of controlling solid fuel heaters by including them in council Local Approvals Policies (LAPs) is available.

A council may also obtain the approval of the Director-General of the Department of Local Government, under Section 162 of the Local Government Act, to specify in Part 1 [Exemptions] of their draft LAPs circumstances in which a person would be exempt from the necessity to obtain approval from the council for installation of a solid fuel heater. This relates to Section 158(3) of the Act.

The Department of Urban Affairs and Planning recommends that, where a council wishes to exempt the installation of a solid fuel heater from the need for an approval, it should consider the following:

- including solid fuel heater **building work** in its LEP as an exempt development, requiring such work to comply with the 'deemed-to-satisfy' requirements of the Building Code of Australia
- including solid fuel heater **installation** in its LAP, citing the EPA Guidelines and a list of approved installers certified as such by the council
- making a link between the LEP and the LAP by including in each a reference to the other.

Consultation

To minimise the likelihood of future nuisance and disputes, councils should consider requesting comments from neighbours when an application for approval is received, as is done for other developments. Where councils wish to exempt the installation of solid fuel heaters from the need for an approval, they should encourage those wishing to install heaters to consult with their neighbours.

Note: At the time of printing, the changes to the legislation and its administration mentioned above are being phased in. Other changes are also being considered. Consequently, the EPA recommends that councils obtain their own legal advice before taking any action. Further information is available from DUAP's Planning System Policy and Reform Branch on its hotline: 1800 358 386.

Solid fuel heaters must be installed in accordance with Australian Standard AS 2918 (Domestic solid fuel burning appliances—Installation), which specifies minimum clearances and thermal shielding. This standard is called up in the Building Code of Australia, which contains the minimum mandatory requirements for building construction. Under State legislation local councils are required to use the Building Code in assessments of building applications. The Department of Fair Trading, which licenses builders specifically for heater installations, also requires builders to follow the Building Code. The EPA and many councils recommend the use of licensed builders who use the Building Code and install heaters according to AS 2918. People who attempt their own installations without being aware of AS 2918 may create fire hazards.

PRACTICAL CONSIDERATIONS

The primary function of a chimney is to use the temperature difference between the warm combustion products and the cold air outside to create a draught that draws combustion air into the fire and combustion products away from the fire and the living area. It should also act as a pollution control device, by discharging the exhaust gases high enough for dispersion and dilution before reaching any neighbouring buildings. The effectiveness of the chimney for both functions depends on its height.

Smoke emissions occur during start-up and after refuelling, even with the best of heaters. Local impacts can be reduced by adequate dispersion, which requires exhaust gases to be discharged as high as possible. Note that the adjacent structures and terrain may affect the dispersion of gases by producing a downwash into the low-pressure area on their downwind side.

Site suitability and chimney height

Chimney height is a significant factor in gaining adequate dispersion of emissions and the avoidance of neighbourhood nuisance. Therefore, councils and installers should consider carefully the positions of nearby houses and adjust chimney heights so as to minimise future problems. If, after adjusting the proposed chimney design, problems are still likely, consideration should be given to not permitting the installation.

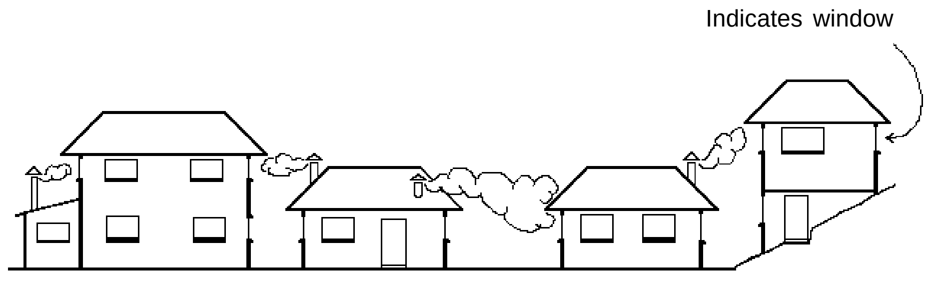
Where council considers that the installation of a solid fuel heater is appropriate, the EPA recommends that the flue be installed so that the discharge height is a minimum of 600 millimetres above any structure within a 3-metre horizontal radius, or according to the distances used in AS2918 Domestic Solid Fuel Burning Appliances—Installation (whichever is the greater).

There are locations, however, where, because of topography or the proximity of multilevel buildings, smoke emissions from a solid fuel heater are likely to cause nuisance to neighbouring dwellings. To assess the suitability of a site in these circumstances, the EPA recommends that the minimum discharge height of the chimney be 1 metre above any structure within a 15-metre horizontal radius. This is a guide—not a rigid rule—and high buildings or terrain beyond the 15-metre radius should also be considered.

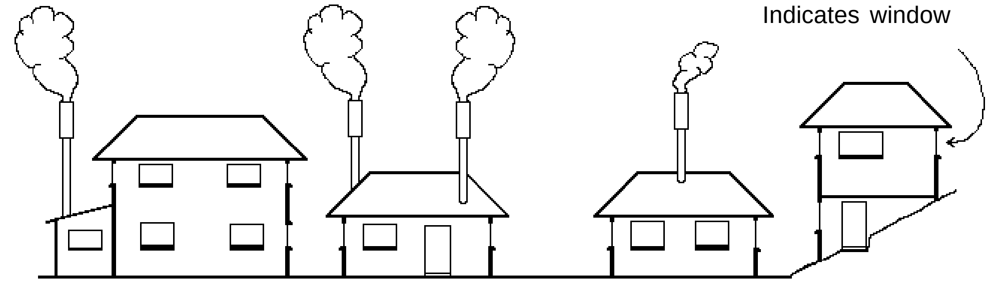
The application of this guide for various house arrangements and terrains is shown in Figure 3. If the chimney height calculation for the site under consideration results in an impractical chimney height, the EPA recommends that approval not be given for the installation of a solid fuel heater at that particular site.

Houses on steep hills should also be given careful consideration, as cold air flowing from high ground into valleys may carry smoke from houses positioned uphill to those downhill. Also, the pooling of cold air in valleys can cause smoke to be trapped near the ground and drawn into homes that have a fire burning. In areas where any of these situations is likely to occur, home owners should consider alternatives to solid fuel heating.

Figure 3. Chimney heights for variable terrain: typical cases where adverse smoke effect may require discharge from a higher point



Higher chimney or better location to solve the problem



SECTION

5 Operation and maintenance

LEGAL CONSIDERATIONS

Protection of the Environment Operations Act 1997

The ***Protection of the Environment Operations Act 1997*** (POEO Act) commenced on 1 July 1999. A number of elements of the Act are relevant to the management of solid fuel heaters.

Section 96: Prevention notices

Section 96 enables prevention notices to be issued to householders who use solid fuel heaters 'in an environmentally unsatisfactory manner'. Prevention Notices attract an administration fee of $320 (payable within 30 days), are appealable, and cannot require action before the expiry of the period for appeal (21 days).

For example, prevention notices could direct a householder:

- ▲ not to use a particular solid fuel heater
- ▲ to turn up a particular solid fuel heater if it causes smoke when turned down
- ▲ to burn only dry wood
- ▲ to operate the solid fuel heater only between stated hours.

If an individual fails to comply with a prevention notice they are committing an offence attracting a penalty of up to $120,000, with an additional daily penalty for continuing offences. If dealt with by way of penalty notice, the fine is $750.

Section 134: Directions by authorised officers regarding fires

By written notice, an authorised officer may direct that a fire be extinguished immediately and that a similar fire not be lit or maintained for up to 48 hours. This may be done if the authorised officer is of the opinion that the fire is causing air pollution that is 'injurious to the health of any person or is causing or is likely to cause serious discomfort or inconvenience to any person'. Non-compliance with the notice may attract an on-the-spot fine of $200 for individuals or $400 for corporations.

Section 126: Dealing with materials

Regarding solid fuel heaters other than on residential premises, an on-the-spot fine may be issued for dealing with materials on premises other than in a proper and efficient manner and in such a way as to cause air pollution. Examples include burning green wood or having a chimney closed so that it smokes. The fine is $750 for individuals or $1500 for corporations.

Local Government Act 1993

Orders

Section 124 of the Act includes a Table of Orders that may be given to certain people under certain circumstances. The following Orders in the Table may be used with regard to solid fuel heaters.

Order 21: To do or refrain from doing such things as are specified in the order to ensure that land is, or premises are, placed or kept in a safe or healthy condition.

This Order could be used to protect the health of people on the premises where the heater is installed. This may be relevant where the owner of the heater lives elsewhere, such as in a rental situation.

Order 30: To comply with an approval for solid fuel heater installation.

This Order could be given instead of prosecuting a person for failure to comply with the terms of an approval.

Nuisance

Section 125 of the Act gives councils the power to deal with public nuisance. As the explanatory note in the Act states:

> Nuisance consists of interference with the enjoyment of public or private rights in a variety of ways. A nuisance is 'public' if it materially affects the reasonable comfort and convenience of a sufficient class of people to constitute the public or a section of the public.

Consequently, if a sufficient number of people, even while in their homes, are subject to a nuisance from an existing solid fuel heater, this section may be used by the council to require the owner to minimise the pollution from the heater. An example of an order under this section would be that a particular heater not be operated under specified climatic conditions or at certain times. Or, if an owner repeatedly failed to operate the heater cleanly, the council may use this Section to prevent its use altogether.

PRACTICAL CONSIDERATIONS

Always follow the manufacturer's operating instructions. The following are general hints and tips on heater operation:

Fuels

The preferred wood fuel is dry, well-seasoned hardwood. Softwood can be used as kindling, or in heaters designed for it. So as to ensure that wood fuel is properly prepared, and actually renewed, those wishing to purchase wood should be encouraged to buy plantation wood that has been adequately seasoned.

- ▲ To check for dryness, tap the wood with a key or coin. Dry wood gives a sharp, resonant sound. Moist wood gives a dull sound.
- ▲ Firewood should be cut and split as soon as possible after felling, then stored for 6 to 12 months:

  —clear of the ground (at least 10 centimetres)

—under a roof to keep rain off, but with open sides and ends

—in alternating layers to allow air circulation

—away from walls and fences (at least 0.5 metres).

- ▲ Firewood should be burnt on a flat hearth, with a shallow bed of ash.
- ▲ Coal, coke and charcoal should be burnt on a grate to provide air under the fire, and to allow ash to fall away. The ashpan should be emptied regularly. Coal should not be burnt in heaters that have not been designed for coal.
- ▲ The burning of unprocessed black coal should be discouraged in densely populated areas because of the sulfur content.
- ▲ Lignite and anthracite briquettes and charcoal burn cleanly without the sulfur problems of unprocessed black coal. Coke may contain sulfur, which could make it unsuitable to burn in domestic heaters.
- ▲ **Never** burn timber treated with creosote, copper-chrome-arsenate (CCA) or lead-based paint**.** Old telegraph poles make excellent firewood, but the black part at the bottom should not be used, as it has been saturated with pesticides such as creosote. CCA-treated timber is easily identifiable as the green pine logs often used for constructing garden edges and park and playground equipment. This timber is safe to handle as logs, but toxic substances are released when it is burnt. For painted wood, it is best to assume that if it is old enough to be discarded it has lead-based paint that may be underneath other layers.
- ▲ Avoid burning varnished or painted timber.
- ▲ Machines are available for compressing wet newspaper into tight cylinders. After drying, these cylinders burn like wood. Glossy paper or ‘finished’ paper from magazines or advertising should not be used in these machines, as the minerals used to produce the finish prevent proper burning.

Catalytic reactor heaters

- ▲ Any heater equipped with a catalytic reactor to promote secondary combustion should burn only wood. Softwood can be used in this type of heater, as the secondary combustion promoted by the catalyst destroys creosote-forming substances associated with the burning of softwoods.
- ▲ Never burn coal or coke, as the sulfur will de-activate the catalyst. Painted timber should be avoided in case the paint contains lead, as this affects the catalyst.

How to burn

The following are general hints on lighting a good fire and keeping it going.

- ▲ Always follow the manufacturer’s instructions.
- ▲ Start with the combustion air-supply wide open and a kindling fire built up with paper or firelighters. Softwood and nutshells make very good kindling because they burn hot and quickly. Use this hot fire to ignite small hardwood logs, and do not adjust the air supply until the logs are burning well.

- ▲ With some heaters, it is possible to place the hardwood logs at the back, with the kindling in front and paper in front of that. The paper is lit, and the fire burns back to the hardwood logs, at which time fresh logs can be added at the front.
- ▲ Keep the fire compact. Place logs in such a way as to maximise the radiation between burning logs while still allowing enough space for air to flow through.
- ▲ Do not cram the firebox full of wood. Frequent small additions are better than a few large additions. Keep the fuel size small.
- ▲ Before adding more fuel, open the air inlet to maximum and open the flue damper for about five minutes. Keep them open for at least 20 minutes afterwards. This creates a fire hot enough to ignite the fresh load quickly and get it burning well.
- ▲ In an open fireplace, logs may need continual adjustment to maintain optimum burning. A poker and tongs are essential, and it is wise to use a firescreen.
- ▲ Check the chimney regularly for smoke. If the heater smokes for more than 15 minutes after the initial light-up from cold or after re-fuelling, there is a problem with either the fuel or the operating method, or both.
- ▲ In autumn and early spring, when the full heating capacity is not needed, it is better to run a small, hot fire and let it go out than to keep a larger fire running at a low rate. A well-insulated house will retain the heat for some time.
- ▲ When the fire is out, close the flue damper to prevent cold air flowing back into the house through the chimney.

Catalytic reactor heaters

- ▲ Follow the manufacturer’s instructions, as the catalyst can be damaged or de-activated by poor practices; this, in turn, lowers efficiency and creates far worse emissions than those from a non-catalyst heater.
- ▲ When the catalyst is functioning correctly the reactor glows red.
- ▲ A hot initial fire is needed to bring the catalyst up to 'light-off' or ignition temperature, before the by-pass is closed. After this it is self-sustaining, provided there is unburnt material in the hot gases from the main fire.
- ▲ The catalyst reactor will not last indefinitely and needs periodic replacement. The replacement time depends on how the fire is used and for how long. It may be months or years. There is no definite rule.

Overnight burning

- ▲ In winter, the maximum concentration of fine particles in the air occurs after midnight. There is now health data linking fine particle concentrations to mortality rates from respiratory and cardiovascular diseases.
- ▲ Unless special care is taken, overnight burning can cause great amounts of smoke. To avoid problems, the air intake of any heater should be kept high enough to maintain a flame at all times. Pay extra attention to heaters that are not one of the newer models certified by the EPA and recommended for this by the manufacturer.

- ▲ Do not leave heaters (especially uncertified ones) overnight at the minimum air setting with a full firebox. This generates very little heat and high levels of smoke.
- ▲ If the heater has been designed for continuous operation (burning overnight), follow the manufacturer's instructions carefully. Do not cram the firebox full. When the last load is put in, run the heater at maximum for half an hour, then adjust it to the overnight setting.
- ▲ An overnight burn will be more effective if there is not excessive radiation from the firebox. A lining of refractory bricks in the firebox maintains combustion temperatures and efficiency at the lower burn rate.
- ▲ A high burn rate should be used for one to two hours for every day of use, especially if the heater has been used on a slow burning rate for long periods. This helps to reduce soot and creosote build-up in the flue.

Maintenance

- ▲ Clean the chimney and flue at the end of every heating season. Do not wait until the next autumn.
- ▲ Inspect the flue and chimney regularly to check for a build-up of soot and creosote; this indicates whether the fire is operating poorly. Mid-winter cleaning may be necessary.
- ▲ Hours of use are not a good indicator of the need for cleaning. Heaters that operate continuously through winter at a high rate may have far less creosote build-up than heaters that are used intermittently.
- ▲ Wood heaters work well with a shallow layer of ash on the hearth, so leave some ash when you are cleaning the heater out. At the end of the heating season remove all the ash to prevent corrosion of the heater.

Resolving problems

To make certain that communities are aware of how to gain access to local environment protection services, councils should ensure that their contact details are widely circulated throughout their areas.

Occasionally there are local problems with solid fuel heater emissions that are difficult to resolve. If a solid fuel heater is producing excessive smoke or is a nuisance to neighbours, the industry representative body, the Australian Home Heating Association Inc., offers a troubleshooting service to councils. The service is coordinated through the Association's national office in Melbourne (see details below), but it is open to all councils in NSW.

When contacted by a council, the Association's national office will arrange for one of its NSW members to visit the solid fuel heater owner and the neighbour. The solid fuel heater in question will be inspected and the owner advised on the optimum operation method, fuel type or flue height—the most common causes of problems. Following the Association's assessment, a written report will be prepared for the council.

Australian Home Heating Association Inc.
7 South Road
BRIGHTON VIC 3186 Phone: (03) 9592 2522 Fax: (03) 9592 8080
E-mail: homeheat@ozemail.com.au

SECTION 6

Relevant Australian standards

Standards Australia has prepared five standards for solid fuel burning appliances of the slow combustion, pot-belly types. The standards are:

- ▲ *AS 2918:1990 Domestic solid fuel burning appliances—Installation* (safety requirements—heat shields, clearances)
- ▲ *AS 3869:1991 Domestic solid fuel burning appliances—Specifications* (construction materials and design features)
- ▲ *AS 4012:1992 Domestic solid fuel burning appliances—Method for determination of power output and efficiency* (design of test chamber and test procedure)
- ▲ *AS 4013:1992 Domestic solid fuel burning appliances—Method for determination of flue gas emission* (emission test procedure in conjunction with AS 4012)
- ▲ *AS 4014:1992 Domestic solid fuel burning appliances—Test fuels*
  Part 1: Hardwood
  Part 2: Softwood
  Part 3: Lignite briquettes
  Part 4: Sub-bituminous coal
  Part 5: Semi-anthracite coal briquettes
  (preparation of test fuels for AS 4012 and AS 4013, to ensure those tests are comparable. At the time of printing Part 5 had not been released, but its release was imminent.)

AS 2918 and AS 3869 apply generally to domestic solid fuel burning appliances with a few exceptions. Applications of AS 4012 and AS 4013 are restricted according to the following clause:

> **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; and
>
> (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.

SECTION 7

Organisations

The following organisations may be able to provide further information on a range of issues relating to domestic solid fuel heaters. The views expressed in the websites mentioned, and any associated links, are not necessarily those of the EPA.

Alternative Technology Association

Association for enthusiastic amateurs and professionals involved in research on renewable energy. Provides information on fuel types and more efficient ways of heating.

PO Box 2001
Lygon Street North
BRUNSWICK EAST VIC 3057
Phone: 03 9388 9311
Fax: 03 9388 9322
E-mail: ata@ata.org.au
Web: www.ata.org.au

Australian Home Heating Association Inc.

Provides advice on selecting, installing and operating domestic solid fuel heaters.

7 South Road
BRIGHTON VIC 3186
Phone: 03 9592 2522
Fax: 03 9592 8080
E-mail: homeheat@ozemail.com.au
Web: www.homeheat.com.au

Environment Australia

The Air Quality Section of Environment Australia is responsible for a wide range of national programs and activities relating to air quality protection, including the wood smoke awareness campaign *Breathe the Benefits*.

John Gorton Building
King Edward Terrace
PARKES ACT 2600
Phone: 02 6274 1111
Fax: 02 6274 1172
E-mail: airquality@ea.gov.au
Web: www.environment.gov.au

Local Government and Shires Associations of NSW

Provides general information on the role of local councils with regard to solid fuel heaters. Individual councils will provide more specific information.

215–217 Clarence Street
SYDNEY NSW 2000
Phone: 02 9242 4000
Fax: 02 9242 4111
E-mail: lgsa@lgsa.org.au
Web: www.lgsa.org.au

Standards Australia

Provides copies of Australian Standards and the Building Code of Australia.

1 The Crescent
HOMEBUSH NSW 2140
Phone: 1 800 672 321
Fax: 02 9746 4765
E-mail: sic@standards.com.au
Web: www.standards.com.au

Sustainable Energy Development Authority

Concerned with fuels, renewable energy and general types of equipment available.

Level 6
45 Clarence Street
SYDNEY NSW 2000
Phone: 02 9291 5260
Fax: 02 9299 1519
E-mail: seda@seda.nsw.gov.au
Web: www.seda.nsw.gov.au

Appendix: Combustion principles

COMPOSITION OF FUELS

Common solid fuels are composed principally of combinations of three elements:

- ▲ Carbon C
- ▲ Hydrogen H
- ▲ Oxygen O

These, and the oxygen and nitrogen in air, are sufficient for a general consideration of combustion and are used in calculations of the flue gas volume and composition. Other elements may be present in solid fuels in small amounts, but may become important in the consideration of factors such as odour, toxicity, corrosion and dust fallout:

- ▲ Nitrogen N
- ▲ Sulfur S
- ▲ Phosphorus P
- ▲ Chlorine Cl
- ▲ Potassium K
- ▲ Magnesium Mg
- ▲ Silicon Si (usually present as silica, SiO_2, or silicate minerals)

There are two methods for describing the composition of fuels. Ultimate Analysis is the method used to describe the composition in terms of chemical elements. In the Proximate Analysis method, the fuel is described in terms of inherent moisture (IM), volatile matter (VM), fixed carbon (FC), and mineral matter (MM). Values for each of these are found by heating the fuel in several stages under standard conditions and weighing the material remaining at each stage.

Inherent moisture (IM) is the water contained in the fuel, not the surface water (for example, rain on wood that has not been stored under cover), or the water that is released by decomposition of the fuel. It does not include water that is formed from hydrogen in the fuel during combustion.

Volatile matter (VM) is the combustible gases and liquids formed by heating the fuel. It is driven off as vapours, some of which can condense into liquids and may even solidify. The remaining gases may be described as **non-condensables**.

Fixed carbon (FC) is the coke or charcoal material left after removal of IM and VM, except for the mineral matter. It usually contains heavy hydrocarbons as well as elemental carbon.

Mineral matter (MM) is the inorganic substances in the fuel. Much of it usually remains as ash, but MM and ash are not equivalent. Some minerals (for example, carbonates) decompose during combustion, while some new inorganics may form.

Compositions may be expressed on various bases, including:

- as received—includes free moisture and extraneous matter
- air-dry—allowed to dry with air circulation, but under cover; includes inherent moisture
- kiln-dry—dried by hot air in a kiln, fired usually with materials such as sawdust
- dry, ash-free—the results are adjusted to exclude the moisture and inert components
- dry, mineral-matter-free—the results are adjusted to exclude the moisture and inert components.

The last two differ according to the different analytical methods used to measure them. For practical purposes, however, they can be taken as the same, because the measurements are looked at in ranges (for example, 15% to 20%) and do not require a high degree of accuracy.

It is difficult to relate the data obtained from Ultimate Analysis to that obtained from Proximate Analysis. For example, in the Ultimate Analysis Method the amount of elemental carbon is found, whilst in the Proximate Analysis method carbon is present in the FC and VM stages. Both methods are useful in their own ways.

Wood

'Green' wood contains about 25% to 50% water. After the wood has been split and seasoned for about 12 months in suitable storage conditions, the moisture content is reduced to the inherent moisture content. Kiln-drying brings the moisture content down to about 10%, but is normally used only for construction timber, to avoid warping during use. Wood typically contains about 50% carbon, 6% hydrogen, 40% to 45% oxygen and about 0.5% nitrogen on a dry, ash-free basis. The VM is about 81% and the FC is about 18% on a dry, ash-free basis. The ash content is usually 1% or less.

The various compositions described above are similar for hardwoods and softwoods. The difference between these two broad types of wood depends on the structure of the wood, as seen under a microscope, rather than on the hardness of the wood. Generally, hardwoods come from broad-leafed trees such as eucalypt, acacia, oak and brush box, while softwoods come from needle-leafed or scale-leafed trees such as pines, cypress, cedar, fir and spruce. However, this is only a broad rule, as narrow-leafed trees such as casuarinas are defined as hardwoods, while ginkgo has broad leaves and is defined as a softwood.

Coals

Coals and coke are usually low in moisture, but charcoal may absorb and hold from 10% to 15% water. Lignite is dewatered in the briquetting process.

On a dry ash-free basis the VM generally increases and the FC decreases, through the progression: anthracite (> 92% FC), semi-anthracite (86%–92% FC), bituminous black coal (69%–86% FC), sub-bituminous black coal and lignite (variable FC but lower heat content than bituminous).

The MM content of coals varies widely between mines and even within a seam. Typically the MM content is between 10% and 25%; some may approach 30%, while others may be as low as 5%.

Australian coals are low in sulfur by world standards, with most below 1% by weight, and some down to less than 0.5%. Even these comparatively low levels can produce sulfur dioxide emissions.

Relative proportions

The VM for black coals and wood is mainly hydrocarbons and oxygenated hydrocarbons respectively. Anthracite, coke and charcoal are very low in VM. Lignite is moderately high in VM.

Wood and charcoal are usually very low in MM, while black coals (bituminous and anthracite) may contain 5% to 20% MM. Coke usually contains more MM than the coal from which it was made. Lignite briquettes are low in MM.

WHAT IS COMBUSTION?

The following examples use wood. Other solid fuels act similarly, with differences due to the proportions of moisture, volatiles, carbon and minerals.

In a simple model of wood combustion, heat initially causes moisture to evaporate from the wood. The temperature then begins to rise and the wood starts to decompose into volatiles (the VM part) and char (the FC part). This actually happens at different times in different parts of the fire. The char can be seen as the glowing part of the logs in the middle of the fire; it burns in the primary air, which enters low in the fire, and is converted to carbon dioxide and water. The VM evaporates, and when it meets hot secondary air it is converted to carbon dioxide and water. A visible flame can be seen while the VM is burning. Nitrogen and any remaining oxygen from the combustion air also form part of the flue gas.

The burning process is actually more complex than the model described in Figure A1, and includes end-products such as smoke, soot and odours (Figure A2).

Figure A1. Ideal combustion

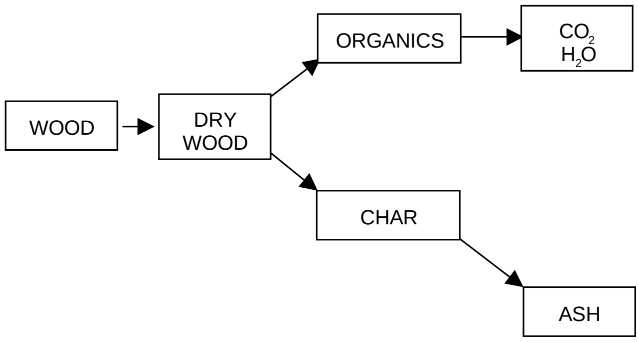
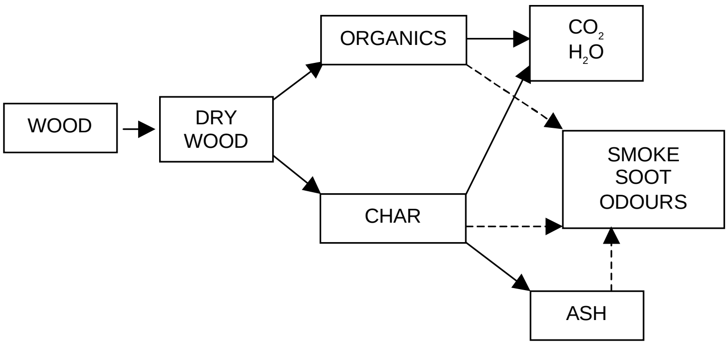


Figure A2. Actual combustion



A number of things can cause a fire to die out, including too few logs too far apart, and logs stacked too closely, not allowing enough air to enter. To continue burning, char needs plenty of heat radiation from logs around it.

Heat being conducted away from the burning char causes logs around it to decompose and vapours to be seen rising out of splits in the wood. If the air and vapours are hot enough these vapours will ignite, producing a visible flame. If this flame is flickering it is a sign that the fire is only just hot enough. If it is not hot enough, unburnt vapours will be carried up into the chimney. As the vapours cool some will condense into extremely fine drops of hydrocarbon liquid or solid, or particles of carbon coated with liquid, forming smoke. As the fire dies down more carbon monoxide is usually formed, as the temperature is too low to convert carbon monoxide to carbon dioxide.

Flames

Blue flames are caused by atomic and molecular changes in burning gases. Yellow flames get their colour from the incandescence of burning particles, which may be solid (like a light bulb filament) or liquid. In the case of yellow flames it is not always obvious whether the flame disappears because the particles have burnt away, or because they have cooled by radiation and contact with cool air. Burning char gives very little flame but radiates in the red-to-yellow range due to incandescence.

Combustion products

The combustion process can be described by using the following chemical equation. Cellulose, a component of wood, is used in this example and is represented by the symbol $C_6H_{10}O_5$.

$C_6H_{10}O_5 + 6\ O_2 \Longrightarrow 6\ CO_2 + 5\ H_2O + \text{heat}$

The oxygen in the first part of this reaction is a component of the air around the burning wood (21% by volume). Nitrogen, small quantities of inert gases, carbon dioxide and water (humidity) also found in the air do not participate in this reaction. The hydrogen and oxygen atoms in the cellulose molecule do not exist as water, but require an initial energy of ignition to be rearranged to form water. During the breakdown of this complex molecule more energy is released than is required to form the water molecule, and it is this heat that we can use.

Other components of wood are also released during the burning process. Most nitrogen is released as nitrogen gas, but a small proportion forms nitric oxide that can be further oxidised to nitrogen dioxide. Sulfur forms sulfur dioxide. Chlorine usually forms hydrogen chloride, which may react with other products. Phosphorus forms phosphorus pentoxide.

Metals such as potassium and magnesium usually stay in the ash as oxides, hydroxides, carbonates or silicates. In fact, the name potassium is derived from pot-ash, the residue under cooking pots on open fires. Potassium is an essential element for plant growth, which is why wood ash is commonly put on gardens. The potassium oxide/hydroxide in ash absorbs water, but when a fire is used regularly, this water is evaporated. Ash should be cleared from a fire at the end of a season, as it will absorb water to form a caustic solution that corrodes metal fireboxes.

Incomplete combustion occurs when there is insufficient oxygen circulating around the wood, or when the oxygen or fuel is not hot enough. While there may be sufficient oxygen overall, there may not be enough in some parts of the fire due to poor mixing. This may lead to incomplete combustion, with the initial products of breakdown not being completely oxidised. The substances formed often include organic acids, aldehydes like formaldehyde, aromatics like benzene, and a range of heavier hydrocarbons such as benzo(a)pyrene. As the hot hydrocarbon vapours cool, they may condense into liquid drops or on to particles of solid carbon. Because these are built up from extremely small particles they are very fine, a high proportion being smaller than 1 micrometre. Masses of these particles can be very visible and can produce unusual optical effects.

At the temperatures that typically occur in chimneys, hydrocarbons can react with water to form creosote, which condenses on to chimney walls. This restricts the gas flow, and thus the whole combustion process, since air will not be drawn into the fire if the product gas cannot escape. The build-up of creosote in chimneys is dangerous for a number of reasons; one being that the product gas can escape into the house. Another is that it may eventually ignite, causing the chimney to heat up, potentially leading to overheating of roof timbers and the start of a house fire.

Efficiency

The efficiency and completeness of combustion depend on attaining a sufficient temperature for ignition (for both the char and volatiles), providing an adequate supply of air (to both char and volatiles) and having sufficient contact time between oxygen and fuel (both char and volatiles). The contact between solid fuel and oxygen is determined by the available surface area, so the rate of combustion is ultimately limited by the surface area of the fuel.

A small piece of fuel has a larger surface area relative to its mass than a large piece, so small pieces of fuel can provide a greater contact area for the oxygen and better combustion than large pieces. If the fuel is tightly packed the effective surface area is reduced, and air-flow to the burning zone restricted.

Volatiles rising from the wood mix with air. If the mixture of air and volatiles is hot enough, the volatiles can ignite and burn. If the mixture is not hot enough or if there is insufficient oxygen, there is no ignition and unburnt volatiles may condense to form smoke. Ignition is more likely if the air has been preheated. This is one reason why slow combustion heaters burn better than open fireplaces. Modern designs provide a separate chamber with extra air added to achieve secondary combustion, that is, burning of the volatiles.

Secondary combustion can be promoted by passing the gas and secondary air over a catalyst. This allows ignition at lower temperatures and accelerated combustion, which generates higher temperatures. The catalyst consists of platinum and palladium deposited on a ceramic honeycomb base similar to those used in car exhausts.

Heaters have to be specifically designed for using catalysts. Secondary combustion can reach temperatures of the order of 700°C, while catalysts can reach over 1000°C. The secondary chamber of the firebox needs to be designed to withstand these higher operating temperatures. The ratio of primary to secondary air may also be different in heaters that have catalysts.