'WASTE-DERIVED FUELS' AND CEMENT KILNS

POST note 60 April 1995

British cement manufacturers are testing fuels derived from combustible wastes. Current trials raise questions over how they should be regulated, and concerns have been expressed in Parliament over the possible risks arising from the use of these fuels.

This note examines the technical aspects of burning waste-derived fuels in cement kilns and the issues raised.

POSTnotes are intended to give Members an overview of issues arising from science and technology. Members can obtain further details from the PARLIAMENTARY OFFICE OF SCIENCE AND TECHNOLOGY (extension 2840).

CEMENT PRODUCTION IN THE UK

There are currently 20 cement factories in the UK which produce between them some 15 million tonnes of cement each year. 90% of all cement sold in the UK is produced by Blue Circle Cement, Castle Cement and Rugby Cement which are the members of the British Cement Association (BCA). Cement is produced by mixing limestone or chalk with clay and fusing in a large rotary kiln (**Figure 1**). In order to form the cement clinker, the kilns have to operate at very high temperatures (usually around 1500° C), requiring high calorific value fuels. The fuel is burned in the combustion chamber, with a residence time of ~5 seconds and an excess of air. Combustion gases are then passed through air pollution control equipment before being vented through the stack. The cement clinker product is ground and mixed with gypsum to form cement.

TYPES OF FUEL USED

Cement manufacture requires large amounts of energy; with fuel and electricity representing 40-50% of running costs. There are thus potential savings from substituting traditional fuels (coal and petroleum coke) with cheaper fuels. One obvious source is combustible wastes, and "waste-derived fuels" (WDF) have been burned for a number of years in cement kilns in other countries (USA, Canada, Belgium, Germany, Sweden, Norway, Switzerland and France); in the UK, WDF is in use on a trial basis at all sites except Ribblesdale which is fully authorised (**Table 1**). The fuels originate from different solvent recovery processes and generally contain solvents, resins, pigments, polychlorinated biphenyls (PCB's), organohalogen compounds and heavy metals. A typical composition of one of the most common fuels (Cemfuel) is given in **Table 2**. WDF acts as a substitute for up to 50% of the traditional coal fuel, although complete substitution occurs in Belgium.

HOW WDF IS REGULATED

Her Majesty's Inspectorate of Pollution (HMIP) is responsible for licensing cement kilns in England and Wales (Her Majesty's Industrial Pollution Inspectorate - HMIPI - in Scotland) through the Integrated Pollution Control (IPC) regime under the Environmental Protection Act (EPA) 1990. HMIP and HMIPI have granted the companies in Table 1 temporary authorisations allowing them to burn WDF on a trial basis for a limited time (normally six months). These specify maximum allowable levels of key substances in the fuel, and the emissions testing and environmental monitoring to be carried out - e.g. for the combustion products. BCA members also operate a voluntary code of practice.

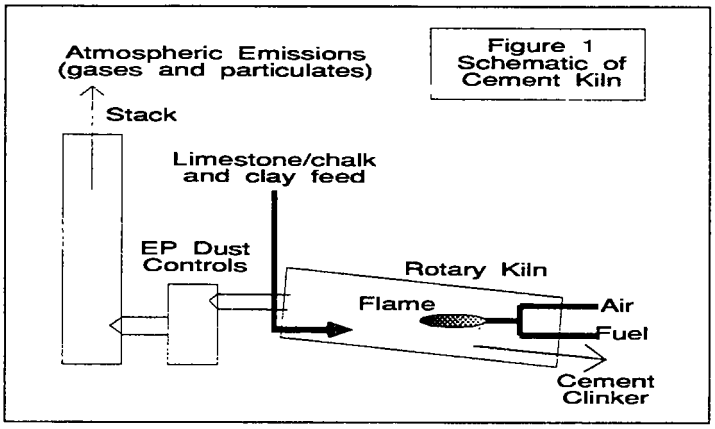

Figure 1 Schematic of Cement Kiln

Table 1 USERS OF WASTE FUELS

Company	Location	Fuel Type/Name	Subsititution
Castle Cement	Ribblesdale	Cemfuel	50%
	Ketton	Cemfuel	10%
Rugby Cement	Barrington	SLF	25%
	Southam	SLF	40%
Blue Circle	Cauldon	Tyre Chips	<35%
	Weardale	SLF	40%
	Dunbar	SLF	5%
Redland	Thrislington	solvent (<7.5% Cl)	<40%
(lime process)	Whitwell	SLF	25%

Source: HMIP

Table 2 TYPICAL COMPOSITION OF CEMFUEL

Solvents	50-60%
Solids	5-15%
Water	5-20%
PCBs	0-10 (max 50 mg/kg)
Chlorine	1-2%
Metals	50-2,000 mg/kg
Dioxins and Furans	not detectable

Source: BCA

ENVIRONMENTAL CONSIDERATIONS

The rationale for burning wastes in cement kilns is that their high temperature, long residence time and excess oxygen should lead to virtually complete combustion. The limestone or chalk should also help neutralise acidic products of combustion, incorporating them into

the clinker along with non-combustible contaminants such as heavy metals. Some dusts are formed in the process, requiring anti-pollution equipment on the stack. Electrostatic precipitators trap the majority of particulate materials - some is fed back into the cement process, while the rest is disposed of as waste to licensed landfill. Emission standards for particulates and other combustion products are summarised in **Table 3**.

HMIP requires the companies to carry out an Environmental Assessment (EA) and demonstrate that the risks involved in burning WDF will be no higher (and preferably lower) than from burning conventional fuel. To date, EAs have been undertaken for the Castle Cement plant at Ribblesdale and the Rugby Cement plant at Barrington. Results of monitoring at each plant with and without WDF are summarised in **Table 4**.

From these tests, it is apparent that:

- Wide variations are found in the results of tests at the same plant.
- Based on the **average** values in Table 4, there are significant differences **between** the plants. At Ribblesdale, acid gases when using WDF are hardly changed, whereas at Barrington, they are substantially reduced (both relative to coal alone). Particulate emissions are increased at Ribblesdale. For dioxins, although little changed at Ribblesdale, Barrington shows an increase (0.1 to 0.2 ngTEQ/m^3).

The overall conclusion drawn by AEA Technology at Ribblesdale was that using Cemfuel to replace up to 50% of the coal had *"no overall effect"* on emissions. At Barrington, HMIP concluded that *"there was no net adverse environmental impact from the earlier phase of trials, and that there was every indication that greater substitution might lead to greater environmental improvements."*

In view of the limited amount of information available from the trials to date and the variability at and between sites, firm conclusions on the general acceptability of the process cannot yet be drawn. However, the levels of dioxins emitted have led many to express concern on this aspect alone. Dioxins can be formed when any chlorine-containing substance is burned, and any incineration process carries with it the potential to form dioxins in both the stack gases and dust. The Royal Commission on Environmental Pollution (RCEP) reviewed the environmental risks of incineration in their 1993 report and concluded that, while some dioxins are known to be highly toxic, much uncertainty surrounds their sources, concentrations in the environment and the definition of a safe concentration. Overall, RCEP concluded that the current standard (1 ngTEQ/m^3) *"appears to be appropriate in the present state of knowledge"* and that the standard represented *"the limits of reliable detecion..."* The results from the trials indicate that dioxin concentrations in the stack gases are within this current standard.

Table 3 EMISSION STANDARDS FOR CEMENT KILNS AND HAZARDOUS WASTE INCINERATORS (mg/m^3 unless stated)

PARAMETER	CEMENT KILN	INCINERATOR Current and (1997) values	
Sulphur Oxides (as SO_2)	750	50	(50)
Nitrogen Oxides (as NO_2)	1200 -1800	350	(300)
Carbon Monoxide		50	(50)
Total Organic Carbon		20	(10)
Hydrogen chloride		20	(10)
Hydrogen fluoride		2	(1)
Dioxins (ng/TEQ/m^3)		1	(0.1)
Particulate mattter	50	20	(10)
Heavy metals		1.2	(1.2)

Source: HMIP

Table 4 TYPICAL RESULTS OF EMISSIONS TESTING (units mg/m^3 unless stated)

PARAMETER	Ribblesdale Coal	Ribblesdale Coal & 50% SLF	Barrington Coal	Barrington Coal & 25% SLF
SO_2	1300	1350	1860	1030
NO_x	1200	1200	970	720
Carbon Monoxide	being	reviewed	70	70
Total Organic Carbon	38	35	6	4
Hydrogen chloride	77	26	30	19
Hydrogen fluoride	0.2	0.2	1.8	1.5
Dioxins (ngTEQ/m3)	0.3	0.3	0.1	0.2
Particulate mattter	50	70	70	60
Heavy metals (total)	<0.4	<1.3	<0.3	<0.3

Source: HMIP

An alternative way of assessing the performance of cement kilns with WDF is to compare their emissions with the standards in place for hazardous waste incinerators (Table 3) which are more stringent. Such incinerators will have to meet a dioxin standard of 0.1 ngTEQ/m^3 from 1997 (if an accurate test method can be found) and there are questions over whether cement kilns would be likely to meet this standard.

The debate on dioxins has intensified following a recent draft report from the US Environmental Protection Agency suggesting that dioxins may be toxic at lower levels than previously thought. The UK Government has asked the Department of Health's Committee on Toxicology to review the health risks. Although the results of this review are not yet available, the Government has restated that current levels of dioxins do not pose health threats on the basis of current knowledge[1].

ISSUES

Is WDF a Waste or a Fuel?

One area of dispute is whether WDF is considered to be a waste or a fuel when used in cement kilns. The producers and users of WDF argue that it is a by-product of solvent recovery and manufactured to a quality specification; hence it should not be regarded as a waste. This is disputed by the incineration industry and some local authorities who do not regard simple blending of waste solvents and residues to represent 'recovery', and hence maintain that WDF should be classed as a waste. The Government's position is set out in DoE Circular 11/94 (WO 26/94, SO 10/94),

1. HC Official Report Written Answers, 25/1/95, Col. 213-4.

indicates that *"a substance which is waste, and is not fit for use in its present form or in the same way as any other raw material, may cease to be waste when it has been recovered"*, and thus sees WDF as a fuel rather than a waste.

The primary definitions of waste are, however, in a state of flux, due to the need to amend UK definitions to accord with the EC Framework Directive on Waste (91/156/EC) and many see the position as unclear. Some Waste Regulatory Authorities (WRA's) consider WDF to be a waste and others a fuel, and the Association of County Councils will petition Government to clarify the situation. Meanwhile, Cambridgeshire County Council has called for the authorisation for trials at Barrington to be revoked as it is claimed that the use of waste fuels *"currently falls outside any planning and waste regulations."* The council would like to see the Barrington site classed as an incinerator, and be subject to the appropriate waste controls and emission standards.

This issue is important as classification as a waste would subject WDF to the Waste Management Licensing Regulations and the Duty of Care Regulations that apply in the movement of hazardous wastes. The member companies of the BCA point out that they took legal advice before commencing trials with WDF and were advised that WDF does not fall within the definition of waste currently used; had it done so, they would have abided by any controls required.

The Government's interpretation classing WDF as fuel continues to be disputed by Friends of the Earth (FoE) and others. Recently, a formal complaint has been lodged over the use of WDF in the UK and the European Commission is investigating whether the UK Government is failing to observe European environmental law in not classing WDF as a waste.

Are There Any Extra Risks from WDF?

Concern has been expressed by environmental groups (such as FoE) and the commercial incinerator companies (such as Cleanaway) over the general principle of burning what are considered by some to be hazardous wastes, in a plant geared towards maximising cement production, rather than destruction of wastes. They question whether the design of cement kilns will ensure as complete combustion as in an incinerator specifically designed for that purpose - for instance, whether high temperatures are maintained throughout; whether turbulence in the kiln may give rise to pockets of incomplete combustion; and whether the level of excess oxygen is adequate. Concerns are also expressed that the planning factors favouring a site for a cement kiln (e.g. proximity to raw materials) are different from those for a waste incinerator.

HMIP recognises that cement kilns can be an efficient way of burning waste solvents, and BCA members argue that conditions in the kiln ensure that complete combustion is achieved. In addition, controls are applied (e.g. on the composition of WDF) to ensure that the quality of the cement product is not adversely affected by the use of WDF, while the inorganic content (i.e. heavy metals) of the fuel is almost wholly incorporated into the clinker.

On the solid residues, BCA argues that the vast majority of heavy metals in the dusts and clinker are derived from the raw materials, and the contribution from WDF is negligible, so cement and dust quality are not significantly affected. However, in the USA, environmental groups are putting pressure on cement users and retailers not to use cement produced from plants utilising WDF because of a perceived risk of contamination.

The trials to date show emissions of some parameters to be reduced, others to remain roughly the same, while others are increased. Moreover, the picture at the two sites is different. It will be necessary to await HMIP's evaluation of the results from all trials before an overall conclusion can be reached on the environmental effects of using WDF. HMIP has placed a moratorium on further expansion of the use of WDF in cement kilns until the results of the current trials have been evaluated, and until such time as it can be established that there are environmental benefits to be gained from this process over the use of traditional fuels.

As far as dioxin levels are concerned, HMIP considers that results to date (Table 4) do not suggest a consistent difference between fuel types, although this will be looked at further in future tests. However, an important policy consideration is whether to apply the emission standards of cement kilns (in which case emissions using WDF are likely to meet current standards), or to apply hazardous waste incinerator levels which are significantly stricter and may well be exceeded on the basis of current information. Current Government policy is that the emission standards applied at a particular plant should be a *pro rata* combination of cement kiln and hazardous waste incinerator standards. Moreover, the cement industry has stated that, should HMIP require the use of WDF to be regulated according to the EU Hazardous Waste Incineration Directive, the industry will apply the necessary controls.

A further consideration on the conduct of future tests is their reliability and how representative they are of normal operations. Here there is some dispute between FoE and Cleanaway on the one hand, and the kiln operators on the other over the validity of the trials, on the grounds either that operating conditions were not typical, or some results were spurious. It will be for HMIP to determine the acceptability of the results presented. Other points at issue concern the adequacy of monitoring around the plants. Models used in the EA predict that *"whether coal or WDF was used, a cement*

kiln would not contribute more than 2% of the tolerable daily intake of dioxins", and a MAFF study of dioxin levels in milk from farms near the Ribblesdale plant found no detectable effect, consistent with these models. Nevertheless, HMIP will continue to review monitoring of air, soils and water around the kilns.

Consistency with the National Waste Strategy

In terms of general policy on waste disposal, the Government has adopted the EU hierarchy of waste management options which makes waste reduction at source the preferred option, followed by reuse, materials recycling, incineration with energy recovery, incineration without energy recovery and finally, landfill. This hierarchy has been included in the DoE's recent consultation paper on the National Waste Strategy[2], and as such, HMIP seeks to eliminate wastes at source.

How does WDF measure up in the hierarchy? WDF is a mixture of materials of which, WDF suppliers argue, up to 60% cannot be recycled and would otherwise be landfilled or incinerated. When used, WDF reduces the need for primary fuel and should thus be equivalent in the hierarchy to incineration with energy recovery. The BCA argues, therefore, that the place of these materials in the hierarchy is enhanced.

Others disagree and claim that the demand for WDF could divert wastes from solvent recovery directly to the cement kilns, representing a shift downwards in the hierarchy, counter to the National Waste Strategy. The draft Waste Management Strategy for England and Wales, released by the DoE in January 1995 seeks to avoid this and states that "*solvents which could have been redistilled should not be burned in kilns.*" In line with this policy, one solvent recovery company (Croda Solvents) has recently opted not to supply waste fuels as it believes that solvents are being burned which could readily be recycled in normal distillation equipment. Waste producers such as Ciba Geigy also believe that disposal via cement kilns is incompatible with 'cradle-to-grave' responsibility for wastes, and have also decided not to allow such wastes to be blended in fuels, although other producers consider disposal via cement kilns to be acceptable.

Further concerns have been raised over the effect on the viability of commercial hazardous waste incinerators. There are currently three hazardous waste incinerators in the UK and these have utilised the components of WDF as high calorific value waste. Diversion of such high calorific value wastes to cement kilns not only reduces their market, but may also require their replacement by fossil fuels. This, it is argued, would negate any benefits from substituting coal by the cement industry, and merely transfer the high fuel costs to the incineration industry, thereby increasing incineration prices.

One recent study[3] has attempted to look at the overall economic effects of these trends. The report suggests that there will be a transfer of WDF from incinerators, co-disposal sites and solvent recovery businesses to cement manufacturers, with a consequential halving of the demand for incineration. In addition, the report indicates that marginal mixed solvents will no longer be sent for recovery, causing an increase in the price of certain products. This would indicate, therefore, that although benefits would accrue to the cement industry (thereby increasing their ability to compete in world markets), adverse effects would result to commercial incineration and solvent-recovery businesses.

Waste incinerator companies thus see Government policy defining WDF as a fuel as discrimination in favour of one industrial sector at the expense of another and not maintaining a 'level playing field'. The economics of the waste solvent industry are, however, highly dynamic and could change. To date, some cement companies have been paid to burn WDF by the blenders, but growing competition could lead to cement companies having to pay for the fuel. At the same time, rising prices for some solvents (such as methanol), are making recovery a more attractive option.

Whilst the use of WDF has been attracting much attention, the burning of shredded tyres, waste paper and other wastes as supplementary fuels in cement kilns and other industrial processes has been developing on a commercial scale in the UK and overseas in efforts to move these materials higher in the heirarchy. Moreover, the UK Government has suggested that, as the volumes of polychlorinated biphenyls (PCBs) available for disposal are likely to increase over the next few years, cement kilns could be used for disposal of these and other difficult waste materials provided that "*emissions are tightly monitored and controlled, so as to protect human health and the environment.*". BCA members have, however, chosen not to burn such wastes, nor to allow higher concentrations of PCBs in WDF.

Against this backdrop, it appears likely that cement companies may have increasing options to use alternative substitute fuels, and the issues currently being raised by WDF may thus have wider ramifications. In favour of current policy is the advantage of obtaining beneficial use from materials of low or negative value which could cause environmental damage if not disposed of properly. Against current policy is concern over the adequacy (or equity) of current environmental standards. More research may be needed before it is clear which approach represents the best practicable environmental option.

2 See POST Technical Report No. 58. Waste Recycling. March 1995.

3 Oakdene Hollins Ltd (1995). Recycled liquid effluents in cement kilns - a study of economic costs and benefits.

(B0354) Produced by the Vote Office on recycled paper