The Secretary

FUEL RESEARCH INSTITUTE OF SOUTH AFRICA

TECHNICAL MEMORANDUM NO. 20 OF 1965

THE OPEN FIRE AND AIR POLLUTION

by

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The open fireplace is a popular and, in not too severe winters, an adequate heating device under South African conditions. Unfortunately, it can be operated in such a manner that, apart from the cheerful blaze, a considerable quantity of smoke is produced, especially when lighting up.

Since in this country the fire usually does not burn all day, kindling the fire is a frequently recurring operation. If this could be achieved smokelessly, air pollution in domestic areas could be reduced considerably.

In order to arrive at the best kindling method, the manner in which smoke arises may be considered in some detail.

The bituminous coal, preferably and almost universally used as the fuel for this purpose, releases a considerable amount of tar when the coal is heated. This tar can be seen to escape as a yellowish or brownish fume when a coal particle is warmed. These vapours will burn easily when they are sufficiently hot, but not when cold.

Thus, when the fire is laid in the usual manner, that is with paper and firewood on the grate and some coal, or the full charge, on top, the following happens:

The paper and wood ignite readily and start heating the overlying coal. This coal then releases tarry vapours, which, together with the combustion gases from the wood, rise through the cooler parts of the coal bed. When these gases escape at the top, the temperature is low, and even though sufficient air for combustion is present, the tar fumes are too cold to ignite. Combustion of these fumes only takes place when the coal bed and the fire bank have become hot.

There is, however, another method, generally known as the

Scotch/...

Scotch fire, which considerably reduces the amount of smoke produced.

In this method, the coal is first charged onto the grate and the kindling material placed on top. Upon ignition the hot zone of the fire moves downward slowly. The tarry vapours released by the coal as it is heated are, therefore, drawn, initially, through the glowing charred remnants of the firewood, and later through the glowing coal which already has lost its tar. The tar fumes are thus pre-heated and burn readily when they reach the top of the fire bed, where plenty of fresh air is available for combustion.

Figures 1 and 2 illustrate what happens when fires are lighted according to the normal and the Scotch method respectively.

Some objections are sometimes made to this method of lighting the fire, namely:

1. The fire starts slowly.

2. Less heat is given off.

In order to investigate whether these objections were justified, some comparative tests were conducted by the Fuel Research Institute. Fires in an open fireplace were lighted by various methods. Instruments were installed by means of which the heat produced and the smoke generated could be recorded at any instant. The results are presented in the attached diagram, Figure 3.

This diagram illustrates that the first objection is indeed founded upon truth: whereas the normal fire builds up rapidly and gives off maximum heat after roughly fifty minutes, the Scotch fire takes just over two hours to do this.

The second objection is, however, unfounded. The normal fire produces a maximum heat output of 3.6 Kilowatts (which is rather more than that of a 3-bar electric heater), the Scotch fire achieves 2.85 Kilowatts, which, though rather less, is still more than that of the normal 2-Kilowatt electric heater, and, what is even more important, gives off more heat than the normal fire

during/...

during its useful life.

The average heat output is 1.6 Kilowatt for the normal fire and 1.8 Kilowatt for the Scotch fire. The Scotch fire, therefore, produces a more even heat for a longer period.

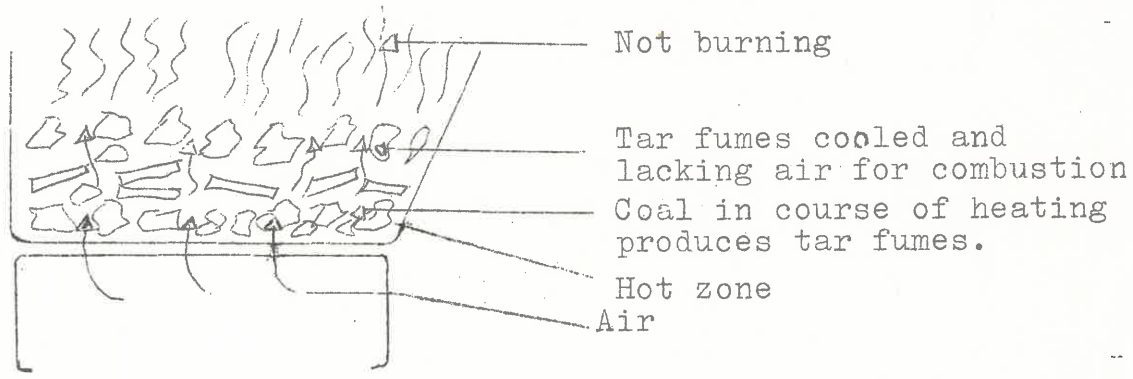
Figure 4 illustrates the quantity of smoke produced, and it is clear that the Scotch fire is far less objectionable in this respect.

Refuelling the Scotch fire will only be necessary after about three hours. If desired, little fuel should be added at a time and the fire should be poked gently from underneath. In this manner, further evolution of smoke will be greatly reduced.

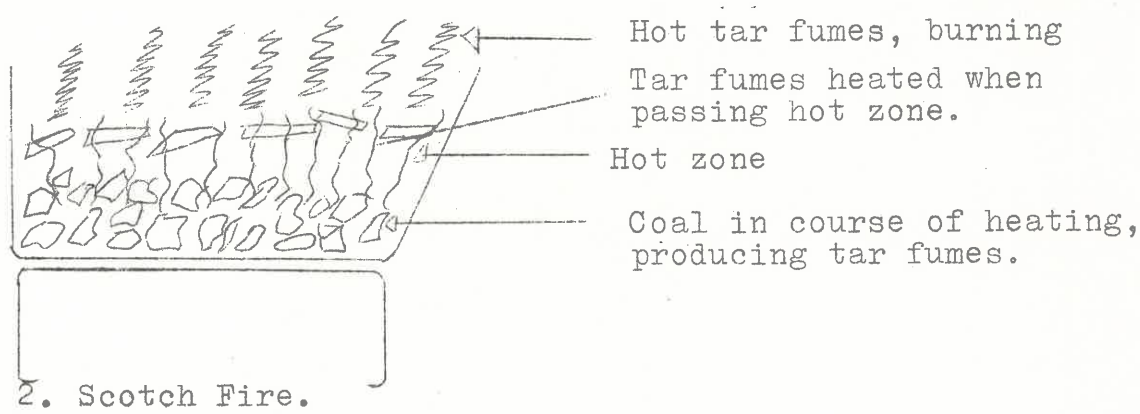
G.A.W. VAN DOORNUM
Chief of Division.

PRETORIA,
2nd June, 1965.

Fire Gas.

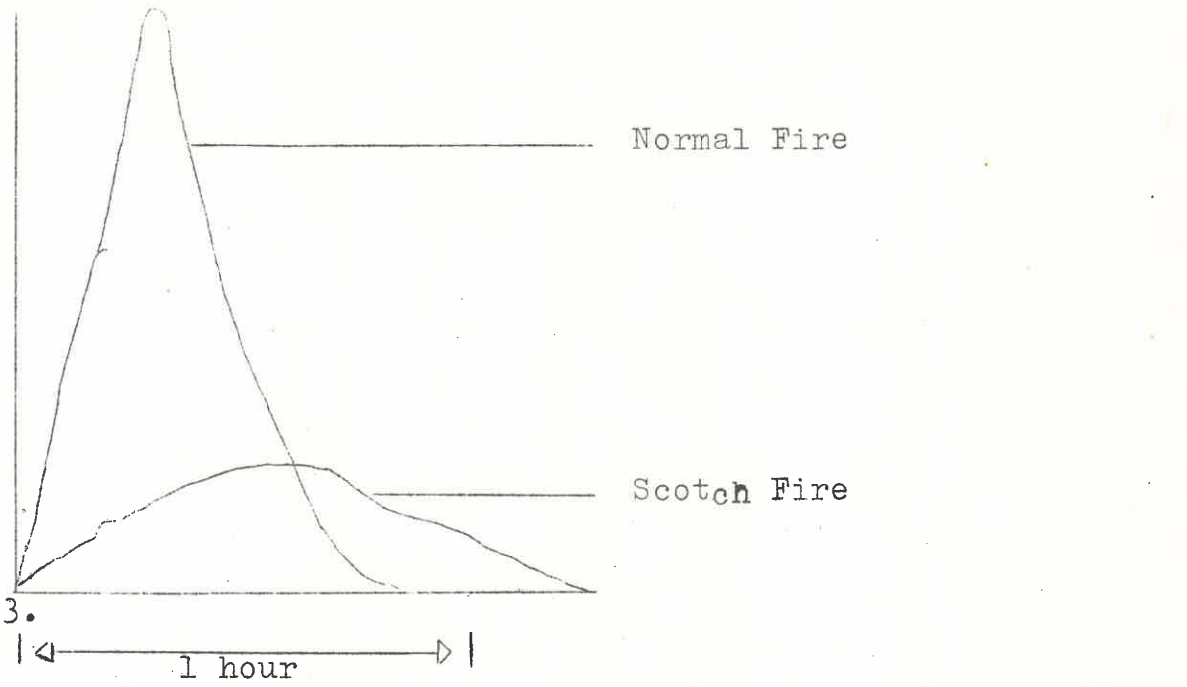


1. Normal fire.

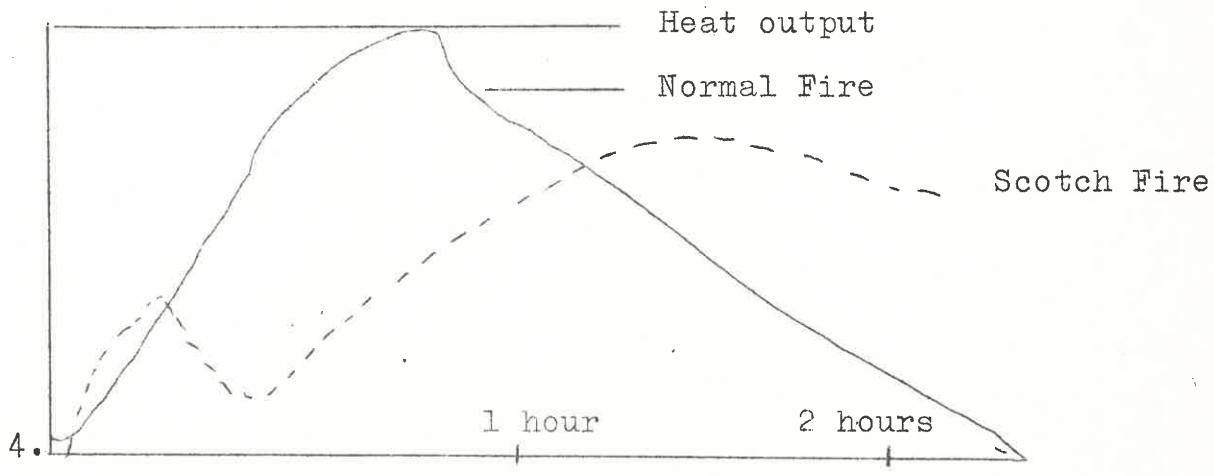


2. Scotch Fire.

Smoke production



3.



4.

AIR POLLUTION - THE OPEN-HEARTH FIRE

Introduction

Due to the importance of limiting the degree of air pollution, caused mostly by coal fires, it has become necessary to seek a practicable solution to the problem of smoke generation in open-hearth fires, where the combustion is uncontrolled.

Smoke Generation

The first hour after lighting an open fire is the period of potentially greatest smoke emission. As the introduction of a gas flame is a useful, but not a very practical, way of limiting the amount of smoke emitted, the paper and wood method of kindling a fire is the one commonly used in South Africa.

It has been found that smoke emission can be greatly reduced by simply arranging the wood, paper and coal in a specific manner before lighting the fire. An example of this method is the well-known "Scotch Fire". The object of this arrangement is the ignition of the smoke and volatile matter when they leave the fuel bed. Accordingly, a series of comparative tests for a standard fire and variations of the Scotch fire was conducted in the appliance testing section of the Fuel Research Institute of South Africa.

In these tests an open fireplace simulated the everyday household practice, but the test conditions were strictly controlled in order to obtain comparable results. The main object of these tests was to produce figures for smoke density and radiation intensity for the standard fire and variations of the Scotch fire.

Results

It was found that the most suitable coal for use in an open fire is a non-coking type of coal with a high volatile-matter content. The coal should be 1" to 2" in diameter, but it is essential that the coal should not be larger than 2" in diameter.

Five tests were conducted, the first test being of a standard open fire and the other four of variations of the Scotch fire. For test

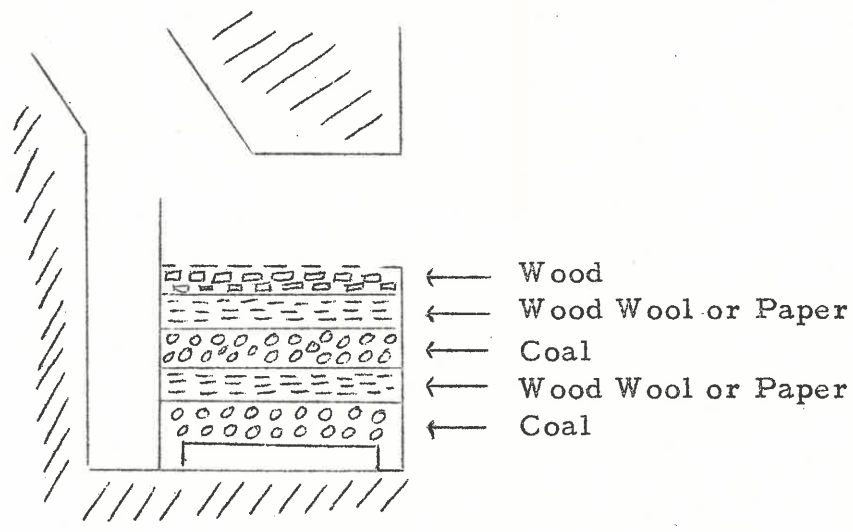
purposes/...

purposes, wood wool was used instead of paper. The placing of wood wool, wood and coal is given in the following table.

Test	Standard	Variation I	Variation II	Variation III	Variation IV
Top (i)				Wood	
Top (ii)			Coal	Wood Wool	Wood
Top (iii)	Coal	Wood	Wood	Coal	Coal
Middle	Wood	Wood Wool	Wood Wool	Wood Wool	Wood
Bottom	Wood Wool	Coal	Coal	Coal	Wood Wool

The wood wool, wood and coal are placed in the grate in the order denoted in each column.

Variation III may be described as a Scotch fire on top of a standard fire, the fuel being placed as follows:



Side View of Grate and Fuel.

The fire is always lighted as near the top of the fuel bed as possible. In the case of Variation III, the top layer of wood wool is lighted.

After the proper placing of the fuel components, the next important factor in limiting the amount of smoke generated is the

recharging/...

recharging of the fire. It is of the utmost importance not to "overload" the fire, i.e. placing too much coal on the grate at once.

Experimentally it was found that the most effective method of recharging is the half-hourly addition of a small quantity of coal after allowing approximately two to three hours for the burn-out of the initial charge. The fire should be poked gently from underneath the grate once an hour, just before adding the charge of green coal. Care must also be taken to avoid disturbing the top layer of burning coal.

Evaluation of the test results revealed that the method followed in Variation III was most effective in limiting the amount of smoke emitted. The initial period, before maximum radiation emission is reached, is approximately $2\frac{1}{2}$ hours, compared with about one hour for the standard fire. In order to obtain the same heat output at a specified time, therefore, it is necessary to start the Variation III fire approximately $1\frac{1}{2}$ hours earlier than the usual time of starting the standard fire. It is very important not to disturb the fire until after the peak heat-output has been reached.

The standard fire has the advantage over the Scotch fire of rapid heating-up, and the maximum heat output is soon obtained. This might, however, be a disadvantage in that the fire could be regarded as being uncomfortably hot. In the case of the Variation III fire the heating-up period is longer, but after a period of about $2\frac{1}{2}$ hours it will afford a much more "comfortable" heat.

We are faced with the difficult task of limiting the degree of air pollution in our country. It is, therefore, not unreasonable to expect general co-operation in trying to counter the generation of smoke from open fires. As it has been proved that the method of kindling described above provides a very definite curb on smoke generation, it is the responsibility of everybody involved in the practice of kindling an open fire to use this method in order to keep the air clean.

R.B. VAN HEERDEN
Assistant Technical Officer.

PRETORIA,
2nd June, 1965.
/OvR.

THE OPEN FIRE AND AIR POLLUTION

In the more densely populated areas of the world, air pollution has become a major problem. Not only is it decidedly unpleasant in various ways, but it is also detrimental to health. Indeed, in medical circles there is grave concern about the possible ill-effects of air pollution on the health of people exposed to it. In recent years the death rate due to lung cancer has shown a disquieting increase in England, and air pollution is suspected of being one of the major causes.

During the past two decades, air pollution has taken on alarming dimensions in South Africa. This is especially noticeable during the winter months, when black clouds of smoke can be seen hanging over the cities. The fact that these conditions are worse during winter than in summer can to a great extent be attributed to the popularity of the open-hearth fire as a heating device. As a result of South Africa's mild winter days the fire is seldom kept burning throughout the day and kindling the fire is a frequently recurring operation. Unfortunately, the kindling of the open-hearth fire causes the emission of great quantities of smoke. If the kindling of the fire could be achieved smokelessly, air pollution in domestic areas could be reduced considerably.

Lately the Fuel Research Institute of South Africa has done a good deal of research into the causes of air pollution and possible methods of combating it. Amongst others, the open-hearth fire was subjected to extensive scientific tests. Several interesting facts have come to light, some of which certainly deserve some attention.

The bituminous coal which is almost universally used in the open-hearth fire, releases a considerable amount of tar when heated. This tar can be seen to escape as a yellowish or brownish fume when the coal is heated. These vapours will burn easily when hot, but not when cold.

When a fire is laid in the usual way, that is with paper and wood on the grate and coal on top, the paper and wood ignite readily and start heating the overlying coal. This coal then releases tarry

vapours/...

vapours which move upwards through the cooler regions on top. Though there is sufficient oxygen available for combustion, the tar fumes are too cold to ignite. Combustion of these fumes only takes place when the coal bed and fire bank have become hot.

There is another method of kindling a fire, known as the Scotch fire. In the case of this fire the coal is charged onto the grate and the paper and wood placed on top. When the fire is ignited, the hot zone of the fire moves downward. Tar fumes which are released move upward through the hot zone and burn readily when they come into contact with sufficient oxygen. Although the Scotch fire takes longer to reach its maximum heat output ($2\frac{1}{2}$ hours to the one hour of the normal fire), it gives off more heat during its useful life than the normal fire. It also gives off a more even and comfortable heat than the normal fire and requires less recharging.

The need to reduce air pollution makes the use of the Scotch fire instead of the normal fire imperative. One has only to observe the damage done to the ducoed surfaces of cars, to the paint on walls, etc., by the fall-out of soot to realize the seriousness of the situation and the urgent need to reduce air pollution.

E. BURGER
Technical Assistant.

PRETORIA,
2nd June, 1965.

/OvR.