

Integrated Pollution Prevention and Control (IPPC)

Guidance for the Cement and Lime Sector



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AGENCY**

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Note:

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Executive summary

This guidance has been produced by the Environment Agency for England and Wales in collaboration with the Scottish Environment Protection Agency (SEPA) and the Northern Ireland Environment and Heritage Service (EHS). Together these are referred to as “the Regulator” in this document. Its publication follows consultation with industry, government departments and non-governmental organisations.

What is IPPC

Integrated Pollution Prevention and Control (IPPC) is a regulatory system that employs an integrated approach to control the environmental impacts of certain industrial activities. It involves determining the appropriate controls for industry to protect the environment through a single Permitting process. To gain a Permit, Operators will have to show that they have systematically developed proposals to apply the ‘Best Available Techniques’ (BAT) and meet certain other requirements, taking account of relevant local factors.

The Regulators intend to implement IPPC to:

- protect the environment as a whole;
- promote the use of “clean technology” to minimise waste at source;
- encourage innovation, by leaving significant responsibility for developing satisfactory solutions to environmental issues with industrial operators; and
- provide a “one-stop shop” for administering applications for Permits to operate.

Once a Permit has been issued, other parts of IPPC come into play. These include compliance monitoring, periodic Permit reviews, variation of Permit conditions and transfers of Permits between Operators. IPPC also provides for the restoration of industrial sites when the Permitted activities cease to operate.

This Guidance and the BREF

This UK Guidance for delivering the PPC (IPPC) Regulations in the Cement and Lime sector is based on the BAT Reference document BREF (see Ref. 1) produced by the European Commission. The BREF is the result of an exchange of information between member states and industry. The quality, comprehensiveness and usefulness of the BREF is acknowledged. This guidance is designed to complement the BREF and is cross-referenced to it throughout. It takes into account the information contained in the BREF and lays down the standards and expectations in the UK (England and Wales, Scotland and Northern Ireland) for the techniques and standards that need to be addressed to satisfy the Regulations. The reader is advised to have access to the BREF.

The aims of this Guidance are to:

The aims of this Guidance

- provide a clear structure and methodology which Operators making an application should follow to ensure that all aspects of the PPC Regulations (see Appendix 2 for equivalent legislation in Scotland and Northern Ireland) and other relevant Regulations have been addressed (see Section 1.2), and it should thereby assist the Operator to make a satisfactory application;
- minimise the effort by both Operator and Regulator in the Permitting of an installation by use of clear indicative standards and the use of material from previous applications and from accredited Environmental Management Systems (EMSs);
- improve the consistency of applications by ensuring that all relevant issues are addressed;
- increase the transparency of the Permitting process by having a structure in which the Operator’s response to each issue, and any departures from the standards, can be seen clearly;
- improve consistency of regulation across installations and sectors by facilitating the comparison of applications;
- provide a summary of the BAT techniques for pollution control from the BREF and UK experience which are relevant in the UK context expressed, where possible, as clear indicative standards and which need to be addressed by Applicants;
- provide an arrangement of information which allows the reader to find, quickly all of the guidance associated with:
 - a subject (e.g. accidents, energy or noise) (Sections 2.1 and 2.5 - 2.11);
 - the technical areas (e.g. cement processes or lime processes) (Sections 2.3 - 2.4);
- particular emissions (e.g. NO_x or pesticides) (Section 3).

Additionally, to assist Operators in making applications, separate, horizontal guidance is available on a range of topics such as waste minimisation, monitoring, calculating stack heights etc. The majority of this guidance is available free through the Environment Agency, SEPA or EHS (Northern Ireland) web sites (see References).

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1 INTRODUCTION

1.1 Understanding IPPC and BAT

IPPC and the Regulations

Integrated Pollution Prevention and Control (IPPC) is a regulatory system that employs an integrated approach to control the environmental impacts of certain industrial activities. It involves determining the appropriate controls for industry to protect the environment through a single Permitting process. To gain a Permit, Operators will have to show that they have systematically developed proposals to apply the 'Best Available Techniques' (BAT) and meet certain other requirements, taking account of relevant local factors.

The essence of BAT is that the selection of techniques to protect the environment should achieve an appropriate balance between realising environmental benefits and costs incurred by Operators.

IPPC operates under the Pollution Prevention and Control (England and Wales) Regulations, ([see Ref. 3 and Appendix 2](#)). These Regulations have been made under the Pollution Prevention and Control (PPC) Act 1999 and implement the EC Directive 96/61 on IPPC. Further information on the overall system of IPPC, together with Government policy and more detailed advice on the interpretation of the Regulations, can be found in the Department of the Environment, Transport and the Regions (DETR) document *IPPC: A Practical Guide*, ([see Ref. 4](#)).

Installation based, NOT national emission limits

The "BAT" approach of IPPC is different from regulatory approaches based on fixed national emission limits (except where General Binding Rules have been issued by the Secretary of State or equivalent). The legal instrument which ultimately defines BAT is the Permit and this can only be issued at the installation level.

Indicative BAT standards

Indicative BAT standards (essentially for BAT but also covering other aspects) are laid out in national guidance (such as this) and should be applied unless there is strong justification for another course of action. It should be noted that BAT includes both the technical components of the installation given in Section 2 and the benchmark levels identified in Section 3. Departures from those standards, in either direction, can be justified at the local level taking into account the technical characteristics of the installation concerned, its geographical location and the local environmental conditions. Notwithstanding this, if there are any applicable mandatory EU emission limits, they must be met, although BAT may go further than them.

BAT and EQSs

The "BAT" approach is also different from, but complementary to, regulatory approaches based on Environmental Quality Standards (EQS). Essentially BAT requires measures to be taken to **prevent** or, where this is not practicable, to reduce emissions. That is, if emissions can be reduced further, or prevented altogether, at reasonable cost, then this should be done **irrespective** of whether any environmental quality standards are already being met. It requires us not to consider the environment as a recipient of pollutants and waste, which can be filled up to a given level, but to do all that is practicable to minimise the impact of industrial activities. The process considers what can be reasonably achieved within the installation first (this is covered by Sections 2 and 3 of this Guidance) and only then checks to ensure that the local environmental conditions are secure, ([Section 4](#) of this Guidance and [Ref. 6](#)). The BAT approach is, in this respect, a more precautionary one, which may go beyond the requirements of Environmental Quality Standards.

Conversely, it is feasible that the application of what is BAT may lead to a situation in which an EQS is still threatened. The Regulations therefore allow for expenditure beyond BAT where necessary. However, this situation should arise very rarely assuming that the EQS is soundly based on an assessment of harm. The BAT assessment, which balances cost against benefit (or prevention of harm) should in most cases have come to the same conclusion about the expenditure which is appropriate to protect the environment.

Advice on the relationship of environmental quality standards and other standards and obligations is given in *IPPC: A Practical Guide*, ([see Ref. 4](#)) and in Section 3.

Assessing BAT at the sector level

The assessment of BAT takes place at a number of levels. At the European level, the EC issues a BAT reference document (BREF) for each sector. The BREF is the result of an **exchange of information** which member states should take into account when determining BAT, but which leaves flexibility to member states in its application. This UK Sector Guidance Note takes into account the information contained in the BREF and lays down the indicative standards and expectations in the UK. At this national level, techniques which are considered to be BAT should, first of all, represent an appropriate balance of costs and benefits for a typical, well-performing installation in that sector. Secondly, the techniques should normally be affordable without making the sector as a whole uncompetitive either on a European basis or worldwide.

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Assessing BAT at the installation level

When assessing the applicability of the sectoral, indicative BAT standards at the installation level departures may be justified in either direction as described above. The most appropriate technique may depend upon local factors and, where the answer is not self evident, a local assessment of the costs and benefits of the available options may be needed to establish the best option. Individual company profitability is **not** considered.

In summary, departures may be justified on the grounds of the technical characteristics of the installation concerned, its geographical location and the local environmental conditions but not on grounds of individual company profitability. Further information on this can be found in the Guide for Applicants, (see Refs. 4 and 5).

Costs may only be taken into account at the local level:

- where the BAT cost/benefit balance of an improvement only becomes favourable when the relevant item of plant is due for renewal/renovation anyway (e.g. BAT for the sector may be to change to a different design of furnace when a furnace comes up for rebuild). In effect, these are cases where BAT for the sector can be expressed in terms of local investment cycles.
- where a number of expensive improvements are needed, a phasing programme may be appropriate as long as it is not so long as to be seen as rewarding a poor performing installation, (see Ref. 6 for more details).

Innovation

The Regulators encourage the development and introduction of new and innovative techniques which meet the BAT criteria and are looking for continuous improvement in the overall environmental performance of the process as a part of progressive sustainable development. This Sector Guidance Note describes the appropriate indicative standards at the time of writing. However, Operators should keep up to date with the best available techniques relevant to the activity and this Note may not be cited in an attempt to delay the introduction of improved, available techniques. Furthermore, the technical characteristics of a particular installation may allow for opportunities not foreseen in the Guidance; as BAT is ultimately determined at the installation level (except in the case of GBRs) it is valid to consider these even where they go beyond the indicative standards.

New installations

The indicative requirements apply to both new and existing activities but it will be more difficult to justify departures from them in the case of new activities. For new installations the indicative requirements should normally be in place before the commencement of operations. In some cases, such as where the requirement is for an audit of ongoing operations this is not feasible and indicative upgrading timescales are given for such cases.

Existing installations - standards

For an existing activity a less strict proposal (or an extended timescale) may, for example, be acceptable where the activity operates to a standard that is very close to an indicative requirement, but using different plant or processes from that upon which the indicative requirement is based. In such a case it may impose a disproportionate cost to replace the old plant with the new techniques for only a small decrease in emissions.

Existing installations - timescales

The timescales for the major cost improvements for the control of NO_x, SO_x and particulate in this sector will depend upon local factors and the results of the cost benefit assessments. The timescales for such improvements should be to the approval of the Regulator.

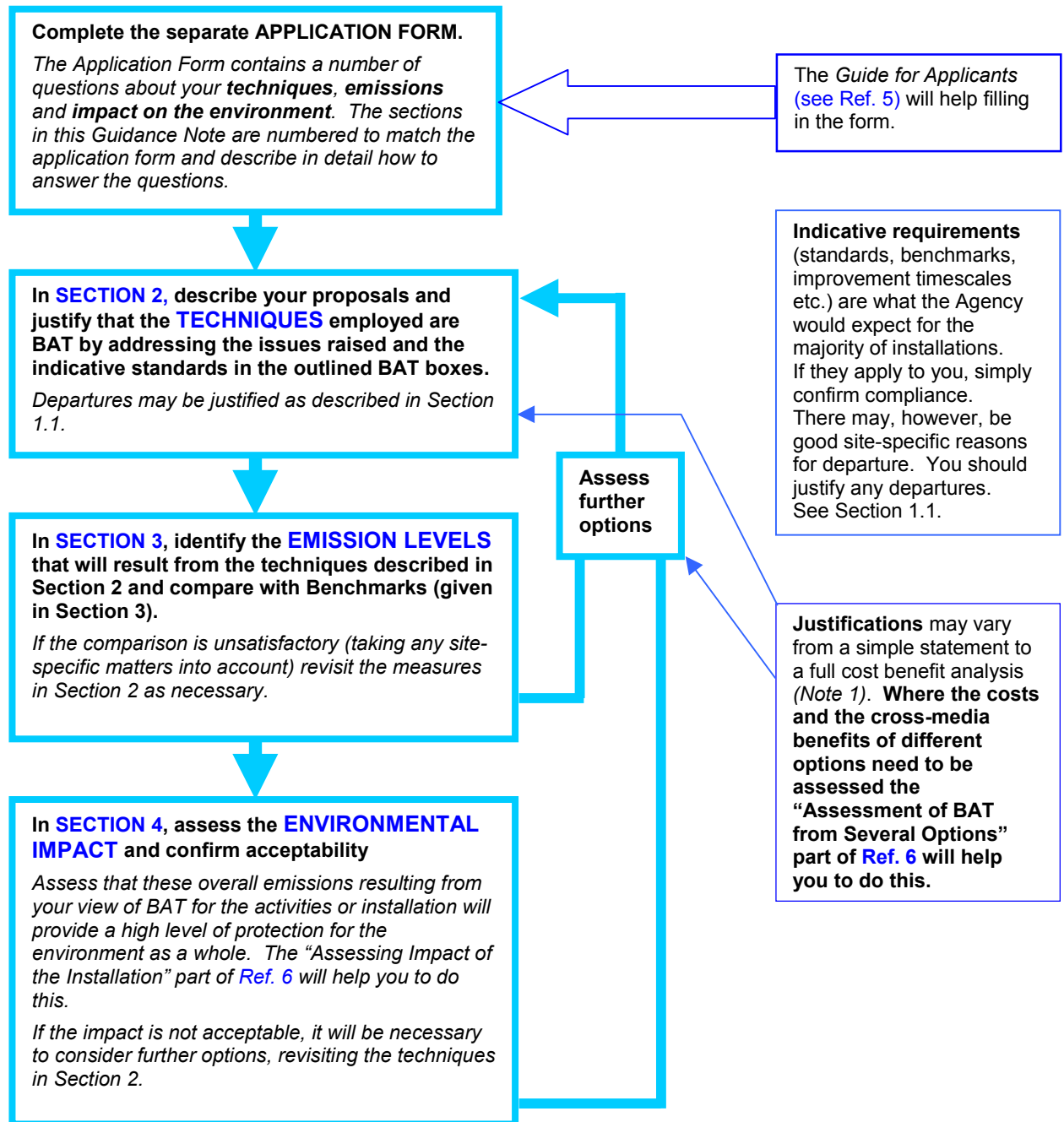
The whole programme of any other items should be completed at the latest within 3 years of the issue of the Permit. Any longer timescales will need to be justified by the Operator in accordance with the principles above.

All improvements should be carried out at the earliest opportunity and to a programme approved by the Regulator.

The Applicant should include a proposed timetable covering all improvements.

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1.2 Making an Application



- Note 1** The amount of detail needed to support the application should be sufficient to support the Applicant's contention that either the conditions of the guidance have been met or an alternative measure has been justified. The level of detail should be commensurate with the scale of the operation and its ability to cause pollution. An Applicant is not required to supply detail that could not reasonably be expected to contribute to a decision to issue a Permit.
- Note 2** **For existing IPC or Waste Management Permit holders**, your response to each point in Sections 2, 3 or 4 may rely heavily on your previous application. The Regulator does not wish you to duplicate information as long as the previous information adequately addresses the issues. However, the more the information can be reorganised to demonstrate that all the issues have been adequately addressed the better. You will need to send us copies of any information referred to.
- Note 3** The contents of the outlined BAT boxes in Sections 2, 3 and 4, and additional blank tables etc., are available electronically on the Environment Agency's Website, for the assistance of Applicants.

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1.3 Installations Covered

This Note covers installations, described in Part A (Part A(1) in England and Wales) of Schedule 1 to the PPC Regulations (see Ref. 3) as follows:

Production of Cement and Lime:

- a) *Producing or grinding cement clinker,*
- b) *Producing lime:*
 - (i) *in kilns or other furnaces with a production capacity exceeding 50 tonnes per day; or*
 - (ii) *where activity is likely to involve the heating in any 12 month period of 5,000 tonnes or more of calcium carbonate or magnesium carbonate or, in aggregate, both.*

The installation includes the main activities as stated above and associated activities which have a technical connection with the main activities and which may have an effect on emissions and pollution. They include, as appropriate:

- raw material storage and preparation (this may, under some circumstances, be included where it takes place at a quarry);
- raw material storage and preparation;
- fuel storage and preparation;
- kiln operation;
- slaked lime production;
- cement grinding and storage;
- product handling and storage;
- storage and despatch of finished products;
- the control and abatement systems for emissions to all media.

However, the impact of the activities on the environment may be wider than just the on site activities. The Note, and the regulations, cover issues downstream of the installation such as the final disposal of wastes and wastewaters.

Advice on the extent of the physical site which is contained within the installation, e.g. split sites, is given in *IPPC Part A(1) Installations: Guide for Applicants* (see Ref. 5). Operators are advised to discuss this issue with the Regulator prior to preparing their application.

Lime kilns, which are technically connected to other Schedule 1 activities such as sugar refining and soda ash production should be considered associated activities in Permit applications for the “**installation**”.

Where it is decided that associated activities are carried out in conjunction with the main activities and are not covered in this guidance note (for example combustion etc.), reference should be made to:

- other relevant IPPC Guidance Notes and,
- where appropriate, the Secretary of State’s Guidance for Local Authority Air Pollution Control. (NB In Northern Ireland this guidance is produced by the Department of the Environment)

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1.4 Review Periods

Permits can be reviewed or varied at any time. However, the PPC Regulations impose a requirement on Regulators to review Permits in certain specific circumstances such as where the pollution caused by the installation is of such significance that the existing emission limit values need to be revised or new limits set.

In addition, Regulators are required to review the conditions of Permits "periodically". The Government stated in its third consultation paper (England, Wales and Scotland) on the implementation of IPPC, that the new sector-specific IPPC Sector Guidance Notes would provide guidance on appropriate review periods for each sector. These would take into consideration guidance on the relevant criteria, to be provided by the Government. Examples of the likely relevant criteria for setting these review periods are "the risk and level of environmental impacts associated with the sector" and "the cost to the Regulators and regulated industry of undertaking the reviews".

The Regulators consider that at the present time, having regard to those criteria, it is in fact appropriate to set indicative minimum review periods which differ only between those sectors which have been subject to integrated Permitting (i.e. IPC or Waste Management Licensing) and those which have not. It is therefore proposed that Permit conditions should normally be reviewed on the following basis:

- for individual activities **NOT** previously subject to regulation under IPC or Waste Management Licensing, a review should normally be carried out within four years of the issue of the IPPC Permit;
- for individual activities previously subject to regulation under IPC or Waste Management Licensing, a review should normally be carried out within six years of the issue of the IPPC Permit.

This means that activities/installations not currently in IPC or Waste Management Licensing will be initially reviewed within four years and thereafter within six years.

An exception to this is where discharges of List I or List II substances have been permitted or where disposal or tipping for the purposes of disposal, of any matter which might lead to an indirect discharge of any substance on List I or II. In such cases the review must be carried out within four years.

This period will be kept under review and, if any of the above factors change significantly, may be shortened or extended.

This period will be kept under review and, if any of the above factors change significantly, may be shortened or extended.

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1.5 Key Issues for this Sector

The industry is a large user of raw materials and energy, with the potential for significant releases to air and land.

Raw Materials

Cement manufacture is a high volume process and correspondingly requires adequate quantities of raw materials, which are usually extracted locally. The industry has considerable potential to utilise a variety of waste streams as substitute raw materials.

Energy

Energy consumption is influenced by available raw materials and kiln technology. In order to reduce primary fuel costs, cement companies are actively developing the use of waste-derived alternative fuels which have the potential to make significant contributions to UK recovery targets for tyres, packaging wastes and CO₂ reductions. The scope for the lime sector to utilise waste derived fuels are in general limited by product quality constraints.

Climate Change Levy

The cement and lime industries have negotiated a programme of energy reductions with the DETR in return for a reduction in levy.

The applicability of techniques and basic energy standards for IPPC are explained in [Section 2.7](#).

Accident risk

On site storage facilities for materials such as LPG and SLF may qualify for regulation under the COMAH regulations.

Noise and vibration

Activities associated with noise and vibration pollution are:

- heavy machinery;
- air flow generated;
- transport systems.

Visual

Scale of operation, tall stacks and preheater towers, visible plumes and nuisance dusts.

Particulate Emissions

Stack emissions and fugitive releases are a priority for control.

Gaseous Emissions

Oxides of nitrogen and sulphur dioxide are often a priority for control.

Odour

Usually SO₂ is the most significant of odorous compounds in kiln exhaust gases, although in exceptional cases a significant contribution can be made from organic and nitrogen compounds depending on raw materials used. Likewise some alternative fuels have the potential for fugitive odour emissions during handling and storage.

Long distance and transboundary pollution

Cement and lime plants are unlikely to be of sufficient size to have significant transboundary effects.

Monitoring

Continuous and some limited spot monitoring, with representative sampling.

Solid waste

Production waste, e.g. cement kiln dust.

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1.6 Summary of Releases for this Sector

<p style="text-align: center;">SOURCE →</p> <p style="text-align: center;">RELEASES ↓</p>	Raw material preparation, handling and storage	Fuel preparation, handling and storage	Kiln	Cooler ^{Note 1}	Hydrator ^{Note 2}	Cement milling ^{Note 1}	Product handling and storage	Site drainage
Particulate matter	A W	A W	A L	A	A	A	A	
Oxides of sulphur			A					
Oxides of nitrogen			A					
Oxides of carbon			A					
VOCs		A	A					
Metals and their compounds			A L					
Halogens & their compounds			A L					
Dioxins & furans			A L					
Ammonia			A					
Suspended solids								W
PH								W

KEY A – Release to Air, W – Release to Water, L – Release to Land

Notes: 1 Cement processes only
2 Lime processes only

Releases to air usually result in a subsequent, indirect emission to land and can therefore affect human health, soil and terrestrial ecosystems

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1.7 Overview of the Activities in this Sector

Both the cement and lime industries use calcium carbonate as feed material and heat it in a kiln producing CO₂. They are both energy-intensive processes. The secondary processes associated with preparation of the feed and the treatment of the product are inherently dusty and generate large quantities of particulates. Stack emissions from kiln systems are similar; the principal pollutants are oxides of nitrogen, sulphur dioxide, oxides of carbon, and particulates,

The main difference in the two processes is that lime (CaO) is produced by simply heating calcium carbonate whereas cement manufacture takes the process further to produce clinker which is ground to form cement.

1.7.1 Cement process description

There are three broad categories of cement products: Portland cement, Portland cement with the addition of PFA or blast furnace slag and special cements. All but certain special cements are manufactured by using substantially the same process route, which is discussed in this Note. Portland cement, which is manufactured to British Standard BS12:1991, is defined as an active hydraulic binder based on ground clinker formed from a predetermined homogenous mixture of materials comprising lime (CaO), silica (SiO₂) and a small proportion of alumina (Al₂O₃) and generally iron oxide (Fe₂O₃).

A fundamental difference between cement manufacturing routes is whether the kiln process is wet or dry. However, all processes have the following stages in common:

- raw material procurement (from on site quarry or importing);
- raw material preparation (size reduction and blending to achieve a given homogenous chemical specification);
- fuel handling (fuel grinding if solid fuels are used);
- kiln processing (where raw materials are chemically reacted by the application of heat in a kiln system to produce clinker);
- cement milling (clinker size reduction with additional materials); and
- cement packing and dispatch.

A detailed description of the cement manufacturing activities can be found in [Section 2.3.2](#) and the BREF.

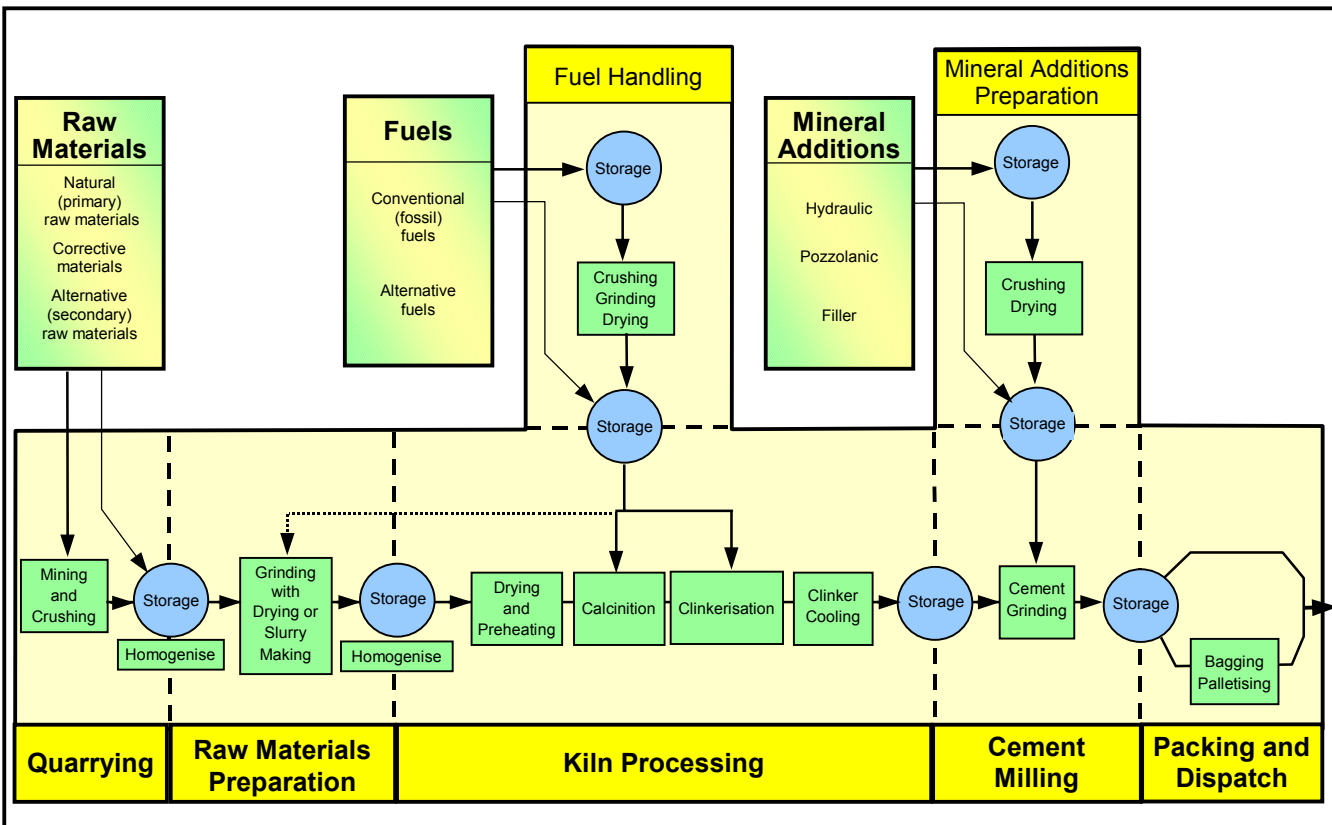


Figure 1-1 - Processes / Sub-Processes Identification and System Boundaries of Cement Production

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The major releases from the process are from the kiln system to air. However, significant releases of particulates can occur from all other parts of the process.

The primary raw materials used in cement manufacture are limestone/ chalk, marl and clay/ shales. These materials provide the essential calcium carbonate, silica, alumina and ferric oxide which, when burned, produce cement clinker that consists mainly of calcium silicates, aluminates and ferrites. The main clinker phases in Portland cement are:

Tri calcium silicate	$3 \text{ CaO} \times \text{SiO}_2$	C_3S	Alite
Di-calcium silicate	$2\text{CaO} \times \text{SiO}_2$	C_2S	Belite
Calcium aluminate	$3 \text{ CaO} \times \text{Al}_2\text{O}_3$	C_3A	Aluminate
Calcium ferrite	$4 \text{ CaO} \times \text{Al}_2\text{O}_3 \times \text{Fe}_2\text{O}_3$	C_4AF	Ferrite

Raw materials contain varying proportions of the required constituents as well as impurities and moisture levels peculiar to the specific location from which they are quarried. The raw materials, therefore, are carefully blended in proportions suitable for a given cement production site to produce cement with the desired properties.

Regardless of whether the process route is wet or dry, the heating of the raw materials follows certain stages:

- **drying and pre-heating** (20 - 900°C): release of free and chemically bound water;
- **calcination** (600 - 900°C): Initial reactions with formation of clinker materials and intermediate phases with the release of carbon dioxide;
- **sintering** (1250 -1450°C): in a liquid state, where the free lime reacts with the other components to form calcium silicates, aluminates and aluminoferrite (the principal ingredients of Portland cement). This sintered product is known as cement clinker and this process stage is also referred to as "burning" or "clinkering"; and
- **cooling** where the temperature of the liquid is reduced from 1450 to 1100°C to form stable crystals within the kiln followed by cooling to about 250°C in a clinker cooler.

Minor mineral constituents in cement clinker include uncombined calcium oxide (free lime) and magnesium oxide, as well as alkali sulphates. Additional chemical elements present in the raw materials such as manganese, phosphorus, titanium or heavy metals are mainly incorporated in the mineral structure of the major clinker phases.

Some elements in the raw materials such as alkalis, sulphur and chlorides are volatilised at the high temperatures in the kiln system resulting in a permanent internal cycle of vaporisation and condensation. A large part of these elements will remain in the kiln system and will finally leave the kiln with the clinker. A small part will be carried with the kiln exhaust gases and will be mainly precipitated with particulates in the dedusting system.

At a high surplus of volatile elements the installation of a pre-heater "bypass" may become necessary where part of the dust laden exhaust gases of the rotary kiln is extracted from the system. Kiln dust removed from the abatement system and by-pass dust can totally or partially be recycled to the cement manufacturing process.

A typical pre-heater kiln processing diagram is given in [Figure 1-2](#) showing the broad variation in chemical composition and temperature with time and position within the kiln system. The fate of materials such as sulphur and trace metals is not shown.

Dehydration and calcination are endothermic and clinkering is exothermic. However, cement manufacture is an energy intensive activity and the choice of fuels affects both the environmental releases and the economics of the process. Total energy cost can represent 65-75% of the variable costs of the process.

In order to retard the setting time of the final cement product, 3-8% gypsum (calcium sulphate) and other additives is ground with the cement clinker to form Portland cement.

The finished cement is stored in silos and can be sold in bulk or bagged forms. Finished cement is not usually stored on site for more than a few days but clinker can be stored in silos or covered buildings if longer-term storage is required.

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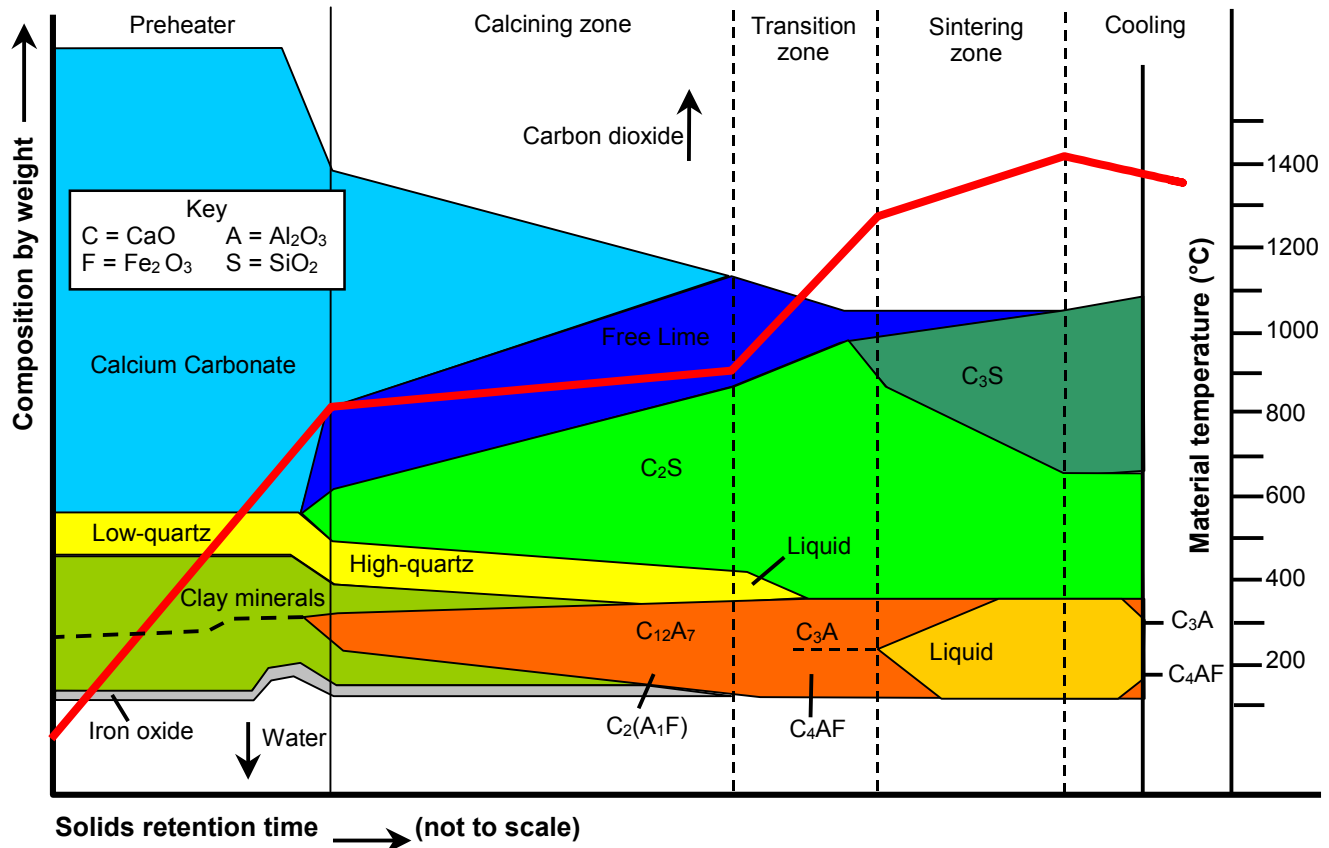


Figure 1-2 - Typical Pre-heater Kiln Processing System

1.7.2 Lime process description

There are two basic products from the UK lime industry: quicklime (CaO) and hydrated or slaked lime (Ca(OH)₂) and to a smaller extent, their magnesia (MgO) equivalents. In contrast to the cement industry, lime is used in a wide variety of different applications such as steel and non-ferrous metal production, liquid waste treatment, construction, flue gas desulphurisation, sugar refining, and agriculture. There are, therefore, various specifications for finished lime products dependent on the end use. For instance, some uses of hydrated lime may require low levels of impurities such as iron oxide, silica, magnesium oxide, fluoride and a specified surface area. Steel making processes using quicklime require limits on such things as calcium carbonate and sulphur contents.

Lime specifications are controlled by raw material/fuel selection and the type of kiln process used. Lime processes follow the following basic steps:

- limestone quarrying, usually from an on site quarry;
- limestone size reduction;
- fuel handling (grinding if solid fuels are used);
- kiln processing (where limestone is heated to produce quicklime and drive off CO₂);
- quicklime size reduction;
- packing and dispatch of exported quicklime;
- quicklime hydration; and
- packing and dispatch of hydrated lime.

Major releases are generally from the kiln to air. However, significant releases of particulates can occur from any part of the process, notably the hydrator.

The lime making process consists of the burning of calcium or magnesium carbonates at a temperature ranging between 900 to 1500°C, which is sufficiently high to liberate carbon dioxide, and to obtain the derived oxide. For some processes, significantly higher burning temperatures are necessary, for example dead-burnt dolomite.

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Calcium carbonate when heated produces 56% (by weight) calcium oxide and 44% carbon dioxide. Consequently, lime production produces a very large quantity of carbon dioxide.

Magnesium carbonate is processed in a similar way, the product being magnesia. Magnesium carbonate when heated produces 48% magnesia and 52% carbon dioxide. Dolomite and dolomitic limestone are mixtures of calcium carbonate and up to 44% magnesium carbonate, and are processed in a similar fashion to limestone.

High purity limestone (96-98% calcium carbonate) or dolomite is quarried, crushed and transported to the kiln. Within the kiln, carbon dioxide is liberated by the application of heat and exhausted to atmosphere. The calcium oxide product is transported from the kiln to silo storage. From the silo, the burnt lime is either taken to the end user for use in the form of quicklime, or it is transferred to a hydrating plant where it is reacted with water to produce hydrated or slaked lime.

Some kilns are located with other process plant. For instance, both quicklime and CO₂ released during kiln processing are used in sugar refining.

The lime kiln process therefore differs from the cement process in that the only raw material used is limestone or dolomite and only drying and calcination occurs within the kiln system. Wet processing is not used in the UK lime industry.

A detailed description of the lime manufacturing activities can be found in [Section 2.3.3](#) and the BREF.

1.7.3 Releases from cement and lime kiln systems

Kiln releases

The main releases from the production of cement are to air from the kiln exhaust gases, the clinker cooler exhaust and any bypass gases. There may also be significant release of kiln dust to land depending on the alkali content of the raw materials used. Polluting releases result from the particular chemical composition of the raw materials and fuels used. Similar releases can occur from lime production.

The production of cement clinker in kiln systems is characterised by cycles of components such as dust, chlorides, sulphur compounds and alkalis. These cycles may be internal to the system or partially induced by the recycling of kiln dust back into the system from abatement equipment. These cycles have a large effect on the inherent releases from any kiln processing system. The cycles result from the variation in the capacity of the material within the kiln system to absorb or release substances. The absorptive capacity of material varies with its physical and chemical state, which in turn depends on its position within the kiln system. For instance, material leaving the calcination stage of the kiln process has a high free lime content and therefore has a high absorptive capacity for acid species such as SO₂. However, when this same material passes to the sintering stage some of the absorbed sulphur will be released back to the gas phase. This variation, combined with the counter current nature of the air and solids flow through the system, results in the capture into the clinker of many of the pollutants that would otherwise potentially be released to air.

Lime kilns are similar to cement kilns in that pollutants are captured by the lime product and tend to leave with this stream but, as there is no sintering zone, the opportunity of internal kiln cycles is limited. The counter current air flow will tend to release any volatile impurities contained in the raw material limestone into the exit kiln gases but with the generally large feed sizes compared with cement production, this effect will be smaller.

The type of kiln processing system also has a marked effect on the magnitude of releases to air. The pre-heater section on a dry cement kiln is a very efficient absorber of volatile or acid species such as sulphur oxides. This is due to the high gas-solid contact with the raw meal within the cyclone array, which acts as a dry scrubbing system.

The wet end (back end) of a wet cement kiln also acts as a pollutant absorber but it is not so efficient as a pre-heater kiln. Wet cement kilns also tend to release greater masses of some pollutants per tonne of clinker production compared with dry kilns due to their increased fuel requirements and larger gas flows.

Kiln dust, alkalis and kiln bypasses

In the cement industry levels of alkalis, sulphur and chlorides (volatile components) in the product clinker are controlled to achieve the required quality of the product cement. UK construction contracts often impose an alkali specification of 3 kg/m³ of concrete because of the risk of alkali-aggregate reactions and thus the alkali content of the cement is limited. Volatile components can also be a problem in the kiln system, as high levels can cause blockages in pre-heater cyclones or form rings in the in the rotary kiln inlet zone.

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The cement industry has several options to control clinker alkali content. The careful control of the alkali content of raw materials can be used but the practicality of this depends on the availability of low alkali raw materials.

In wet cement kilns, some of the volatile components evaporate in the sintering section but condense in the drying zone on the fine particulate matter. Hence, if an EP is used for arrestment, the finer proportion of the cement kiln dust (CKD) containing the highest concentration of volatile components can be removed whilst the remaining dust is recycled (by selecting the correct fields in the EP). The recycle can be achieved by introducing CKD into the rotary kiln by using specially designed scoops in the cylindrical walls of the kiln or, more frequently by injecting CKD into the burning zone of the kiln (insufflation). In dry process kilns, CKD is often blended into the raw feed for reintroduction or part of it is fed directly to the cement mill. Typically an EP collects the equivalent of 10% of clinker production.

The inherent absorption capacity of pre-heater dry cement kilns can cause problems with blockages in the cyclone systems caused mainly by build-ups of volatile components. One option to curtail volatile component levels is by bypassing part of the particulate laden gas stream out of the kiln back end away from the cyclone system and condensing the volatiles by cooling. Bypasses of up to 100% of the kiln gas flow may be necessary although this level would be extreme with 30% being more typical. This bypass stream can be high in pollutants (particulates and sulphur oxides) and must be separately treated (see below). The particulates removed from the bypass stream are high in volatile components.

Both kiln dust and bypass dust can be completely returned to process providing clinker alkali levels are controlled. When this is not possible dust is sent to controlled landfills or sold as binder for waste stabilisation.

In the lime industry, material collected in the kiln particulate abatement equipment is high in CaCO_3 but also contains ash (depending on fuel type) and quicklime. The composition and fine nature of this material makes it unsuitable for direct recycle.

Nitrogen oxides

There are two principal mechanisms acting in any combustion process to form NO_x : the oxidation of molecular nitrogen in the combustion air (known as thermal NO_x) and the oxidation of nitrogen compounds in the fuel (fuel NO_x).

In the production of cement and lime, thermal NO_x is a significant formation route.

Thermal NO_x formation is strongly dependent on the combustion temperature, with a marked increase in formation above 1400°C.

In cement production, as the flame temperature in a kiln is around 2000°C, it is in the sintering zone where most of the thermal NO_x is formed. In the calcination stage, temperatures are 800-900°C, which is not high enough to form significant thermal NO_x compared with fuel NO_x . As in pre-calciner kilns up to 60% of the fuel is burnt in the calciner stage, the amount of NO_x produced is less than in wet process kilns, where all the fuel is burnt in the sintering zone. However, some studies have shown that in comparing pre-calciner and pre-heater dry kilns, the reduction in thermal NO_x generation can be offset by an increase in fuel NO_x production in pre-calciners.

In lime kilns, flame temperatures can be less than in cement production and so the contribution of thermal NO_x can be lower.

NO_x formation is also dependent on the amount of excess air present in the flame, with higher oxygen contents enhancing formation. However, a notable exception is the production of dead burnt lime.

Different raw material characteristics can influence the amount of NO_x produced. For instance, some limestones require far less burning than others to produce cement clinker and consequently less thermal and fuel NO_x are produced per tonne of clinker made. In the production of dead burned dolomite, higher kiln temperatures are required thus producing higher levels of NO_x .

In addition, some raw materials contain chemically bound nitrogen, which can convert to NO_x at temperatures between 300-800°C. However, this source of NO_x is usually insignificant for cement and lime processes.

Sulphur oxides

The release of sulphur oxides from cement and lime production can occur from the kiln exhaust. The release is mainly in the form of SO_2 (99%) although some SO_3 is produced and, under reducing conditions, H_2S could be evolved.

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Sulphur oxides arise due to the sulphur content of the fuel and raw materials. Raw materials, such as limestone, can contain sulphur in the form of sulphates (e.g. calcium sulphate), sulphides (e.g. pyrites) and organic compounds.

The proportion of sulphur released from cement kilns depends on the balance between the absorption and release of SO₂ at various stages of the process. The mechanisms of sulphur release are not yet fully understood and the figures given in the discussion below are indicative of some kilns but there are exceptions. For instance, although it is generally accepted that dry process kilns are better at absorbing SO₂ than wet kilns, some wet kilns are particularly good absorbers giving sulphur retention in excess of 90%. The absorption capacity of a kiln varies with chemistry, alkali, sulphate and chloride balance, temperature, oxygen content and kiln design.

Chemical reactions with SO₂

$\text{Na}_2\text{O} + \text{SO}_2 + \frac{1}{2} \text{O}_2 = \text{Na}_2\text{SO}_4$
$\text{K}_2\text{O} + \text{SO}_2 + \frac{1}{2} \text{O}_2 = \text{K}_2\text{SO}_4$
$\text{CaO} + \text{SO}_2 = \text{CaSO}_3$
$\text{CaCO}_3 + \text{SO}_2 = \text{CaSO}_3 + \text{CO}_2$
$\text{CaSO}_3 + \frac{1}{2} \text{O}_2 = \text{CaSO}_4$

Figure 1.3 gives an indication of the sulphur cycle for wet cement kiln system. Between 30 and 80% of the sulphates entering the kiln sintering zone may decompose and form SO₂, the exact amount being dependent on raw materials and kiln combustion conditions. Absorption of SO₂ can then occur in the dust cloud within the kiln and the wet absorbing conditions in the chained zone towards the back end of the kiln as the kiln gases pass through the calcination and drying zones. However, due to the generally less effective contact between the kiln gases and the raw material, compared with a dry pre-heater kiln, more of the total sulphur may escape the absorption zone. Releases of SO₂ will also occur from the raw material sulphide content (and also organic sulphur compounds) being burned in the drying/heating zones, temperatures between 400-600°C. At these temperatures, not enough calcium oxide is available to react with the SO₂. It is estimated that up to 30% of the total sulphur entering a wet kiln system could be emitted as SO₂ in the kiln exhaust gases, the remainder being absorbed in the clinker and CKD. Of this release, up to 50% may be due to the sulphur content of the fuel assuming that low sulphur raw materials are used, although the contribution from raw material is often dominant.

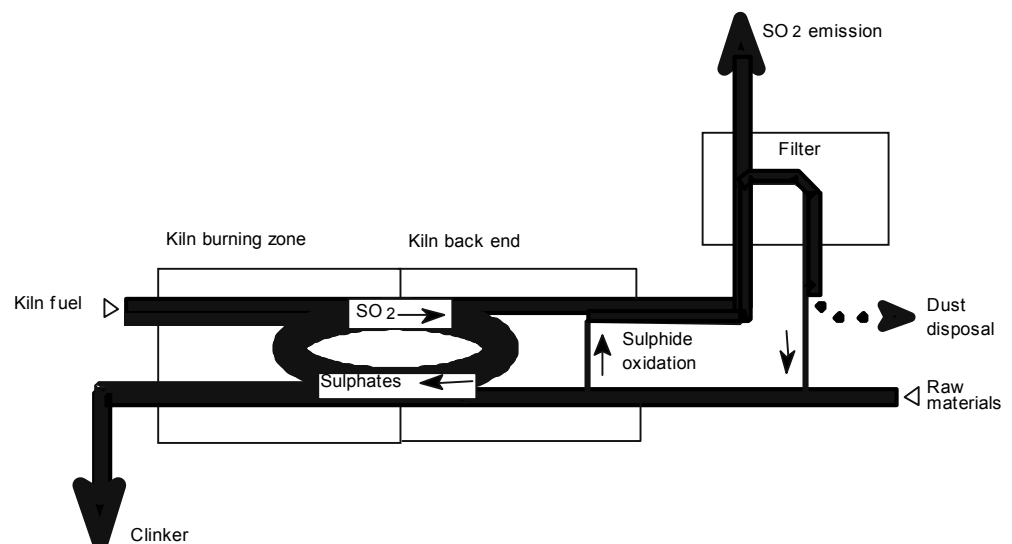


Figure 1-3 - Sulphur Cycle for Wet Cement System

In dry preheater kilns about 30% of the total sulphide input may leave the pre-heater section as SO₂. During direct operation, i.e. when the raw mill is off, most of it is emitted to atmosphere. During compound operation, i.e. with the raw mill on-line, additional SO₂ (up to 90%) is adsorbed by the freshly ground raw meal particles in the raw mill.

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In grate pre-heater kilns SO₂ absorption is good because the gas is passing through the turbulent flow of material from grate to kiln and then passing at low velocities firstly through the bed of materials which is partly calcined and then through the moist calcium carbonate in the drying chamber.

Pre-calciner systems provide more intimate contact between calcined materials (higher free lime content) and the kiln exit gases and therefore a greater proportion of SO₂ can be absorbed than in pre-heater kilns. However, it should be noted that pre-heater or calciner kilns fitted with bypasses can lead to significant release of SO₂ unless the bypass stream is abated. The bypass gases do not pass through the pre-heater cyclones and therefore the SO₂ absorption in this section is lost.

In long dry kilns the chemical absorption capacity for SO₂ is generally less efficient than dry pre-heater kilns due to the reduced contact between kiln exhaust gas and raw materials.

In lime production, in most circumstances, only a small fraction of the sulphur dioxide generated within the kiln (whether originating from the raw materials or from the fuel) is released to atmosphere, since it is mainly incorporated into the lime by chemical combination.

Fluidised bed kilns are particularly efficient at absorbing SO₂ due to the high contact between gas and solid streams. However, it is possible to operate rotary lime kilns without bypasses to reduce absorption of sulphur into the quicklime product leading to higher SO₂ levels in kiln gases.

Figure 1-4 shows the sulphur cycle in a pre-heater or pre-calcinator kiln.

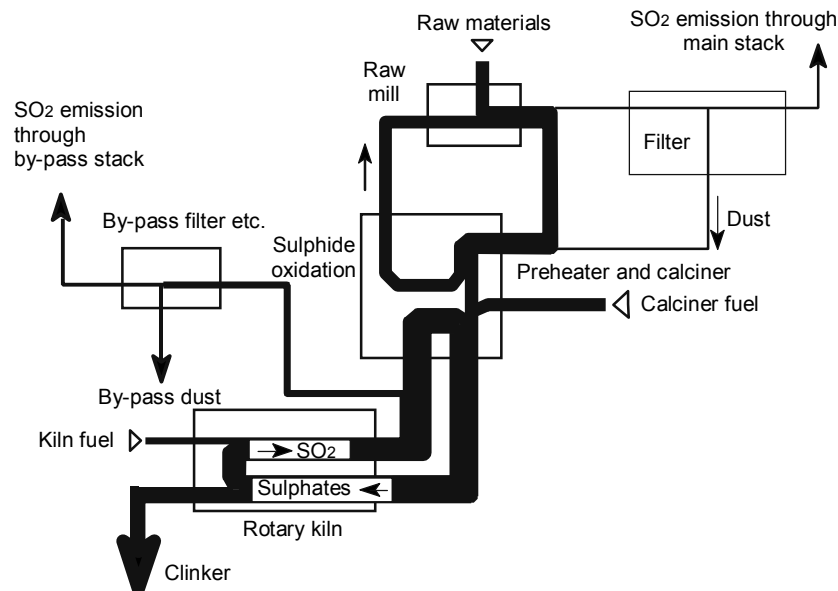


Figure 1-4 - Sulphur Cycle in a Pre-Heater or Pre-Calcinator Kiln

Particulates

Due to the fineness of the raw materials used in the cement kilns, the generation of particulates is inevitable and they will pass to atmosphere in the kiln exhaust gases unless abatement techniques are used. Cement clinker cooler exhausts are also a source of particulate releases.

The cooling of clinker to a temperature suited for conveying and milling requires a greater volume of air than is needed for combustion in an efficient kiln system.

With grate coolers, after the maximum recovery of heat for preheating, pre-calcining and drying of materials and coal, the surplus air from the outlet (cool) end is vented to air via dust arrestment equipment, which must be capable of withstanding wide variations in air flow and temperature (flushes) arising from surges of material in the kiln.

The facility to use excess air does not exist with planetary coolers, which may have difficulty in achieving satisfactory clinker temperatures without using external or internal water spray systems. As cooling air is drawn through planetary coolers to the kiln by an induced draught fan, the possibility of dust emissions is greatly reduced. Rotary coolers also use internal water sprays but this practice adversely affects thermal efficiency.

When operating rotary kilns it is possible to build up rings of material around the circumference of the kiln. Break up of these rings ("ring fall") can produce surges of particulates, which can cause problems for abatement equipment.

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Lime processes produce dust from attrition within the kiln system and from fuel ash. However, the level of dust produced in shaft kilns is inherently lower than for rotary kilns. The hydration process also produces a particulate stream which, being wet, can be particularly difficult to abate.

The dust produced in lime kilns tends to be less dense than from cement production and in general more difficult to abate.

Particulates are also generated by all other process operations. Low level dust emissions, for instance, from material handling, can be more significant than dust releases from the kilns and hydrator operations.

Other releases

Organic compounds

Evidence from measurements made by the cement industry suggests that the release of organic compounds from kiln systems is mainly due to small amounts of organic materials contained in the raw materials rather than due to the fuel. This is because the conditions within typical kilns (temperatures greater than 1400°C and residence times of more than three seconds) should efficiently destroy fuel organics, but, as with sulphur, any volatile organic content in the raw materials can be released into the kiln's exhaust gases without being exposed to high temperatures.

Dioxins can be formed in any combustion system provided that chlorine and organic compounds are available. The combustion conditions within kilns should help to ensure that the any dioxins are effectively destroyed. However, heterogeneous catalytic formation (“*de novo* synthesis”) at temperatures of 200-450°C is possible. This can occur due to the reaction of chlorine with any evaporated organics from the raw materials, as the kiln gases cool.

Research has indicated that trace amounts of chlorinated aromatic compounds can also be formed in the pre-heater section of dry cement kilns.

Oxides of carbon and CO trips

Carbon dioxide is inevitably produced by the kiln process from the calcination stage and from the burning of fuel.

Carbon monoxide can arise due to the incomplete combustion of fuel and from any organic carbon content of the raw materials. The contribution from the raw materials, due to preheating, will be exhausted with the kiln gases, again similarly to sulphur.

It should be noted that carbon monoxide contributions from raw materials in cement production can be very significant compared with that from combustion.

Control of CO levels is critical in cement and lime kilns when EPs are used for particulate abatement, to ensure concentrations are kept well below the lower explosive limit. If the level of CO in the EP rises (typically to 0.5% by volume) then the electrical system is tripped to eliminate the risk of explosion. This leads to unabated particulate releases from the kiln, which can cause considerable local dust nuisance. CO trips can be caused by unsteady state operation of the combustion system often caused when feeding solid fuels. Solid fuel feeding systems must be designed to prevent surges of fuel into the burner. The moisture content of solids fuels is a particularly critical factor in this respect and must be carefully controlled to prevent hold ups or blockages in the fuel preparation and feeding systems.

Metals and chlorine

Metals released from the kiln system arise from quantities contained in the raw materials and fuel.

The release of metals is characterised by cycles within the kiln system and their volatility. Metals (and compounds of the those metals) fall into three classes:

- refractory (relatively non-volatile), including barium, beryllium, chromium, arsenic, nickel, vanadium, aluminium, titanium, calcium, iron, manganese and copper;
- semi volatile, such as antimony, cadmium, lead, selenium, zinc, potassium and sodium; and
- volatile, such as mercury and thallium.

Metals are released from the kiln system absorbed into the clinker or quicklime, in the kiln exhaust gases or in CKD/lime dust. The high alkali content and the scrubbing action within kilns favours retention of metals within the clinker/quicklime. Measurements on cement kilns indicate that <0.1% of refractory metals and <0.5% of semi volatile metal compounds entering the kiln are released in the kiln exhaust gases. However, semi volatile metals tend to condense on the CKD and in some cases concentrations can be many times greater than in the clinker. Volatile metals partially remain in the kiln exit gases.

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Metal chlorides tend to be more volatile than the elemental form. In cement production chlorine tends to leave the kiln in the form of alkali salts in the CKD. The cement industry can therefore encourage the formation of alkali metal chlorides to reduce the residual levels of alkalis in the clinker.

Ammonia

There are a few cement sites throughout the world where ammonia or ammonium salts are contained in the raw materials fed to the kiln. The ammonia can react with chlorides and perhaps sulphates to form ammonium salts, which leave the kiln with the exhaust gases. On cooling downstream of the kiln or in the atmosphere, dense fume of condensed ammonium salts can form resulting in a visible plume. There is currently only one cement site in the UK where this is apparent.

Ammonia emissions can also occur when selective non-catalytic reduction (SNCR) is used to abate NOx emissions. SNCR usually involves the injection of ammonia into the kiln exhaust gas to reduce NO to nitrogen. Careful control is required to minimise the potential for unconverted ammonia to be emitted (NH₃ slippage).

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1.8 Economic Aspects for this Sector

1.8.1 Cement sector information

The UK cement industry operates in a highly competitive and increasingly globalised market where there is potential to replace UK production with imports. A long-term fall in prices has been accommodated in part by the industry through significant improvements in production and distribution efficiency. Prices, however, have hardened and are forecast to increase.

The main companies operating in the UK, are Blue Circle, Castle Cement and Rugby Cement. The recent activity in acquisitions/take-over bids is indicative of the sector **restructuring** in response to market conditions and is expected to lead to an acceleration of plant modernisation and capacity upgrades which together with further economies of scale will result in **lower production costs**.

UK cement company group profitability is lower than their European peers on most criteria. Cement product profitability, however, is higher than group profitability as a whole.

Cement holding company liquidity is strong and because of their strength and size, they are able to command competitive rates when borrowing funds.

The cost of capital in this sector should be relatively competitive and discount rates for expenditure on environmental improvements would be expected to be between 6% and 10%.

Restructuring

In general conventional wet kilns are being replaced. Since the last sector review (Aug 1996) there have been a number of major changes:

Blue Circle (recently taken over by Lafarge but subject to UK approval) closed its Plymstock (dry) and Masons (wet) works in 1999, and is currently awaiting a Planning Inquiry decision on a proposed replacement for the Northfleet plant (semi-wet) at Holborough.

Castle Cement (now owned by Heidelberg) are planning to build a new dry kiln at Padeswood and this will replace the existing kiln.

Rugby Cement (now owned by RMC) has concentrated its production on the new Rugby works, (commissioned March 2000). This development has resulted in the closure of kilns at Chinnor (wet), old Rugby (wet), Southam (semi-wet) and Rochester (semi-wet). Rugby Cement production will be concentrated at just three works, new Rugby (semi-wet with calciner), South Ferriby (semi-dry) and Barrington (wet).

Buxton Lime Industries (owned by Anglo American) is planning to install a new cement kiln at Tunstead to replace the existing kiln.

[Appendix 3](#) details current cement clinker capacity in the UK.

Reducing Production Costs

The sector has considerable potential to utilise waste streams as a substitute for both raw materials and fossil fuels. Blue Circle, for example, whose last accounts showed less than 3% usage of alternative fuels, has recently signed a joint venture with Michelin to use up to half the tyres scrapped in the UK each year, leading to savings of £6million per annum.

The effect of competition to reduce costs combined with the implementation of the Landfill Directive, Climate Change Levy and Landfill Tax has encouraged the sector to actively pursue the recovery of wastes.

The Landfill Directive and Landfill Tax are discouraging landfilling, making it more expensive and encouraging waste producers to look for alternative disposal methods. The landfill tax is based on the weight of material to be deposited. The tax rate for active waste is £11 per tonne (from 1 April 2000; this will increase by £1 per tonne per year to April 1 2004). Inert wastes are taxed at £2 per tonne. Landfill tax in the UK is low in comparison with the rest of Europe. After 2004, it is likely that levels of tax will increase substantially in order to harmonise with the rest of the European Union.

Cement manufacturers have agreed with Government an energy reduction programme, which qualifies for an 80% rebate on the Climate Change Levy.

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Conclusion

Cement manufacturing is a capital-intensive industry and there are obvious economic constraints on existing plants adopting techniques that are considered BAT for new plant. Nevertheless, there are many techniques given in Section 2 that can be adopted at relatively low cost and where, for more major improvements an assessment of the costs and benefits is needed. Cost data quoted in the BREF note may be of assistance.

Typical costs of abatement technology per tonne of cement (based on a production capacity of 1 million tonnes per annum) are £1 per £1million of total annualised costs relative to an average selling price of £40 - £50 per tonne using H1 methodology.

1.8.2 Lime sector information

The production of lime in the UK is carried out both in-house and commercially. There is over capacity in the commercial lime market resulting in intense competition. Imports are low due to low UK prices together with high transport costs and the limited shelf life of the product.

Three main companies practise in-house production: Corus UK, British Sugar and Brunner Mond. Corus UK produces lime at the Shapfell Quarry plant to supply its iron and steel production plants across the country, supplemented as required by supplies from the commercial sector. British Sugar operates kilns to provide carbon dioxide and milk of lime for use in the sugar refining process (9 sites). Brunner Mond also produces a substantial amount of lime internally for soda ash production (2 sites).

The UK commercial lime industry is dominated by a small number of companies: Hansons Aggregates, Buxton Lime Industries, Singleton Birch, Lafarge Redland Aggregates and Lhoist. Together these companies account for 85% of all commercial lime production in the UK.

Where separate financial information is available for UK companies, the accounts show steady growth, good profitability and ROCE, together with reasonable liquidity and low gearing.

The accounts for the multinational companies don't identify lime sales or profitability separately. Group accounts as a whole, however, indicate good profitability and ROCE. Gearing is medium to high, which is indicative of these companies continuing acquisition policies.

[Appendix 4](#) details current lime capacity in the UK.

The scope for the sector to utilise waste streams as a substitute for both raw materials and fossil fuels are in general limited by product quality constraints.

Lime manufacturers have agreed with Government an energy reduction programme, which qualifies for an 80% rebate on the climate change levy.

Environmental releases from lime processes and the techniques employed for their control are similar to those proposed for cement processes in Section 2. However, when assessing the cost and benefit of techniques, regard should be given to scale of operation compared with the cement sector. Cost data quoted in the BREF note may be of assistance.

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2 TECHNIQUES FOR POLLUTION CONTROL

BAT Boxes to help in preparing applications

This section summarises, **in the outlined BAT boxes,**

- what is required in the application
- the indicative BAT requirements (i.e. what is BAT in most circumstances) against which the application will be judged.

At the top of each BAT box is the question which is being addressed. It will be seen that these deal with the questions in the Application Form relating to environmental performance of the installation.

Although referred to as "BAT", the requirements also cover the other requirements of the PPC Regulations and requirements of other Regulations (such as the Waste Management Licensing Regulations (see Appendix 2 for equivalent legislation in Scotland and Northern Ireland) and the Groundwater Regulations insofar as they are relevant to an IPPC Permit).

Indicative BAT requirements

Where it has been possible for the Agency to make a judgement on what will normally be BAT, the indicative requirements are clear and prescriptive. In such cases:

- If you propose to comply with the indicative requirement, you need only describe how you will do so, if this is not obvious from the wording of the requirement itself.
- If you propose to depart from any indicative requirements, you should justify your proposal. Such departures may be stricter or less strict than the indicative requirements:
- Stricter proposals may be appropriate where:
 - new techniques have become available after the publication of the guidance;
 - the particular technical configuration at your installation makes higher standards practicable;
 - the local environment is particularly sensitive.
- Less strict proposals may be justified due to particular factors relating to your installation or the local environment. For example, you may operate to a standard that is very close to an indicative requirement, but using different plant or processes from that upon which the indicative requirement is based. In such a case it may impose a disproportionate cost to replace the old plant with the new techniques for only a small decrease in emissions.

In other cases, the main BAT candidates are identified, but the final choice can only be made on an installation-specific basis. In further cases, aspects of the installation may not be covered by the guidance at all.

Justifying proposals

Whether you are:

- justifying departures from clear indicative requirements;
- assessing options to determine which of those identified by guidance is best for a your site; or
- developing proposals for parts (or possibly all) of an installation that are not covered by guidance.

the costs and benefits of a range of options should be compared. However, the level of detail required depends on the environmental significance of the matter in question. In the more complex cases (e.g. where the options available would lead to significantly different environmental effects, or where the cost implications are a major factor) it will be necessary to develop proposals through a more detailed analysis of the costs and benefits of options. The Agency's methodology for such assessments is set out in the IPPC H1 "Assessment of BAT and Environmental Impact for IPPC (in preparation).

In many situations, however, it will not be necessary to carry out a detailed analysis of options. For example, where an indicative standard is inappropriate for obvious technical reasons, or where there are only minor additional emissions, it may be possible to justify a departure in just a few words.

Prevention is the priority.

In responding to the requirements the Operator should keep the following general principles in mind.

- As a first principle there should be evidence in the application that full consideration has been given to the possibility of **PREVENTING** the release of harmful substances. e.g by:
 - substituting materials or processes (see Section 2.2.1);
 - preventing releases of water altogether (see Section 2.2.3); or by
 - preventing waste emissions by reuse or recovery.
- Only where that is not practicable should the second principle be adopted of reducing emissions which may cause harm.

Further explanation of the requirements of Section 2 is given in Section B2 of the Guide for Applicants.

Techniques in green text (viewable on electronic versions) are additional to the BREF requirements.

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2.1 Management Techniques

Within IPPC, an effective system of management is a key technique for ensuring that all appropriate pollution prevention and control techniques are delivered reliably and on an integrated basis. The Regulators strongly support the operation of environmental management systems (EMSs). An Operator with such a system will find it easier to complete not only this section but also the technical/regulatory requirements in the following sections.

The Regulators recommend that the ISO 14001 standard is used as the basis for an environmental management system. Certification to this standard and/or registration under EMAS (EC Eco Management and Audit Scheme) (OJ L168, 10.7.93) are also strongly supported. Both certification and registration provide independent verification that the EMS conforms to an assessable standard. EMAS now incorporates ISO 14001 as the specification for the EMS element. For further details about ISO 14001 and EMAS contact British Standards Institute (BSI) and the Institute of Environmental Management and Assessment (IEMA) respectively.

The steps required in this and subsequent sections may help the Operator to make good any shortfalls in their management system. An effective EMS will help the Operator to maintain compliance with regulatory requirements and to manage other significant environmental impacts. While the requirements below are considered to be BAT for IPPC, they are the same techniques as required in a formal EMS and are also capable of delivering wider environmental benefits. However it is information on their applicability to IPPC which is primarily required in this Application.

Application Form
Question 2.1

Provide details of your proposed management techniques.

With the Application the Operator should:

1. Describe their management system to demonstrate how it meets the **“Requirements for an effective management system”** below. The description should make clear who holds responsibility for each of the requirements. The second column explains where in the application the response to each requirement is best dealt with to avoid duplication. Copies of all procedures are not needed, but examples may be included in your application.

If you are certified to ISO 14001 or registered under EMAS (or both) you may provide a statement derived from certification records/assessments to support your application.

Further specific management procedures are dealt with under the appropriate section on the remainder of the document. It is recommended that you understand all the requirements of the application before completing this section, as many management issues are dealt with in other sections.

2. The type of management system employed will depend upon the scale and complexity of the operations undertaken. The Operator should demonstrate that the proposals are BAT, by confirming compliance with the indicative requirements below or by justifying departures (as described in Section 1.2 and in the Guide to Applicants) or alternative measures.

Indicative BAT Requirements

The Operator should have a management system in place for the activities which delivers the requirements given in column 1 below.

Requirement for an effective management system	How delivered for IPPC
1. Clear management structure and allocated responsibilities for environmental performance, in particular meeting the aspects of the IPPC Permit	Describe in this section who has allocated responsibilities
2. Identification, assessment and management of significant environmental impacts	By responding to the requirements in Section 4.1 in the Application
3. Compliance with legal and other requirements applicable to activities impacting on the environment	Compliance with the Permit satisfies this requirement

Cont.

**BAT for
management
techniques**

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4. Establishing an environmental policy and setting objectives and targets to prevent pollution, meet legal requirements and continually improve environmental performance	The Applicant should make proposals in response to each of Sections 2.2 to 2.12 . These proposals may be incorporated within the Permit improvement programme
5. Environmental improvement programmes to implement policy objectives and targets	
6. Establish operational controls to prevent and minimise significant environmental impacts	By responding to the requirements in Sections 2.2 to 2.7, 2.11 and 2.12 in the Application
7. Preventative maintenance programmes for relevant plant and equipment – method of recording and reviews	Describe system here. List procedures in Section 2.3
8. Emergency planning and accident prevention	By responding to the requirements in Section 2.8 in the Application
9. Monitoring and measuring performance Identify key indicators of environmental performance and establish and maintain a programme to measure and monitor indicators to enable review and improvement of performance	Describe in this Section
10. Monitoring and control systems: <ul style="list-style-type: none"> to ensure that the installation functions as intended; to detect faults and unintended operations; to detect slow changes in plant performance to trigger preventative maintenance 	By responding to the requirements in Section 2.10 in the Application
11. Training Provision of adequate procedures and training for all relevant staff (including contractors and those purchasing equipment and materials), which should include: <ul style="list-style-type: none"> a clear statement of the skills and competencies required for each job; awareness of the regulatory implications of the Permit for the activity and their work activities; awareness of all potential environmental effects from operation under normal and abnormal circumstances; prevention of accidental emissions and action to be taken when accidental emissions occur; implementation and maintenance of training records; Expertise required depends on the activities being carried out. However, both technical and managerial staff upon whom the installation's compliance depends need sufficient qualifications, training and experience for their roles. This may be assessed against any industry sector standards or codes of practice	To be described in this Section confirming that training for each of the areas covered by Sections 2.2 to 2.3 and 2.5 to 2.10 are covered
12. Communication and reporting of incidents of actual or potential non-compliance and complaints Actions taken in response, and about proposed changes to operations.	Describe in this Section
13. Auditing Regular, (preferably) independent, audits to check that all activities are being carried out in conformity with these requirements. All of these requirements should be audited at least once per year	Describe in this Section

Cont.

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<p>14. Corrective action to analyse faults and prevent recurrence</p> <p>Define responsibility and authority for handling and investigating non-conformance, taking action to mitigate any impacts caused and for initiating and completing corrective and preventive action</p> <p>Recording, investigating, taking corrective action and preventing recurrence, in response to environmental complaints and incidents</p>	<p>Describe in this Section how this is dealt with for each of Sections 2.2 to 2.3 and 2.5 to 2.10 as appropriate</p>
<p>15. Reviewing and Reporting Environmental Performance</p> <p>Senior management review environmental performance and ensure appropriate action taken where necessary to ensure that policy commitments are met and that policy remains relevant. Review progress of the Management Programmes at least annually.</p> <p>Incorporate environmental issues in all other relevant aspects of the business, insofar as they are required by IPPC, in particular:</p> <ul style="list-style-type: none"> • the control of process change on the installation; • design and review of new facilities, engineering and other capital projects; • capital approval; • the allocation of resources; • planning and scheduling; • incorporation of environmental aspects into normal operating procedures; • purchasing policy; • accounting for environmental costs against the process involved rather than as overheads <p>Report on environmental performance, based on the results of management reviews (annual or linked to the audit cycle), for:</p> <ul style="list-style-type: none"> • information required by the Regulator; and • effectiveness of the management system against objectives and targets, and future planned improvements. <p>Report externally preferably via public environmental statement</p>	<p>Describe in this Section</p> <p>Describe in this Section</p> <p>This will become a Permit requirement</p> <p>Describe in this Section</p> <p>Describe in this Section</p>
<p>16. Managing documentation and records</p> <p>List the core elements of the EMS (policies, responsibilities, procedures etc) and links to related documentation in order to be able to control, locate and update documentation.</p> <p>Describe how environmental records and results of audits and reviews are identified, maintained and stored.</p>	<p>Describe in this Section</p>

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Selection of raw materials

2.2 Materials Inputs

This section covers the use of **raw materials and water** and the techniques for both minimising their use and minimising their impact by selection. (The choice of fuels is covered under [Section 2.7.3](#), Energy).

As a general principle, the Operator will need to demonstrate the measures taken to:

Reduce
Substitute
Understand

- **reduce** the use of chemicals and other materials ([Section 2.2.2](#));
- **substitute** less harmful materials or those which can be more readily abated and when abated lead to substances which in themselves are more readily dealt with;
- **understand** the fate of by-products and contaminants and their environmental impact ([Section 4](#)).

2.2.1 Raw materials selection

Summary of materials in use

This section looks at the **selection and substitution** of raw materials used while [Section 2.2.2](#) describes the techniques to **minimise** their use.

Application Form Question 2.2 (part 1)	Identify the raw and auxiliary materials, other substances and water that you propose to use.
<p>With the Application the Operator should:</p> <ol style="list-style-type: none"> 1. supply a list of the materials used, which have the potential for significant environmental impact, including: <ul style="list-style-type: none"> • the chemical composition of the materials where relevant; • the quantities used, • the fate of the material (i.e. approximate percentages to each media and to the product), • environmental impact where known (e.g. degradability, bioaccumulation potential, toxicity to relevant species). • any reasonably practicable alternative raw materials which may have a lower environmental impact including, but not be limited to, any alternatives described in BAT Requirement 5 below (the substitution principle). <p>A suitable template is included in the electronic version of this document.</p> <p>Generic information about materials, and grouping information of those of a similar type, is normally adequate rather than listing every commercial alternative used. A common sense approach to the level of detail should be used; ensuring that any material could have a significant effect of the environment is included. Product data sheets should be available on-site.</p> 2. justify (e.g. on the basis of impact on product quality), the continued use of any substance for which there is a less hazardous alternative and that the proposed raw material section is therefore BAT; 3. for existing activities, identify shortfalls in the above information, e.g. the environmental impact of certain substances, which the Operator believes require longer term studies to establish. <p>Indicative BAT Requirements</p> <ol style="list-style-type: none"> 1. The Operator should: <ul style="list-style-type: none"> • complete any longer-term studies (Item 3 above), • carry out any substitutions identified, as improvement conditions to a timescale to be approved by the Regulator; 2. The Operator should maintain a detailed inventory of raw materials used on-site. 3. The Operator should have procedures for the regular review of new developments in raw materials and the implementation of any suitable ones which are less hazardous. 4. The Operator should have quality assurance procedures for the control of the content of raw materials. 	

BAT for selection

Cont.

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Selection of raw materials

5. The following raw material selection techniques should be applied where appropriate:

Selective quarrying

During cement manufacture significant SO₂ emissions can arise from sulphur in raw materials. It is claimed that a variation can be as much as a factor of 4 to a factor of 10. The Operator should survey the quarry and where applicable implement selective quarrying to achieve a controlled even emission of SO₂ throughout the lifetime of the quarry. The benefits are a more even stack release with reduced peaks.

Slurry thinners

Materials such as sodium carbonates, silicates and phosphates as well as lignosulfonates and modified petrochemicals are used as slurry thinners in the wet and semi-wet cement manufacturing process. Operators are required to include such materials in the raw material inventory for the process.

Substitute aggregates

Cement manufacture has considerable potential to utilise substitute materials that are rich in argillaceous, siliceous and ferrous materials. Current examples include:

- pulverised fuel ash used as a clay substitute,
- foundry sand utilised as a substitute for virgin sand,
- utilisation of iron oxide rich materials from iron and steel manufacture.

The cement sector is expected to actively pursue the use of substitute raw materials given the changing economics of the landfill sector. The effect of Landfill Tax combined with the implementation of the Landfill Directive (99/31/EC) has given a significant boost to such initiatives.

Mineralised clinker

Mineralised clinker production utilises fluxing agents to reduce sintering temperatures and increase clinker activity. The environmental benefits are twofold, fuel input can be reduced and less clinker is required per tonne of blended cement. Customer resistance has limited the widespread use of this technique.

Substitute fuels

Physical state of the fuel

Liquid fuels are easier to handle and burn and can lead to more stable kiln conditions, (e.g. switching some of the solid fuel burning to SLF at some sites has resulted in reductions of NO_x due to improved flame characteristics).

Composition of the fuel

The type and amounts of constituents of the fuel, which contribute to pollutant releases, should be assessed and substitutions made to minimise emissions e.g.:

- low sulphur content to minimise fuel SO₂ emissions.
- low nitrogen content to minimise fuel NO_x emissions. For instance, burning petroleum coke may result in increased NO_x releases compared to coal.
- low metal content. Metal content has two main effects. Volatile metals, such as mercury, tend to pass out of the kiln in the exhaust gases so any increases in fuel mercury content may be reflected in increased releases. Semi-volatile metals will tend to condense onto CKD/lime dust impeding subsequent recovery.

BAT will be the appropriate selection of fuel, kiln design and abatement plant to minimise emissions.

Operators should note the supplementary guidance on the procedures to be followed and the considerations to be given to the use of substitute fuels in cement and lime kilns. ([Substitute Fuels Protocol, Ref. 26](#))

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Use of raw materials

Principles

2.2.2 Waste minimisation (minimising the use of raw materials)

The prevention and minimisation of waste and emissions to the environment is a general principle of IPPC. Operators will be expected to consider the application of waste minimisation techniques so that, wherever practicable, all types of wastes and emissions are prevented or reduced to a minimum. The steps below will also help to ensure the prudent use of natural resources.

Waste minimisation can be defined simply as:

“a systematic approach to the reduction of waste at source, by understanding and changing processes and activities to prevent and reduce waste”.

A variety of techniques can be classified under the general term of waste minimisation and they range from basic housekeeping techniques through statistical measurement techniques to the application of clean technologies.

In the context of waste minimisation and this Guidance, **waste** relates to the inefficient use of raw materials and other substances at an installation. A consequence of waste minimisation will be the reduction of gaseous, liquid and solid emissions.

Key operational features of waste minimisation will be:

- the ongoing identification and implementation of waste prevention opportunities;
- the active participation and commitment of staff at all levels including, e.g. staff suggestion schemes;
- monitoring of materials usage and reporting against key performance measures.

For the primary inputs to waste activities e.g. the waste to landfill, the requirements of this section may have been met “upstream” of the installation. However, there may still be arisings which are relevant.

See Ref. 8 for detailed information, guides and case studies on waste minimisation techniques.

Application Form
Question 2.2 (part 2)

Identify the raw and auxiliary materials, other substances and water that you propose to use.

With the Application the Operator should:

1. identify, from a knowledge of the plant, the main opportunities for waste minimisation and supply information on waste minimisation audits and exercises and the improvements made or planned.

Indicative BAT Requirements

1. A regular waste minimisation audit should be carried out. Where one has not been carried out recently, an initial comprehensive audit should be carried out at the earliest opportunity within the improvement programme. New plants will need to have been operating for some time before an audit will be meaningful. Further audits should be at least as frequent as the IPPC Permit reviews. The audit should be carried out as follows:

The Operator should analyse the use of raw materials, assess the opportunities for reductions and provide an action plan for improvements using the following three essential steps:

- i) process mapping;
- ii) raw materials mass balance;
- iii) action plan.

The use and fate of raw materials and other materials, including reactants, intermediates, by-products, solvents and other support materials, such as inerting agents, fuels, catalysts and abatement agents, should be mapped onto a process flow diagram (see Ref. 8) using data from the raw materials inventory (see Section 2.2.1) and other company data as appropriate. Data should be incorporated for each principal stage of the operation in order to construct a mass balance for the installation.

Using this information, opportunities for improved efficiency, changes in process and waste reduction should be generated and assessed and an action plan prepared for the implementation of improvements to a timescale approved by the Regulator.

BAT for waste minimisation

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Water use

2.2.3 Water use

Water use should be minimised within the BAT criteria for the prevention or reduction of emissions and be commensurate with the prudent use of water as a natural resource.

Reducing water use may be a valid environmental (or economic) aim in itself, perhaps because of local supply constraints. In addition, from the point of view of reducing polluting emissions, any water passing through an industrial process is degraded by the addition of pollutants, and there are distinct benefits to be gained from reducing the water used, in particular:

- reducing the size of (a new) treatment plant thereby supporting the cost benefit BAT justification of better treatment;
- cost savings where water is purchased or disposed off to another party;
- associated benefits within the process such as reduction of energy requirements for heating and pumping, and reduced dissolution of pollutants into the water leading to reduced sludge generation in the effluent treatment plant.

The use of a simple mass balance for water use will reveal where reductions can be made.

Advice on cost-effective measures for minimising water can be found in ETBPP publications ([see Ref. 9](#)).

Reasons for reducing water use

Application Form
Question 2.2 (part 3)

Identify the raw and auxiliary materials, other substances and water that you propose to use.

With the Application the Operator should:

1. supply information on water consumption and comparison with any available benchmarks;
2. supply a diagram of the water circuits with indicative flows ;
3. describe the current or proposed position with regard to the indicative BAT requirements below or any other techniques which are pertinent to the installation;
4. demonstrate that the proposals are BAT, by confirming compliance with the indicative requirements, by justifying departures (as described in Section 1.2 and in the Guide to Applicants) or alternative measures;
5. describe, in particular, any water audits already conducted and the improvements made or planned.

Indicative BAT Requirements

1. A regular review of water use (water efficiency audit) should be carried out. Where one has not been carried out recently, an initial comprehensive audit should be carried out at the earliest opportunity within the improvement programme. New plants will need to have been operating for some time before an audit will be meaningful. Further audits should be at least as frequent as the IPPC Permit reviews. The audit should be carried out as follows:
 - The Operator should produce flow diagrams and water mass balances for the activities.
 - Water efficiency objectives should be established by comparison with sector guidance or, where not available, national benchmarks ([see Ref. 10](#)). In justifying any departures from these ([see Section 1.2](#)), or where benchmarks are not available, the techniques described below should be taken into account. The constraints on reducing water use beyond a certain level should be identified by each Operator, as this is usually installation-specific.
2. The following general principles should be applied in sequence to reduce emissions to water:
 - water-efficient techniques should be used at source where possible;
 - water should be recycled within the process from which it issues, by treating it first if necessary. Where this is not practicable, it should be recycled to another part of the process which has a lower water quality requirement;
 - in particular, uncontaminated roof and surface water, which cannot be used, should be discharged separately.

Cont.

BAT for water efficiency

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Water use

BAT (cont.)

3. Measures should be implemented to minimise contamination risk of process or surface water (see [Section 2.3.7](#)).
4. To identify the scope for substituting water from recycled sources, the water quality requirements associated with each use should be identified. Less contaminated water streams, e.g. cooling waters, should be kept separate where there is scope for reuse, possibly after some form of treatment.
5. Water used in cleaning and washing down should be minimised by:
 - vacuuming, scraping or mopping in preference to hosing down;
 - evaluating the scope for reusing wash water;
 - trigger controls on all hoses, hand lances and washing equipment.

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2.3 The Main Activities and Abatement

(includes “**directly associated activities**” in accordance with the PPC Regulations)

Application Form
Question 2.3

Describe the proposed installation activities and the proposed techniques and measures to prevent and reduce waste arisings and emissions of substances and heat (including during periods of start-up or shut-down, momentary stoppage, leak or malfunction).

With the Application the Operator should:

- provide adequate **process descriptions** of the activities and the abatement and control equipment for all of the activities such that the Regulator can understand the process in sufficient detail to assess the Operator’s proposals and, in particular, to assess opportunities for further improvements. This should include:
 - process flow sheet diagrams (schematics);
 - diagrams of the main plant items where they have environmental relevance; e.g. kiln system, abatement plant design etc;
 - details of any chemical reactions and their reaction kinetics/energy balance;
 - control system philosophy and how the control system incorporates environmental monitoring information;
 - annual production, mass and energy balance information;
 - venting and emergency relief provisions;
 - summary of extant operating and maintenance procedures;
 - a description of how protection is provided during abnormal operating conditions such as momentary stoppages, start-up, and shut-down for as long as is necessary to ensure compliance with release limits in Permits;
 - additionally, for some applications it may be appropriate to supply piping and instrumentation diagrams for systems containing potentially polluting substances.

If there is uncertainty, the degree of detail required should be established in pre-application discussions.

- describe the current or proposed position for all of the indicative BAT requirements for each subsection of 2.3, or any others which are pertinent to the installation;
- identify shortfalls in the above information which the Operator believes require longer term studies to establish.
- demonstrate that the proposals are BAT, by confirming compliance with the indicative requirements, by justifying departures (as described in Section 1.2 and in the Guide to Applicants) or alternative measures;

In assessing the integrated impacts of proposals and balancing the impacts of different techniques it should be noted that energy should be taken into account whether or not there is a Climate Change Agreement in place (see Section 2.7.3).

Indicative BAT Requirements

See each subsection of this Section 2.3.

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Raw materials & quarries

2.3.1 Raw materials

Primary raw materials are usually extracted from quarries that are near the cement or lime production plant. Operations, such as size reduction, can fall under Part B of the PPC Regulations (Ref. 3), but are generally part of the installation if they are related to and carried on as part of the process. In addition, quarries associated with the production process are often used for the disposal of solid waste, particularly waste dust either from dust abatement plant or other parts of the process. The Operator is advised to discuss the extent of the installation(s) with the Regulator.

Raw materials such as limestone are quarried using hard rock techniques. The process usually involves the drilling and blasting of stone followed by crushing and grinding. Lime kilns generally use much coarser and purer feed limestone than cement processes. Usually the fine grinding stages will be carried out at cement production sites rather than in the quarry.

Materials such as chalk and clay are quarried in a wet state.

For cement production other raw materials may be required to adjust chemical composition of the kiln feed including sand, iron oxide and bauxite. The storage and handling of these materials can result in the release of dust. Secondary raw materials such as PFA, blast furnace slag and other process residues may partially replace primary raw materials and correctives subject to their chemical suitability and the environmental releases associated with their use.

Application Form Question 2.3 (cont.)	Raw materials and quarries
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With the Application the Operator should:

- supply the general Application requirements for Section 2.3 listed on [page 28](#) for this aspect of the activities;

Indicative BAT Requirements

- If it is decided that quarries, as Part B processes, are included in the permit then reference should be made to Part B guidance PG3/8 (GNB 3/3 in N. Ireland) for control of releases to air.
- Should process wastes be disposed of in quarry operations the Operator should demonstrate ground water and surface water are adequately protected.

No further issues are identified.

BAT

**BREF
Sections:**

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Cement production

Processes

2.3.2 Kiln and associated processing - cement production

For cement manufacture, a rotary kiln is usually used for the sintering stage. There are a number of systems for drying and calcining, all of which are integral to the kiln. The main types are given below:

- **wet process** where the slurry feed is dried and calcined within the kiln (conventional wet process); or to slurry drier prior to a pre-heater/pre-calciner kiln (modern wet process);
- **semi-wet process** where the slurry is dewatered in filter presses and the resulting filter cake is either:
 - extruded into pellets and fed to a travelling grate pre-heater or;
 - fed directly to a filter cake drier for (dry) raw meal production prior to a pre-heater/pre-calciner kiln.
- **semi-dry process** where dried ground material (raw meal) is nodulised with water, then dried and partly calcined in a grate pre-heater; or in some cases, to a long kiln equipped with internal cross pre-heaters;
- **dry process** where the raw meal is preheated in a series of cyclones (four or five stages), possibly incorporating a pre-calcining stage in which some of the fuel is burned or, in some cases, to a long dry kiln with internal chain pre-heater.

In all systems the kiln feed moves counter currently against a hot air stream. This counter current flow regime affects pollutant releases, which are discussed further below.

The choice of process route can be influenced by two factors: the energy costs and the nature of the raw materials available. For instance, chalk naturally occurs in a wet state and so the modern wet process may be the preferred route.

The specific energy requirements of the different kiln systems generally decrease significantly from the wet to the dry process (typical figures are given in Table 2-1) as do the specific amounts of most pollutants released.

Table 2-1 - Typical energy consumption of different kiln systems

Kiln system	Specific fuel consumption (MJ/ tonne clinker)
Wet (conventional)	6000 to 6500
Dry process long kiln	Up to 5000
Modern wet and semi-wet (pre-heater and pre-calciner)	4000 to 4800
Semi-wet (grate pre-heater)	3700
Semi-dry (grate pre-heater)	3300
Dry (pre-heater)	3500 to 4000
Dry (pre-heater and pre-calciner)	2900 to 3200
Theoretical heat of reaction	1700 to 1800

The electricity demand is about 90-130kWh/ tonne cement

Wet process

Figure 2-1 gives a flow diagram of a typical wet kiln process. The conventional wet process is now declining in use due to the cost penalty associated with driving off water from the wet slurry feed into the kiln.

Typical slurry moisture fed to the kiln are in the range 30% to 40%, depending upon the physical properties of the raw materials. Additives may be used to reduce moisture. Raw materials may contain considerable moisture (up to 22% in some cases) and may be ground together or separately with the addition of water to form a slurry in wash mills or drums. Polyelectrolytes may be used to minimise the amount of water which has to be added whilst still maintaining the pumpability of the slurry.

Oversize material is screened off for reprocessing and the finely divided liquid slurry is pumped to large blending and storage tanks in which further adjustments may be made to the composition.

From the slurry storage tanks the raw mix is pumped to the rotary kiln where the water has to be evaporated in the drying zone at the kiln inlet. The slurry feed requires accurate metering. The drying zone is fitted with chains and crosses to facilitate the heat exchange between the kiln feed and the combustion gases.

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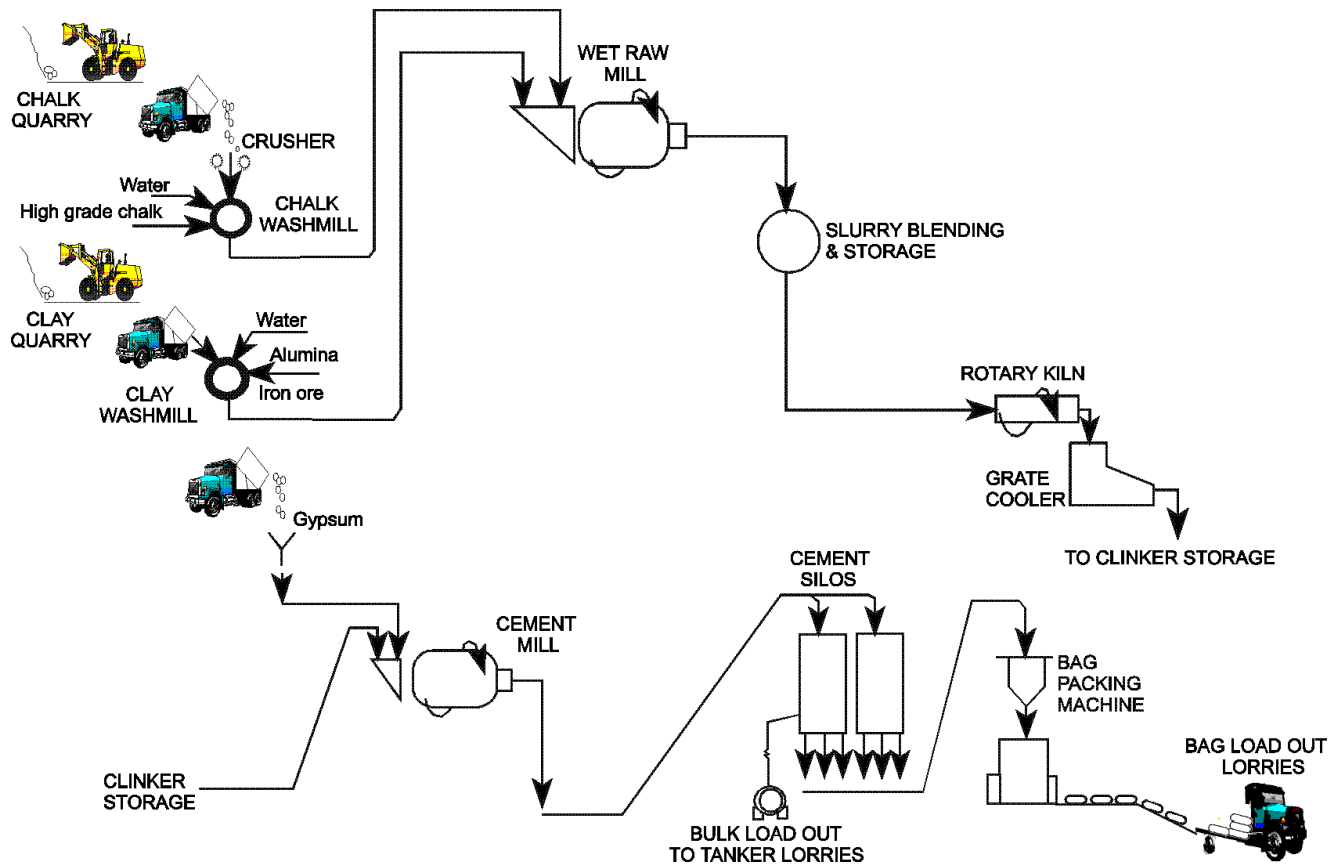


Figure 2-1 - Typical Wet Kiln Process

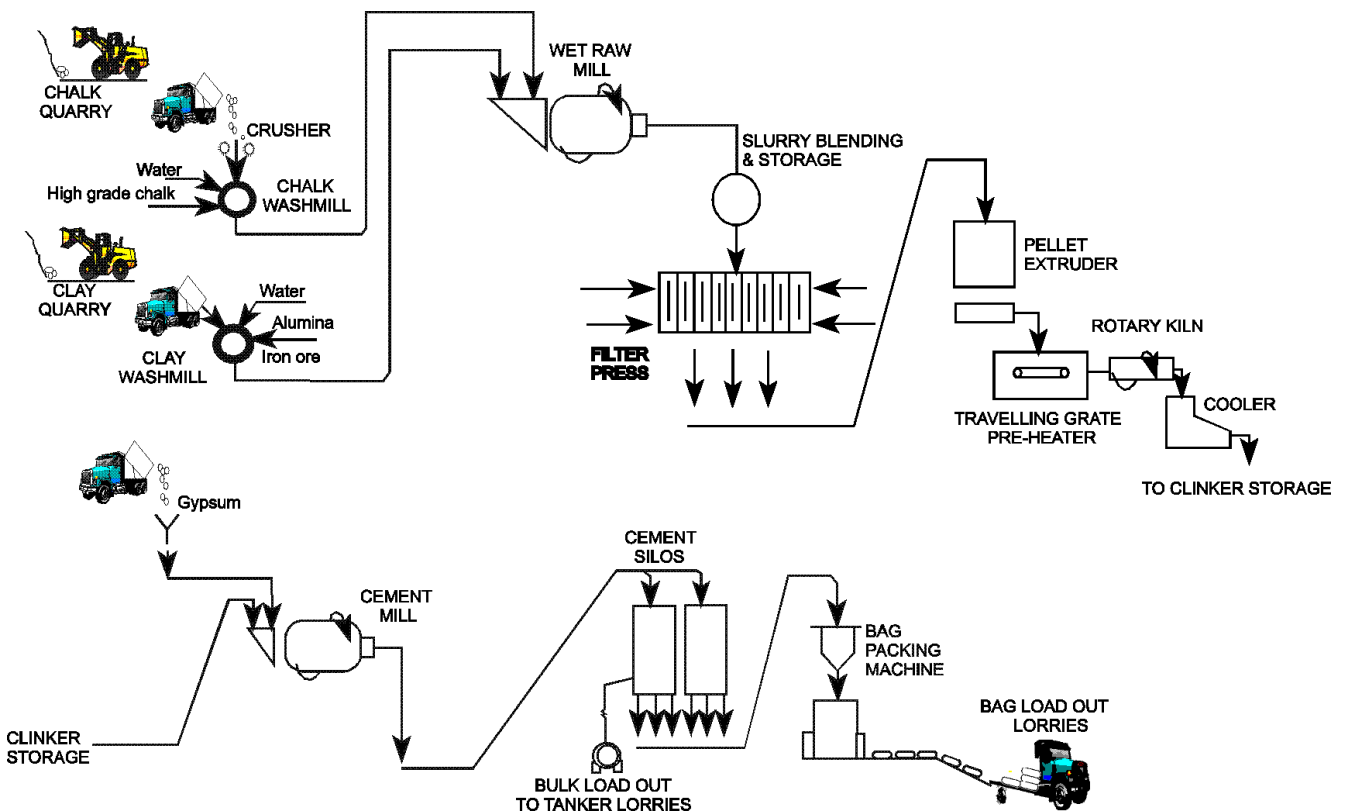


Figure 2-2 - Typical Semi-Wet Process

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Cement production

Due to the rotational movement of the kiln and its slight downward inclination raw material is gradually transferred from the drying zone down the kiln towards the burner end to be calcined and burnt to clinker in the sintering zone. The kiln performs all the thermal functions of the process: drying, calcining and sintering.

The length and diameter of wet kilns are large in relation to output and a higher induced draught fan volume is required compared with other processing techniques because of the steam generated (by drying within the kiln) and higher volumes of products of combustion (from the higher fuel consumption).

In modern wet kiln systems, the raw slurry is fed to a slurry drier where the water is evaporated prior to the dried raw meal entering a cyclone pre-heater/pre-calciner kiln. Modern wet kiln systems have far lower specific heat consumption compared to conventional kilns.

Semi-wet process

The semi-wet process relies on mechanically removing the majority of the water content of the slurry prior to feeding to the kiln thus lower specific fuel consumptions can be achieved compared with the wet process. [Figure 2-2](#) shows a typical semi-wet process flow diagram.

Slurry preparation is identical to the wet process but followed by pressure filtration to reduce moisture content to 17-20%.

Traditionally filter cake is passed through an extrusion press where pellets are formed. The pellets are transferred to a moving grate pre-heater where, before entering the rotary kiln, they are dried and partly calcined by the hot kiln exit gases. Alternatively, the filter cake can be fed to a hammer crusher which acts as a drier, again using hot kiln exhaust gases. A third option, which is less fuel efficient, is to feed the cake directly to the kiln equipped with chains as in the wet process.

With modern cement plants, slurry filtration is applied only where raw materials have a very high moisture content i.e. chalk. Filter cake coming from the filter presses is kept in intermediate storage bins before it is fed to heated crushers or dryers where a dry raw meal is produced which is fed to a modern pre-heater or pre-calciner kiln.

Semi-dry process

The raw meal preparation route for the semi-dry process is as for the dry process, the raw meal is then nodulised, using the minimum quantity of water necessary, and the nodules fed directly to a horizontal travelling grate pre-heater in front of the rotary kiln ("Lepol" system). The pelletised material is dried, pre-heated and partly calcined on the two-chamber travelling grate making use of the hot exhaust gases from the kiln. A higher degree of calcination can be achieved by burning part of the fuel in the hot chamber of the grate preheater.

The hot gases from the kiln first pass through a layer of preheated pellets in the hot chamber. After intermediate dedusting in cyclones, the gases are drawn once again through a layer of moist pellets in the drying chamber of the grate. As much of the residual dust is precipitated on the moist pellet bed, the total dust load of the exhaust gases at the pre-heater is low.

As a drawback of the semi-dry process, kiln exhaust gases cannot be utilised in the raw meal drying and grinding system due to low temperature level. The maintenance costs of grate pre-heaters are high. A typical semi-dry process diagram is given in [Figure 2.3](#).

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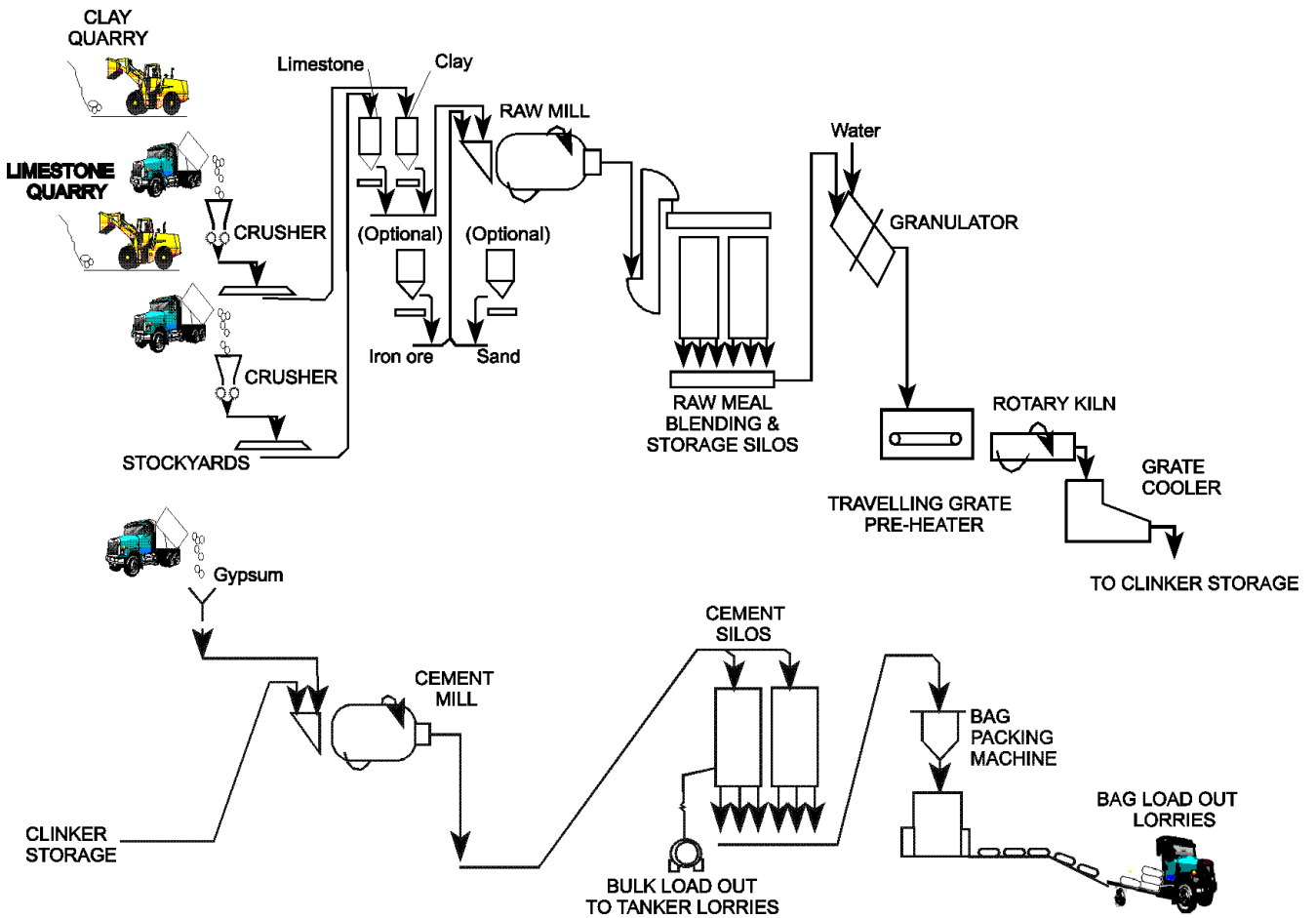


Figure 2-3 - Typical Semi-Dry Process

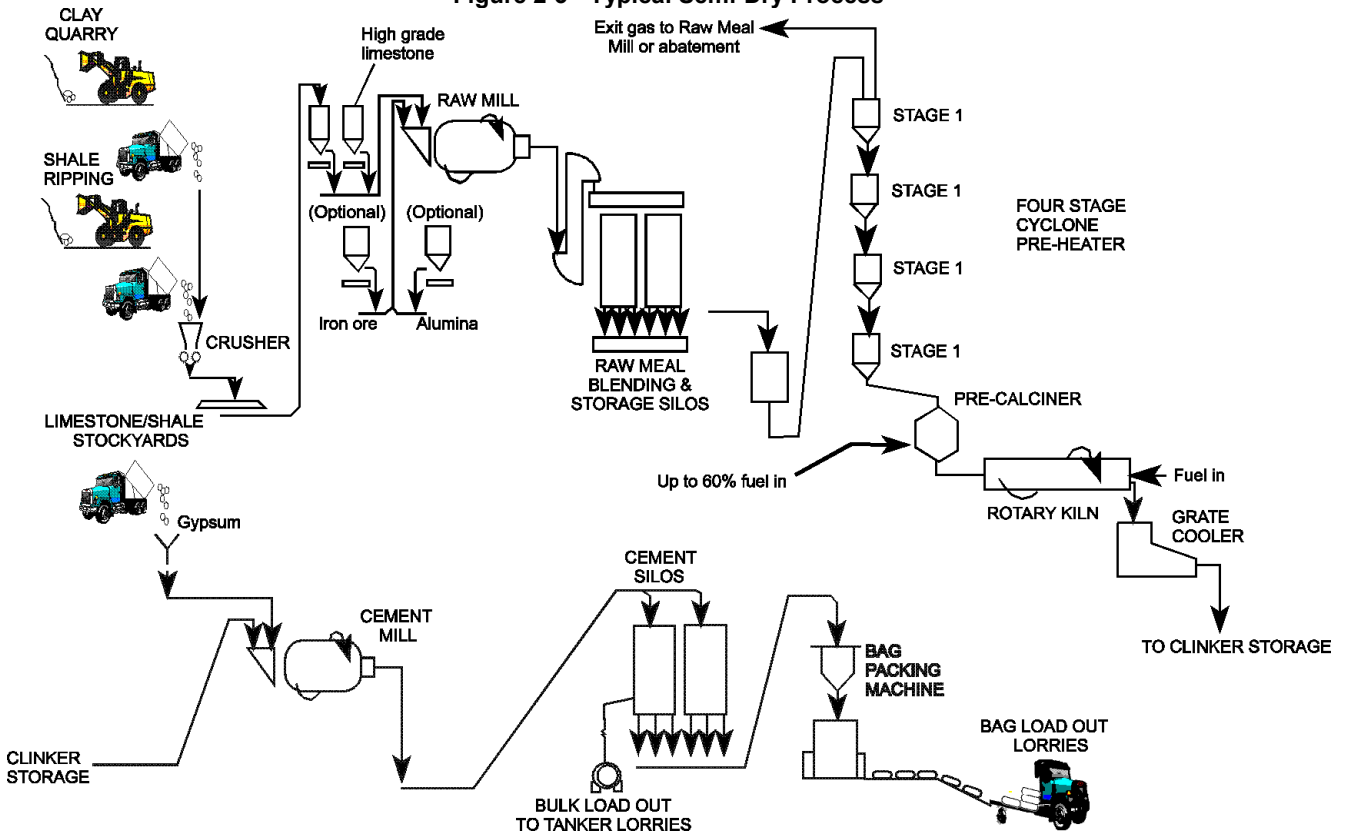


Figure 2-4 - Typical Pre-Calculator Dry Kiln

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Cement production

Dry processes

Dry kilns have three basic variants: long dry kilns, pre-heater kilns and pre-calciner kilns. A typical pre-calciner dry process flow diagram is given in [Figure 2-4](#).

Raw materials preparation

Raw materials, usually with a moisture content of less than 12%, are fed at controlled ratios into a raw milling system where they are dried and ground to the required fineness (typically 10% retention on a 90 micron sieve). Several types of mill can be used such as air swept ball mills, closed circuit tube mills or roller mills. Drying is achieved by using hot exhaust from the pre-heater cyclones or cooler exhaust air. If additional drying capacity is required then an auxiliary furnace can be used.

The raw meal is transferred to the homogenising silos where it is pneumatically fluidised and mixed. After homogenisation, the raw meal is stored in silos prior to use.

Long dry process kilns

Dry process kilns have a lower thermal duty than wet process kilns. A long dry kiln performs the functions of final drying, i.e. driving off the final 0.5 to 1% moisture in the raw meal, calcining the raw meal and sintering in the burning zone. A system of chains in the inlet part of the rotary kiln provides the heat exchange between the hot combustion gases from the hot zone of the kiln and the kiln feed. Long dry kilns have high dust cycles requiring separate dedusting cyclones.

Cyclone (or suspension) pre-heater kilns

To improve the efficiency of the heat exchange process between the hot gases and the raw meal, cyclone pre-heater systems have been developed that carry out the preheating process outside the rotary kiln.

The pre-heater may consist of a riser pipe and up to six stages of cyclone pre-heaters. After the pre-heater, the hot meal enters a rotary kiln for the calcining and burning stage.

The principle of all the cyclone pre-heaters is the same: raw meal is introduced and moves counter to the upward flowing hot gases leaving the kiln. The meal is swept up in the gas stream, separated out in the cyclone and passed down to the next stage where the procedure is repeated until the raw meal has passed through all stages, rising rapidly in temperature as it does so.

Heat transfer within cyclones is very efficient when compared to the kiln. The contact area with the finely divided raw meal is much greater than with a bed of material lying in the kiln with a limited surface contact area exposed to the hot gases. For example, a four stage cyclone pre-heater will raise the temperature of the raw meal to more than 800°C in 25 seconds, and the gas temperature will fall from 950-1000°C at the exit from the kiln to 370-380°C at the exit from the top or first stage cyclone. Material entering the kiln is up to 30% calcined.

Pre-calciner kilns

A further development is to carry out most of the calcination stage outside the rotary kiln in a separate calciner vessel. This vessel is positioned between the last pre-heater stage cyclone and the kiln and arranged to receive the output from the pre-heater. Up to 60% of the total fuel requirement is added at this stage, thereby ensuring that 80-90% of the calcination of the raw meal takes place. Thus, when the meal enters the kiln only final calcination and clinkering is required.

The precalciner takes its combustion air largely from the clinker cooler at the hot end of the kiln. This hot air may be transferred through the kiln itself or, more commonly, by a tertiary hot air duct parallel to the kiln.

The hot air from the grate cooler arrives at the pre-calciner at approximately 800°C, the kiln exit gases enter it at about 1000°C and calcination takes place at 850 to 900°C.

Kiln systems with 5 to 6 cyclone pre-heater and pre-calciner are considered standard technology for new plants, as the extra cyclone stages improve thermal efficiency.

Clinker cooling

Clinker cooling is carried out after the kiln to allow the clinker to be cooled to a level suitable for downstream processing and to recuperate some of its heat back to process. In addition, rapid cooling prevents undesired chemical reactions in the clinker, which may negatively affect the quality and the grindability of the clinker. All coolers operate by passing air through the clinker and there are three main types:

- grate coolers;
- planetary coolers; and
- rotary (tube) coolers.

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Cement production

Grate coolers are preferably used in modern kiln installations. Cooling is achieved by cross-flow air blown through a clinker layer travelling slowly on a reciprocating grate, which consists of perforated plates. Air passes through the perforations, cools the clinker and is itself pre-heated before passing into the kiln as secondary combustion air or used for solid fuel and/or raw material drying or passed to the pre-calciner as tertiary combustion air.

Planetary (or satellite) coolers consist of a series of 10 to 12 large diameter tubes fastened to the kiln shell and rotating with it. The clinker drops into these and by virtue of the inclination of the kiln, passes through the coolers tumbling across the incoming ambient air stream drawn in by the kiln induced draught fan. Planetary coolers are not suited for pre-calciner kilns, as exhaust air cannot be extracted for combustion in the secondary firing.

A **rotary cooler** is a rotating cylinder, usually mounted beneath the kiln fitted with lifter and tumbling plates. Air flow is as for the planetary cooler. This cooler type is rarely used in the cement industry.

Cement milling

The clinker is transferred to covered storage halls or clinker silos where it is held prior to milling. It is withdrawn from storage and fed to the cement mill by weigh proportioners with an addition of 3 to 8% of gypsum and possibly other additions. The resulting product is cement, which is then conveyed to cement silo storage. Gypsum is added to control the setting properties of finely ground clinker.

Cement milling is typically performed by tube (ball) mills but the use of roller presses may offer energy saving. Tube mills operate in open or closed circuit with air classifiers or separators to improve efficiency. Milling generates considerable heat and internal air cooling plus internal or external water sprays are necessary. Cement milling also produces particulate laden exhaust streams that require abatement.

Product handling and storage

Cement is transferred from the silos either direct into bulk road or rail tankers, or to a bag packing station. Potential particulate releases from this part of the process are significant.

Composite cement manufacture

In the manufacturing of composite (or interground) cements, granulated blast furnace slag, pulverised fly ash, pozzolana and/or fillers are added and ground with the clinker and gypsum, or milled separately and blended with the cement after the grinding stage.

Application Form
Question 2.3 (cont.)

Cement production processes

With the Application the Operator should:

1. supply the general Application requirements for Section 2.3 listed on [page 28](#) for this aspect of the activities;

Indicative BAT Requirements

1. The selected process has a major impact on the energy use and air emissions from the manufacture of cement clinker.
2. For new plants and major upgrades the best available technique for the production of cement clinker is considered to be a dry process kiln with multi-stage preheating and precalcination. The associated BAT heat balance value is 3000 MJ/tonne clinker.
3. Operators may be able to justify a departure from this based on available raw materials such as chalk and /or the use of substitute aggregates with regard to the overall environmental impact.

No further issues are identified.

BAT

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Lime production

Kiln types

2.3.3 Kiln and associated processing - lime processes

There are four basic designs of kiln in use: shaft, rotary, rotating hearth and fluidised bed. All are designed to dry and calcine the limestone feed and cool the product quicklime. Table 2-2 compares the various types of kiln technology.

Table 2-2 - Comparison of different lime kiln types

Kiln type	Feed size range (mm)	Fuel consumption (kcal/kg quicklime)	Power consumption (kWh/quicklime tonne)
Shaft			
Simple	50-250	1100-1700	4-15
Mixed feed	90-200	950-1050	4-15
Double inclined	25-55	1000-1150	22-29
Annular shaft	20-150	950-1150	25-30
Parallel flow regenerative	20-200	850-950	15-34
Rotary			
Long	10-65	1500-2000	14-24
Short with grate pre-heater	10-50	1200-1450	20-25
Short with shaft pre-heater	10-60	1150-1450	17-45
Short with cyclone pre-heater	0-2	1100-1300	23-37
<u>Rotating hearth</u>	8-75	1400-1500	29-36
<u>Fluidised bed</u>	0-2	1100-1300	20-25

The quality of the lime produced depends on the quantity of impurities introduced with the raw materials and the fuels used. The temperature at which the limestone is calcined affects the reactivity to water of the resultant quicklime. Higher temperatures produce harder quicklime with lower reactivity. The calcination temperature is in turn affected by the choice of kiln system.

All kiln systems are characterised by the counter-current flow of solids and gases as in cement production, which has implications for the resulting pollutant releases discussed below.

Vertical shaft kiln

Figure 2-5 gives a schematic diagram of a simple vertical shaft kiln. The vertical shaft kiln receives lump limestone, which is charged at the top of the unit through an air lock where it is preheated to 800°C by combustion gases. Burners are arranged so that they fire into the combustion chamber in a full range of directions to maximise the contact of hot gases with the stone. The injected fuel does not normally penetrate more than about 1 metre into the packed kiln which is therefore limited, in many designs, to 2 metres diameter (or width). The burners are located about a third of the way up the kiln from the base in the lower region of the calcination zone.

Obtaining even heat distribution across the limestone charge is inherently difficult in shaft kilns. Some kilns utilise beams which span across the kiln shaft and contain burner-nozzles which inject fuel more evenly across the limestone charge. Other kilns attempt to achieve the required temperature consistency by injecting fuel through vertical burner lances placed evenly across the charge. The use of a closely graded limestone feed to vertical shaft kilns encourages an even spread of heat in the burning zone.

At the bottom of the kiln there is an air lock and a discharge system. The speed of operation of the discharge mechanism determines the speed of descent of the limestone into the burning zone and through the kiln.

Cooling air is drawn into the kiln by the induced draught fan, and is preheated as it passes through the hot burnt lime leaving the burning zone. Additional air may be injected into the burning zone, from which the hot gases pass up the kiln preheating the slowly descending limestone and cooling the exit gases at the same time.

Operators should note that many older and smaller vertical shaft kilns operate with natural draught using a batch processing technique. Many will not fall under the Regulations (Ref. 3) due to the small throughputs associated with these kilns.

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Lime production

Figure 2-5 - Simple Vertical Shaft Kiln

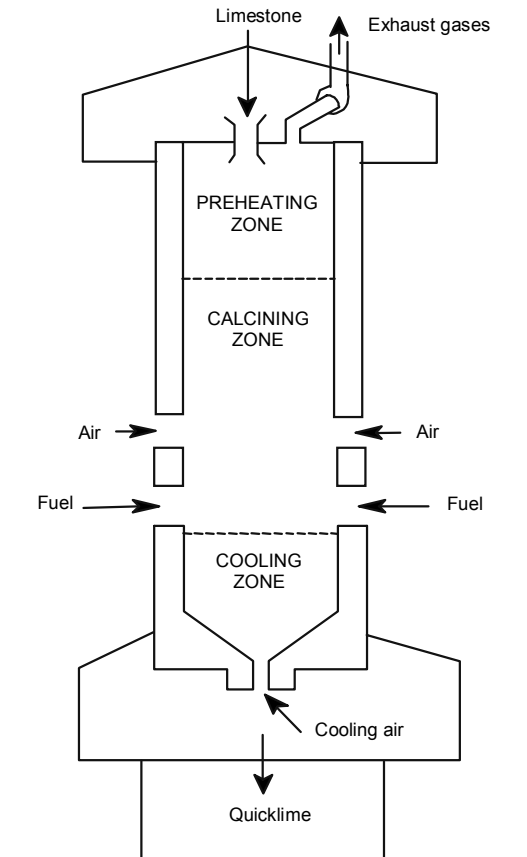
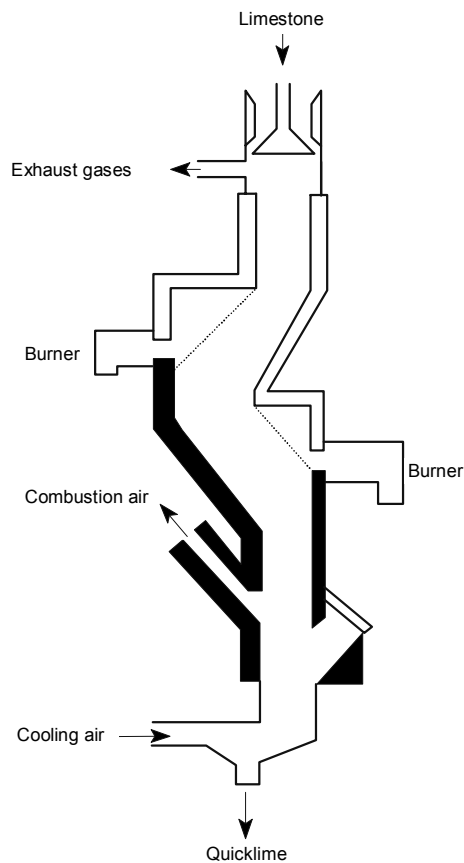


Figure 2-6 - Section of Double Inclined Shaft Kiln



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Lime production

Figure 2-7 - Annular Shaft Kiln

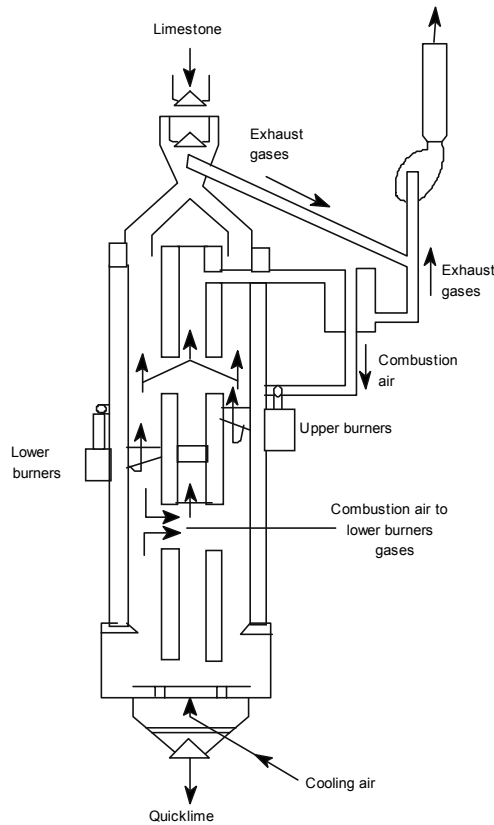
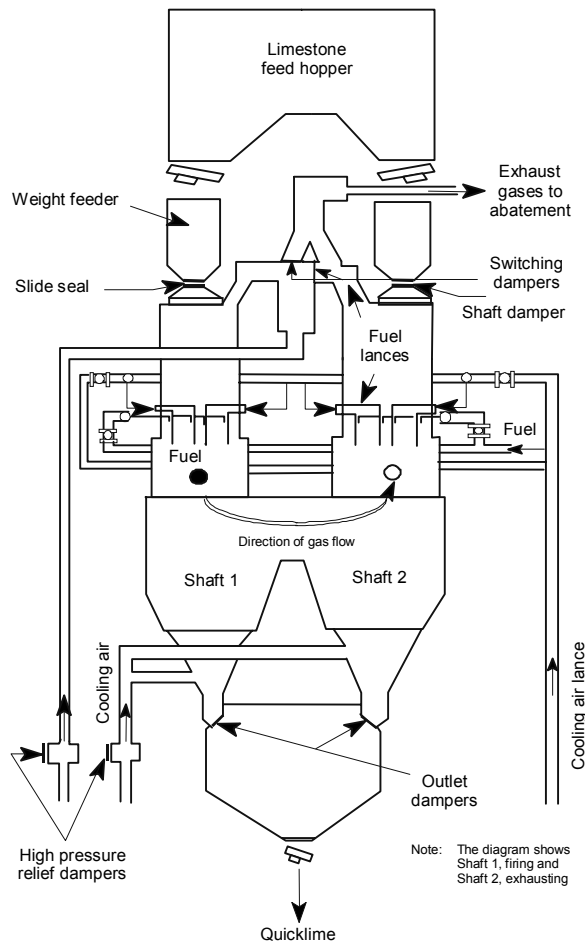


Figure 2-8 - Parallel Flow Regenerative Kiln



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Lime production

Mixed feed shaft kiln

A variation of the simple shaft kiln which uses mixed limestone and coke feed to obtain even heat distribution is known as a mixed feed shaft kiln. The process produces kiln gases with a high CO₂ content so it is suited to processes that use both quicklime and CO₂, such as sugar refining and precipitated calcium carbonate production plants.

Double inclined shaft kiln

Figure 2-6 shows a section through a double inclined shaft kiln in which the feed moves down through two shafts inclined at 60° each equipped with burners.

Annular shaft kiln

Annular shaft kilns have a central cylinder which restricts the width of the kiln and ensures good heat distribution. Recycle of combustion gases back into the lower burner chamber moderates calcination temperatures thus producing high reactivity quicklime. A diagram is given in Figure 2-7.

Parallel flow regenerative kilns

The parallel flow regenerative kiln (or Maerz kiln) has improved fuel consumption compared with other shaft kiln designs. A diagram of the kiln is given in Figure 2-8. The kiln utilises two (or three) interconnected shafts in order to use the limestone as a regenerative heat exchange medium to transfer surplus heat in the exit gas to the combustion air. The burning and charging cycles switch about every 12 minutes between the shafts.

In the Maerz type kiln, it is possible to preheat the combustion air to 800°C and thus the net heat input requirement is lower than in other kilns.

The limestone undergoes its final stages of calcination at moderate temperatures of about 1100°C and so high reactivity quicklime is produced.

Rotary kilns

Modern versions of the rotary kiln incorporate a stone preheater in which hot kiln gases are used to heat the feed limestone. Figure 2-9 shows a diagram of a rotary kiln.

The rotary kiln is set at a slight angle (1 to 2 degrees) from the horizontal, sloping toward the hot end where fuel is introduced. The rotary action of the kiln coupled with the slope causes the limestone to move gradually towards the flame where it is calcined. Having passed the burning zone, the quicklime begins to cool and descends from the kiln into a cooler.

The cooler consists of a chamber in which ambient air is drawn through the quicklime by the kiln induced draught fan. This preheats the combustion air and allows the cooled quicklime to be handled. A series of double flap valves in the bottom of the cooler allow the quicklime to pass out to storage silos.

Rotating hearth kiln

This type of kiln, now almost out of use, consists of an annular travelling hearth carrying the limestone charge. Multiple burners heat the limestone as it travels around the circuit. Use is made of preheating combustion air by using it to cool the product quicklime.

Due to the reduced abrasion compared with rotary and shaft kilns, rotating hearth kilns are used to maximise the production of pebble lime.

Fluidised bed kiln

Figure 2-10 shows a diagram of a fluidised bed kiln. Fine limestone is fed to a preheater vessel using air heated via a heat exchanger on the kiln exhaust gases.

The preheated limestone then enters the first fluidised bed vessel where the temperature is increased and limestone starts to be calcined. As the limestone is calcined, the lighter quicklime flows over the weir wall into the next fluidised bed vessel where calcination is completed.

The quicklime then passes through the cooler where ambient air is used as the cooling medium.

Although fluidised bed technology may offer lower pollutant releases and better heat usage than other lime kiln technologies, it is not well proven and is not generally applicable to the production of all types of lime.

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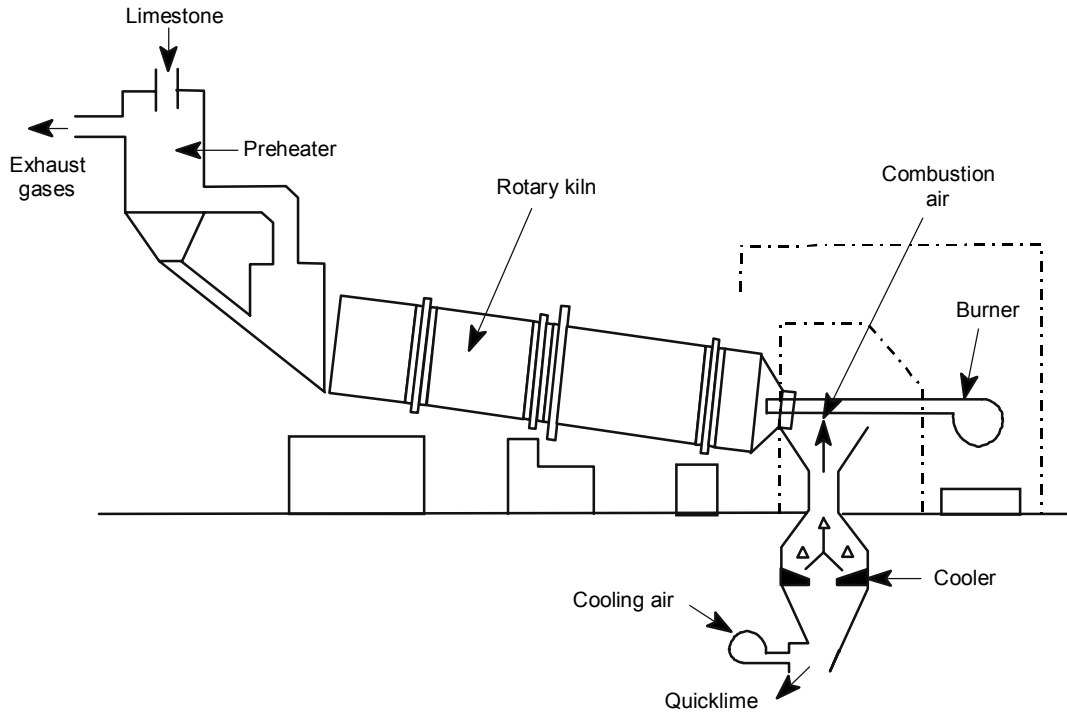


Figure 2-9 - Rotary Kiln

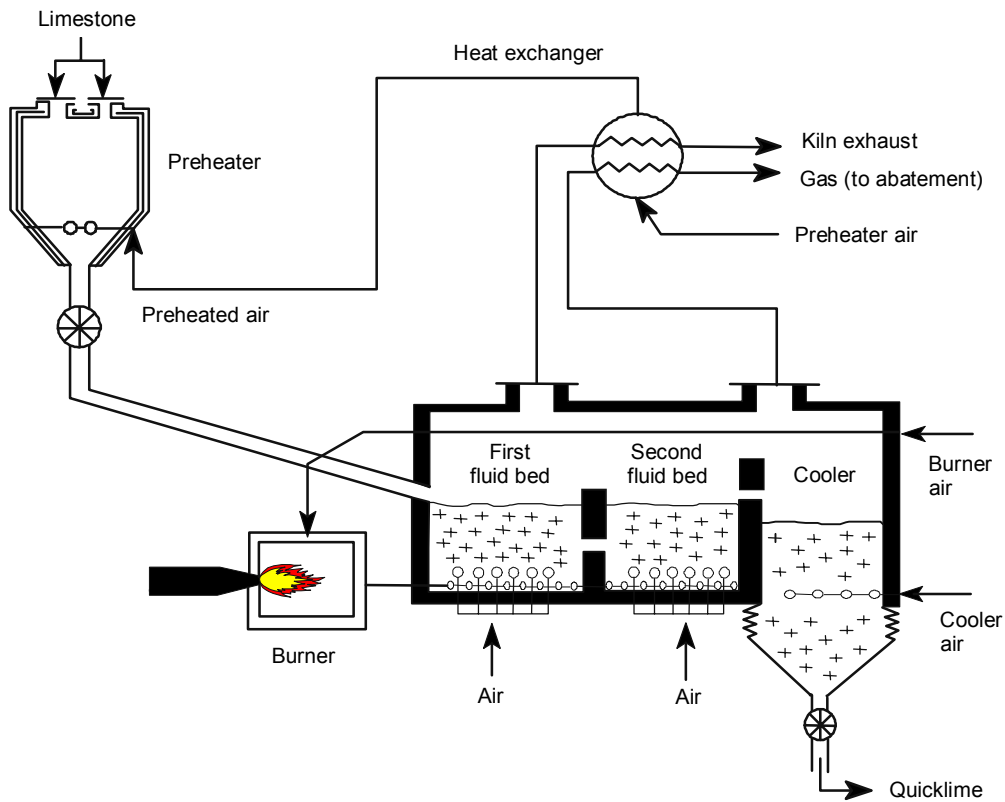


Figure 2-10 - Fluidised Bed Kiln

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Lime production

Product handling and storage

Various grades of quicklime can be produced: for example screened grades which are 6-40mm in size; and, ground grades with 30-99% <75µm. Screen grades are crushed and screened before being stored in a silo. Screened grades may also be milled to produce various grades of ground quicklime which again are transferred to silos for storage. Alternatively, the screened grades may be crushed further before conversion to hydrated lime.

Lime hydration and slaking

The hydration of lime is achieved by the controlled addition of water to the burnt lime in a lime hydrator to produce dry hydrated lime (dry calcium hydroxide powder). The resulting product is air classified prior to storage in silos. Slaked lime is also produced which is a wet product with varying water contents. The term milk of lime is used to describe a fluid suspension of slaked lime in water. Lime putty is used to describe a thick dispersion of slaked lime in water.

For hydrated lime production, the quantity of water is about twice the stoichiometric amount required for the hydration reaction. The excess water is added to moderate the temperature generated by the heat of reaction by conversion to steam. The steam, which is laden with particulates, passes through abatement prior to discharge to atmosphere.

There are many designs of equipment but typically the hydrator consists of pairs of contra-rotating screw paddles which vigorously agitate the lime in the presence of water. A lime hydrator is shown in Figure 2-11. A strongly exothermic reaction takes place generating 272 kcals/kg of CaO. The average residence time of the solids in the main reactor is about 15 minutes. The heat release causes a vigorous boiling action which creates a partially fluidised bed. Dust is entrained in the steam, which is evolved during the process. If this dust is collected in a wet scrubber a milk of lime suspension is produced, which is normally returned to the hydrator. The amount of water that can be added, is limited to the process requirement of the hydrator.

After hydration the product is transferred to an air-swept classifier where the coarse and fine fractions are separated using a recycling air stream. Part or all of the coarse fractions may be ground and recycled. The fine fraction is conveyed to storage silos. From here it is either discharged to bulk transport or transferred to a packing plant where it is packed in sacks or intermediate bulk containers.

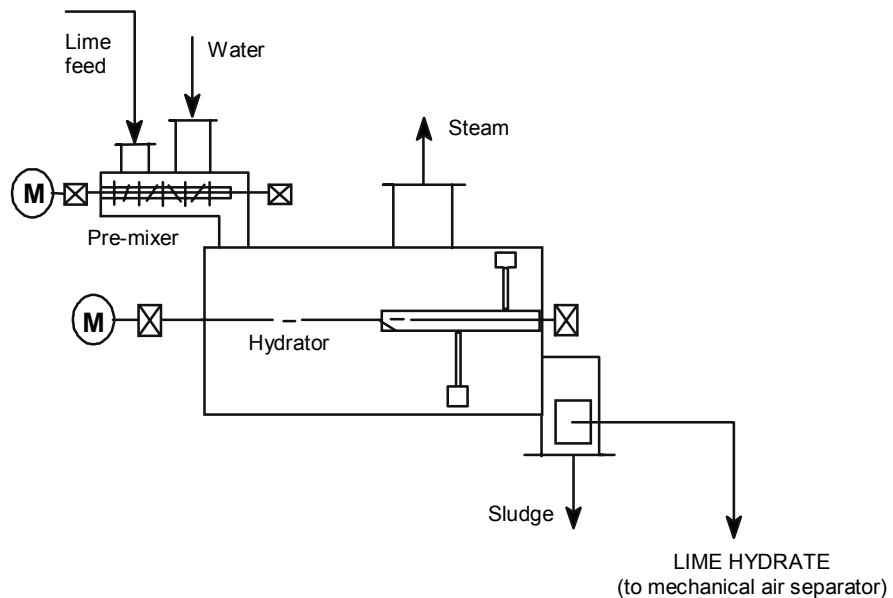


Figure 2-11 - A Lime Hydrator

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Lime production

Application Form
Question 2.3 (cont.)

Lime production processes

With the Application the Operator should:

1. supply the general Application requirements for Section 2.3 listed on [page 28](#) for this aspect of the activities;

Indicative BAT Requirements

1. The choice of lime kiln technology will be installation specific. For new plant and major up-grades Operators should consider the available options and demonstrate that the chosen option is BAT.

BAT

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Abatement to air

Guidance

2.3.4 Control of point source emissions to air

The nature and source of the emissions expected from each activity is given in previous sections and will be confirmed in detail in the Operator's response to Section 3.1.

Cross-sectoral guidance on abatement techniques for point source emissions to air can be found in Ref. 11.

Application Form Question 2.3 (cont.)	Control of Point Source Emissions to Air
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With the Application the Operator should:

- supply the general Application requirements for Section 2.3 on page 28 for control and abatement equipment; and in addition
- describe the measures and procedures in place and proposed to prevent or reduce point source emissions to air. This should include, but is not limited to, the general measures described below. Justify where any of the measures are not employed.
- provide the following with the application as appropriate. If there is doubt, the degree of detail required should be established in pre-application discussions:
 - a description of the abatement equipment for the activity;
 - the identification of the main chemical constituents of the emissions (particularly for mixtures of VOCs) and assessment of the fate of these chemicals in the environment;
 - measures to increase the security with which the required performance is delivered;
 - measures to ensure that there is adequate dispersion of the emission(s) to prevent exceedances of local ground level pollution thresholds and limit national and transboundary pollution impacts, based on the most sensitive receptor, be it human health, soil or terrestrial ecosystems;
 - damage to health or soil or terrestrial ecosystems.
- demonstrate that an appropriate assessment of vent and chimney heights has been made. Guidance is given in Technical Guidance Note D1 (Ref. 13); and may need to be supported by more detailed dispersion modelling as described in Section 4.1
- where appropriate, also recognise the chimney or vent as an emergency emission point and the likely behaviour. Process upsets or equipment failure giving rise to abnormally high emission levels over short periods should be assessed. Even if the Applicant can demonstrate a very low probability of occurrence, the height of the chimney or vent should nevertheless be set to avoid any significant risk to health. The impact of fugitive emissions can also be assessed in many cases

Indicative BAT Requirements

- The Operator should complete any detailed studies required into abatement or control options (see item 3 in Section 2.3) as an improvement condition to a timescale to be agreed with the Regulator but in any case within the timescale given in Section 1.1;

Particulate matter

- Fabric filters** should be used for new plant and to replace EPs on major plant up-grades on cement, raw meal and coal mills. They should also be used as appropriate by the lime industry on kiln exhausts with careful control of temperature using air to air heat exchangers
- The fabric filter should have multiple compartments, which can be individually isolated in case of bag failure. There should be sufficient of these to allow adequate performance to be maintained when filter bags fail. There should be bag burst detectors on each compartment to indicate the need for maintenance when this happens.
- Although fabric filters are unlikely to induce explosion of incompletely combusted fuel or explosive gas mixtures, they may be damaged if such explosions are initiated elsewhere. Explosion venting should be installed, particularly in pulverised fuel systems where fire detection and automatic suppression are also necessary.

Cont.

BAT

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Abatement to air

BAT for particulate matter (cont.)

5. Fabric Filters are favoured because of their simplicity, reliability, higher removal rates than EPs and economic competitiveness. Furthermore they can remove SO₂ by absorption in the alkaline cakes of collected dust on the surface of the bags, particularly in lime production. Also removed are substances that absorb onto particles such as dioxins/furans and metals if present. A recent development is filter bags impregnated with a catalyst designed to destroy dioxins and furans - see item 21 below.
6. **Electrostatic precipitators (EPs)** on existing plant should achieve exit dust loadings of less than 30 mg/Nm³. When existing EPs do not meet this standard Operators are required to submit up-grade proposals. Upgrade techniques include:
 - the introduction of vanes to even out gas flows;
 - upgrading of electrical systems;
 - optimising rapping cycles;
 - consideration of the use of conditioning towers upstream of the EP in order to introduce water vapour into the gas stream and improve precipitator performance;
 - consideration of the use of in-duct conditioning sprays to control gas temperatures;
 - conversion of the final EP field to bag filtration or total replacement with bag filters should be considered where a major up-grade is required.
7. Significant changes in the gas conditions entering EPs can be induced by the intermittent operation of raw meal mills through which kiln gases are exhausted. Operators should demonstrate that procedures are in place for the management of the start-up and shut-down of raw meal mills to eliminate sudden changes in gas conditions and optimise EP performance.
8. A disadvantage of EPs is the risk of sparking off explosions of partially burned fuel or gas mixtures, resulting from incomplete combustion in the kiln. The risk is minimised by automatically tripping the EP when the carbon monoxide content of the kiln gas entering the EP reaches a pre-set level (below the lower explosive limit). Particulate releases will rise significantly during CO trips so every effort should be made to minimise their duration and frequency. Short duration EP trips would be expected to result in lower mass particulate releases over time compared to the alternative of stopping and restarting the kiln. EPs should be fitted with fast measuring and control equipment to minimise the number of CO trips.
9. Equipment suppliers are developing technology that reduces voltages instead of completely tripping the system based on careful monitoring of CO levels thereby reducing the periods when the EP is off line. This technology has yet to be proved in industrial conditions but its availability should be kept under review.

Gravel bed filters do not have the same temperature limitation as fabric filters. They are capable of cleaning gases with temperatures in excess of 500°C, although they also function best at low humidities. They are suited to clinker cooler operations and are capable of achieving between 50 - 100 mg/Nm³ but not much lower. They are no longer installed as their maintenance costs are high and their efficiency is not comparable with that obtainable from EPs and bag filters. Thus for existing plant, Operators are required to assess the releases and consider options to upgrade.
10. **Wet scrubbing**

Various wet scrubbers are in use mainly in the lime industry. They give rise to liquid effluent, which, if not recycled into the process, requires treatment and disposal. This has implications when considering the BPEO. Wet scrubbers are usually chosen when the exhaust gas temperatures are close to, or below the dew point e.g. lime hydrator exhausts.

A common issue with lime hydrators is the very visible water vapour plume. The entrained dust particles act as condensation nuclei thereby causing the plume to be more persistent than would otherwise be the case. Some plants are fitted with a purpose designed wet scrubber while others are fitted only with cyclones, irrigated cyclones or simple water sprays which will not achieve the releases given in Section 3.2. For existing plants, Operators need to assess current performance and where necessary submit up-grade proposals.

It should be noted that procedures should be in place to ensure the water usage matches the needs of the hydrator to avoid a disposal problem of the resulting alkaline milk of lime. In addition, the scrubber performance should not be susceptible to the effects of build-up of solid deposits.

Cont.

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Abatement to air

BAT for NO_x

Oxides of nitrogen

11. The following techniques are recommended to reduce oxides of nitrogen discharges to the atmosphere.

Primary NO_x measures

12. **Kiln control**

Careful control of kiln burning parameters will reduce NO_x formation and level out the variability of releases. Control of oxygen content is critical to NO_x control. Generally the lower the oxygen content at for instance a cement kiln back end, the less NO_x is produced. However, this has to be balanced against increases in CO and SO₂ at lower oxygen levels.

Several cement equipment suppliers have developed expert automatic control systems based usually on the control of the burn by monitoring NO_x levels. These systems have found favour with several cement manufacturers and, it is claimed, can lead to significant reductions on the overall release of NO_x.

Operators should have kiln control strategies in place that ensure optimum kiln performance.

13. **Choice of fuel and raw material**

Some fuels and raw materials contain higher nitrogen contents than others.

The physical state of fuels also affects NO_x releases. Liquid fuels are easier to control and tend to produce less thermal NO_x than solid fuels due to the reduction in local hot spot formation. For solid fuels, thermal NO_x evolution seems to be related to fineness; the finer the grind, the lower the NO_x again probably related to hot spots.

Operators should have control measures in place that ensures solid fuel grinding is maintained at optimum levels of fineness.

14. **Flame cooling**

Addition of water to the fuel or directly to the flame reduces the temperature and increases the concentration of the hydroxyl radicals. This can have a positive effect on NO_x reduction in the burning zone, reduction efficiency from 0 - 50% has been reported. Additional heat is required to evaporate the water, which causes slight additional CO₂ emissions (approximately 0.1 - 1.5%) compared to the total CO₂ emission of the kiln. Water injection can cause kiln operation problems.

15. Operators are required to demonstrate they have considered this technique and give sufficient justification if it is considered not appropriate.

16. **Low NO_x (or low primary air) burners**

The principle of these burners is the reduction of localised hot spots by the use of induced gas swirl and low primary air rates. There has been some debate as to the effectiveness of these burners in reducing NO_x, but there is no doubt that in some applications reduction in NO_x of up to 30% have been achieved. These burners are only suitable for rotary kilns and should be employed on such kilns.

17. **Kiln configuration/staged combustion techniques**

Of cement kilns, dry preheater/precalciner kilns produce the lowest specific NO_x releases, with wet kilns generally giving the highest releases due to the higher fuel requirements. Some kiln suppliers have developed low NO_x kiln technology. This technology relies on producing reducing zones, for instance in the lower section of a pre-calciner chamber where NO_x is chemically reduced. The excess CO produced in these zones is oxidised in other areas of the system such as the upper sections of calciner chambers.

Various designs of lime kilns have been developed based on the technology used in modern cement kilns. These include travelling grate kiln technology and a gas suspension calcination process. Refer to the BREF for details (Section 2.2.4.3).

New plants should be designed to fully exploit low NO_x kiln technology. However, scale of operation should be taken into account when considering this technology for lime production. See section 3.3 for threshold production levels.

Cont.

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Abatement to air

BAT for NO_x (cont.)

18. **Mid-kiln firing**

In long wet and long dry kilns the creation of a reducing zone by burning lump fuel can reduce NO_x emissions. For example there is evidence to show that the burning of tyres and tyre chips significantly reduces NO_x levels in cement production. This reduction is probably due to formation of reducing zones where the tyres are being burned. However, back end oxygen levels may need to be increased to ensure kiln conditions are sufficiently oxidising to minimise SO₂ emissions. Tyres can be introduced into rotary kilns using properly designed feed systems. Tyre chips are not usually burnt in the main kiln burner but are used to fuel the calciners or the pre-heater cyclones in cement processes. NO_x reductions of 20-40% have been reported.

Mid-kiln technology is considered well proven on many plants around the world, ([Ref. 27 Draft Entec report](#)). Consequently Agency protocols for tyre trials are currently being revised to streamline the Permitting process.

Mid-kiln firing should therefore be employed where possible to minimise NO_x emissions.

19. **Mineralised clinker**

The addition of mineralisers to the raw material is a technology to adjust the clinker quality and allow the sintering zone temperature to be reduced. By lowering the burning temperature, NO_x formation is reduced. The NO_x reduction might be in between 10 and 15% but up to 50% has been reported.

Calcium fluoride is one example of a mineraliser, but excessive additions could lead to an increase in HF releases.

The Operator needs to demonstrate consideration of this technique to reduce sintering temperatures.

Secondary NO_x measures

20. **Selective non catalytic reduction (SNCR)**

Injection of **NH₂-X compounds** into kiln systems reduces NO_x formation by chemically reducing it to nitrogen and water. Some cement equipment suppliers offer such systems and substantial reductions in NO_x are claimed. The technique relies on an optimum temperature window of about 800 to 1000°C, and sufficient retention time must be provided for the injected agents to react with NO. The right temperature window is easy to obtain in pre-heater and pre-calciner kilns and possibly in some Lepol kilns. Other kiln systems pose physical injection problems into the required temperature zone. It may be possible to utilise CKD recycling systems for this purpose. The most common NH₂-X agent is ammonia water of about 25% NH₃. Other possible reduction agents which can be employed on an industrial scale are ammonia gas, urea solutions, nitrolime or cyanamide and similar other substances. For most applications ammonia water is used.

There are 18 full-scale SNCR installations in operation in the EU and EFTA countries. This technology could also be applied to lime production.

NO_x levels should be monitored and the addition of ammonia closely controlled to minimise the possibility of ammonia slippage and the potential for the formation of ammonium chloride fume.

SNCR should normally be used where NO_x emissions are above benchmark release levels. Scale of operation should be taken into account when considering this technology for lime production. See [Section 3.3](#) for production threshold levels.

21. **Selective catalytic reduction (SCR)**

SCR reduces NO and NO₂ to N₂ with the help of NH₃ and a catalyst at a temperature range of about 300-400°C. This technology is widely used for NO_x abatement in other industries (coal-fired power stations, waste incinerators). In the cement industry, two systems are being considered: low dust exhaust and high dust exhaust gas treatment. Low dust exhaust gas systems require reheating of the exhaust gases after dedusting, resulting in additional cost. High dust systems are considered preferable for technical and economical reasons. As the catalysts remove hydrocarbons as well, SCR technology has a high reduction potential to reduce VOCs, CO and dioxins.

The first full-scale SCR plant has recently been commissioned (outside the UK) and is undergoing proving trials. This could be considered a proven technique within 12 months.

Cont.

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Abatement to air

BAT for SO₂

22. **NO_x control: cost/benefit study**

Operators should provide a cost benefit study using the methodology in H1 (Ref. 6), to demonstrate the relative merits of primary measures, SNCR and SCR for the installation. The comparison will show the cost per tonne of NO_x abated over the projected life of the plant using the asset lives and typical discount rates given in that document.

Sulphur dioxide

23. Techniques recommended to minimise SO₂ releases are summarised below:

Primary SO₂ measures

24. **Kiln type**

In cement production, pre-heater and calciner kilns offer the highest levels of inherent absorption of SO₂ into the clinker whilst wet kilns generally provide less effective absorption.

Most lime kiln technology ensures that SO₂ is absorbed in the quicklime with fluidised beds and shaft kilns being good absorbers.

25. **Raw materials and fuel selection**

If sulphur does not enter the kiln system then it cannot be released. Limiting sulphur contents of both raw materials and fuels will therefore reduce releases of SO₂.

Selective quarrying techniques may provide the possibility of leaving high sulphur seams of limestone in the quarry. Also the blending of limestones of differing sulphur contents may lead to more uniform release concentrations of SO₂. However, the practicable application of this technique may be difficult, (see Section 1.7.3).

26. **Kiln control**

As with NO_x, close control of kiln conditions, particularly oxygen level can reduce releases of SO₂ and should reduce the variability of the release.

Operators should have kiln control strategies in place that ensure optimum kiln performance.

Secondary SO₂ measures

Up to 75% reductions in SO₂ can be achieved by:

27. **Absorbent addition**

The addition of absorbents such as slaked lime (Ca(OH)₂), quicklime (CaO) or activated fly ash with high CaO content to the exhaust gas of the kiln can absorb some of the SO₂. Absorbent injection can be applied in dry or wet form. The resulting gypsum can be used in cement milling in place of imported gypsum.

For pre-heater kilns it has been found that direct injection of slaked lime into the exhaust gas is less efficient than adding slaked lime to the kiln feed. This technique is suitable for cleaning gas streams with moderate SO₂ concentrations, and can be applied at an air temperature of over 400°C. It is recommended to use a (Ca(OH)₂) based absorbent with a high specific surface area and high porosity. Slaked lime does not have a high reactivity, therefore Ca(OH)₂/SO₂ molar ratios of between 3 and 6 have to be applied. Gas streams with high SO₂ concentrations require 6-7 times the stoichiometric amount of absorbent, implying high operation costs.

SO₂ reductions of 60 to 80% can be achieved by absorbent injection in suspension pre-heater kiln systems. For initial levels above 1200 mg/m³ adding slaked lime to the kiln feed is not cost effective. Also there might be a risk of higher sulphur recirculation and kiln instability as higher levels of sulphur are returned to the kiln when this technique is applied.

Absorbent addition can be used to ensure that emission limits are not exceeded in peak situations.

Cont.

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Abatement to air

BAT for SO₂ (cont.)

28. **Dry scrubber**
 To reduce very high SO₂ emissions (more than 1500mg/m³) a separate scrubber is required. One type of scrubber installed at a cement works uses a venturi reactor column to produce a fluidised bed consisting of a blend of slaked lime and raw meal. The intensive contact between gas and absorbent, the long residence time and low temperature (close to the dew point) allow efficient absorption of SO₂. The gas leaving the venturi is loaded with absorbent which is collected in an electrostatic precipitator. A portion of the collected absorbent is returned to the scrubber, and the other portion is added to the kiln inlet and duly converted into clinker. The additional sulphur content of the clinker reduces the amount of additional gypsum required by the cement mill.
- An SO₂ reduction of 90% may be achieved. A dry scrubber will also reduce emissions of HCl and HF. Dry scrubbers can be fitted to all dry kiln types. However, the economic implications of using these techniques must be carefully considered.
29. **Wet scrubber**
 SO₂ is absorbed by a liquid/slurry sprayed in a spray tower. The absorbent can be calcium carbonate, hydroxide or oxide. This technique is in use in the UK. The slurry is sprayed in counter current to the exhaust gas and collected in a recycle tank at the bottom of the scrubber where the formed sulphite is oxidised with air to sulphate and forms calcium sulphate dihydrate. The dihydrate is separated and used as gypsum in cement milling and the water is returned to the scrubber.
- The SO₂ reduction achieved can be more than 90%. The wet scrubber also significantly reduces HCl, residual dust, metal and NH₃ emissions. A wet scrubber can be fitted to all kiln types. However, the economic implications of using these techniques must be carefully considered.
30. **Activated carbon**
 One equipment supplier markets a two-stage travelling bed filter system using activated coke. The only unit in operation is outside the UK on a pre-calciner cement process. The activated coke system not only removes SO₂, but heavy metals and organic compounds. The plant also uses ammonia injection to minimise NO_x releases and the activated coke removes any consequent ammonia slippage. Removal efficiencies of up to 80% are reported. The spent coke is used to fuel the kiln process.
- The temperatures within the carbon bed have to be carefully controlled to prevent burning of the material within the bed.
- Considerable capital investment is required to install such equipment.
31. **Bypass streams - cement kilns**
 Bypass streams can contain high concentrations of SO₂. This SO₂ can be abated by the addition of hydrated lime to the conditioning tower prior to particulate abatement.
- An equipment supplier also offers a gas suspension absorbers that both cool and desulphurise the bypass gas stream, although the technique is not yet well proven on cement processes.
- The technique uses CKD (with or without added lime) as the absorption medium.
32. **SO₂ control: Cost/benefit study**
 Operators should provide a cost benefit study using the methodology in H1 (Ref. 6), to demonstrate the relative merits of primary and secondary measures for the installation. The comparison will show the cost per tonne of SO₂ over the projected life of the plant using the asset lives and typical discount rates given in that document.
- Other releases**
33. **Carbon oxides (CO₂, CO)**
 All measures that reduce fuel energy use also reduce the CO₂ emissions. The selection, when possible, of raw materials with low organic matter content and fuels with low ratio of carbon content to calorific value reduces CO₂ emissions.
- The selection, when possible, of raw materials with low content of organic matter also reduces the emission of CO.

Cont.

BAT for other releases

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Abatement to air

BAT for other releases (cont.)

34. **Dioxins and furans**

Although fitting carbon filters, or catalyst impregnated fabric filters, can abate the release of dioxins, the primary method of minimising releases is by careful control of post kiln conditions. The gas residence times, temperatures and oxygen contents within kiln systems are such that any dioxins/furans should be efficiently destroyed. However, Operators should ensure that the conditions for *de novo* synthesis after the kiln are avoided. Therefore, kiln exit gas streams should be quickly cooled through the *de novo* temperature region between 450°C and 200°C prior to particulate abatement. Sample points should be located downstream where the gas stream temperature is guaranteed to be below 200°C.

Dioxin/furan formation needs sources of organic materials and chlorine and thus the limiting of chlorine input may have some effect.

Dioxins tend to adhere to particulate matter and therefore efficient particulate abatement will remove dioxin/furans from the gas phase. Bag filters impregnated with catalyst specifically developed for the destruction of dioxins/furans are now commercially available and, where fabric filters are installed, should be used where the benchmarks in [Section 3.8](#) cannot be otherwise achieved.

35. **Metals**

Feed materials high in volatile metals should be avoided.

Non volatile elements remain within the process and exit the kiln as part of the cement clinker composition. Metal emissions (except mercury) are to a large extent bound to particulates and are therefore minimised by the same abatement strategies for particulates.

36. **Wet plumes**

Wet plumes do not disperse well and tend to ground easily. Additionally there can be local visual amenity issues and, in severe cases, loss of light issues. Therefore the gas should be discharged ideally at conditions of temperature and moisture content that avoid saturation under a wide range of weather conditions.

The normal option is to reduce water input to the process. Alternatively heat can be added, however the use of energy should be balanced against the benefits gained. Plumes must be abated sufficiently to ensure good dispersion but a limited visible plume may be acceptable in cold damp conditions.

Alternatively moisture can be removed by cooling and condensation followed by reheat. However, where this is not an inherent part of a wet scrubbing process (where temperature is typically reduced to around 70°C for scrubbing purposes), the disadvantage would be the generation of a significant liquid effluent stream.

As a further option, to minimise expense and energy use, Operators may wish to guarantee to reduce load under extreme weather conditions rather than to over design a plume abatement system.

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Effluent treatment

2.3.5 Abatement of point source emissions to surface water and sewer

The nature and source of the emissions expected from each activity is given in previous sections and will be confirmed in detail in the Operator's response to Section 3.1. In general, wastewater can arise from the process activity, from storm water, from cooling water, from accidental emissions of raw materials, products or waste materials, and from fire-fighting. In addition to the BREF and the techniques below, guidance on cost-effective effluent treatment techniques can be found in ETBPP Guides (Ref. 9).

Application Form
Question 2.3 (cont.)

Effluent Treatment

With the Application the Operator should:

1. supply the general Application requirements for Section 2.3 on page 28 to prevent or reduce point source emissions to water and land; and in addition
2. include, where appropriate, off site treatment in the description of the wastewater treatment system for the activity;
3. provide, where effluent is discharged, a justification for not cleaning the effluent to a level at which it can be reused (e.g. by ultrafiltration where appropriate);
4. describe measures taken to increase the reliability with which the required control and abatement performance is delivered (there may be a biological plant susceptible bulking or poisoning – what measures ensure reliability?, heavy metals are measured only occasionally – what techniques ensure that they are controlled all the time? etc.); identify the main chemical constituents of the treated effluent (including the make-up of the COD) and assessment of the fate of these chemicals in the environment. These steps will be carried out as in response to Sections 3.1 and 4.1 but need to be understood here in order to demonstrate that the controls are adequate. This applies whether treatment is on- or off-site;
5. identify the toxicity of the treated effluent (see Section 2.10). Until the Regulator's toxicity guidance is available, this should, unless already in hand, normally be carried out as part of an improvement programme;
6. where there are harmful substances or levels of residual toxicity, identify the causes of the toxicity and the techniques proposed to reduce the potential impacts;
7. consider of whether the effluent flow is sufficient to fall within the requirements of the Urban Waste Water Treatment Directive.

Indicative BAT Requirements

1. The Operator should complete any detailed studies required into abatement or control options (see item 3 in Section 2.3) as an improvement condition to a timescale to be agreed with the Regulator but in any case within the timescale given in Section 1.1;
2. The following general principles should be applied in sequence to control emissions to water:
 - water use should be minimised and wastewater reused or recycled (see Section 2.2.3);
 - contamination risk of process or surface water should be minimised (see Section 2.3.7);
 - ultimately, surplus water is likely to need treatment to meet the requirements of BAT (and statutory and non-statutory objectives). Generally, effluent streams should be kept separate as treatment will be more efficient. However, the properties of dissimilar waste streams should be used where possible to avoid adding further chemicals, e.g. neutralising waste acid and alkaline streams. Also, biological treatment can occasionally be inhibited by concentrated streams, while dilution, by mixing streams, can assist treatment;
 - systems should be engineered to avoid effluent by-passing the treatment plant.

Cont.

BAT for effluent

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Effluent treatment

BAT for effluent (cont.)

3. All emissions should be controlled, as a minimum, to avoid a breach of water quality standards (see Sections 3.2 and 4.1) but noting that where BAT can deliver prevention or reduction at reasonable cost it should do so (see Section 1.1). Calculations and/or modelling to demonstrate this will be carried out in response to Section 4.1.
4. With regard to BOD, the nature of the receiving water should be taken into account. However, in IPPC the prevention or reduction of BOD is also subject to BAT and further reductions which can be made at reasonable cost should be carried out. Furthermore, irrespective of the receiving water, the adequacy of the plant to minimise the emission of specific persistent harmful substances must also be considered. Guidance on treatment of persistent substances can be found in References (see Ref. 12).
5. Where effluent is treated off-site at a sewage treatment works, the above factors apply in particular demonstrating that:
 - the treatment provided at the sewage treatment works is as good as would be achieved if the emission was treated on-site, based on reduction of load (not concentration) of each substance to the receiving water;
 - the probability of sewer bypass, via storm/emergency overflows or at intermediate sewage pumping stations, is acceptably low;
 - action plans in the event of bypass, e.g. knowing when bypass is occurring, rescheduling activities such as cleaning or even shutting down when bypass is occurring;
 - a suitable monitoring programme is in place for emissions to sewer, taking into consideration the potential inhibition of any downstream biological processes and actions plan for any such event.

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Fugitives

2.3.6 Control of fugitive emissions to air

On many installations fugitive, or diffuse, emissions may be more significant than point source emissions. Details will be found in the appropriate sector guidance but common examples of the sources of fugitive emissions are:

- open vessels (e.g. the effluent treatment plant);
- storage areas (e.g. bays, stockpiles, lagoons etc.);
- the loading and unloading of transport containers;
- transferring material from one vessel to another (e.g. furnace, ladle, reactors, silos);
- conveyor systems;
- pipework and ductwork systems (e.g. pumps, valves, flanges, catchpots, drains, inspection hatches etc.);
- poor building containment and extraction;
- potential for bypass of abatement equipment (to air or water);
- accidental loss of containment from failed plant and equipment.

Application Form
Question 2.3 (cont.)

Fugitive emissions to air

With the Application the Operator should:

1. supply the general Application requirements for Section 2.3 on [page 28](#) for control of fugitive emissions to air; and in addition,
2. identify, and where possible quantify, significant fugitive emissions to air from all relevant sources, including those below, estimating the proportion of total emissions which are attributable to fugitive releases for each substance; these steps will be carried out as in response to [Section 3.1](#) but need to be understood here in order to demonstrate that the controls are adequate.

Indicative BAT Requirements

1. The Operator should complete any detailed studies required into abatement or control options (see [item 3](#) in Section 2.3) as an improvement condition to a timescale to be agreed with the Regulator but in any case within the timescale given in Section 1.1.
2. Where there are opportunities for reductions, the Permit may require the updated inventory of fugitive emissions to be submitted on a regular basis.
3. **Dust** - The following general techniques should be employed where appropriate:
 - covering of skips and vessels;
 - avoidance of outdoor or uncovered stockpiles (where practicable);
 - where unavoidable, use of sprays, binders, stockpile management techniques, windbreaks etc.;
 - wheel and road cleaning (avoiding transfer of pollution to water and wind blow);
 - closed conveyors, pneumatic conveying (noting the higher energy needs), minimising drops;
 - mobile and stationary vacuum cleaning;
 - ventilation and collection in suitable abatement equipment;
 - closed storage with automatic handling system;
 - regular housekeeping.
4. **VOCs**
 - When transferring volatile liquids, eg. SLF, the following techniques should be employed – subsurface filling via filling pipes extended to the bottom of the container, the use of vapour balance lines that transfer the vapour from the container being filled to the one being emptied, or an enclosed system with extraction to suitable abatement plant.

Cont.

BAT for fugitives

[BREF Sections](#)

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Fugitives

BAT for fugitives (cont.)

- Vent systems should be chosen to minimise breathing emissions (e.g. pressure/vacuum valves) and, where relevant, should be fitted with knock-out pots and appropriate abatement equipment.

5. **Odour** - See [Section 2.3.8](#).

Particulate releases from other process operations have the potential for significant fugitive dust release. Control measures to minimise such releases are summarised below:

6. **Housekeeping**

A high standard of house-keeping should be maintained in all areas with particular attention being paid to those parts of the plant where process and waste materials are stored or loaded. Loading and unloading of vehicles should only be done in designated areas provided with proper hard-standing. Hardstanding areas should be constructed with appropriate falls to an adequate drainage system.

7. **Materials handling**

The receipt, handling and storage of all materials should be carried out so as to minimise the emission of dust to the air.

Stocks of dusty materials, should be stored in silos or covered storage, vented to air if necessary through suitable arrestment equipment.

Bulk cement, clinker and quicklime should be stored in closed buildings or silos. These silos should be vented to suitable arrestment plant, for example bag filters. Storage silos should be equipped with audible or visual high level alarms to warn of overfilling. The correct operation and use of such alarms should be checked regularly.

Seating of pressure relief valves to all silos should be checked periodically.

For emissions from ancillary processing equipment (crushing, screening, blending, packing, loading etc.), dust containment and arrestment should be the preferred option. However, it is recognised that in some cases, such as remote mineral conveyors, suppression techniques where properly designed, used and maintained, can be an effective alternative means of control.

The transfer of cement or lime should be by air slide, elevator, screw feeder, enclosed chain conveyor, gravity or pneumatic means or suitably enclosed belt conveyor. Transport of other dusty materials, such as clinker, inside buildings should be carried out so as to prevent or minimise airborne dust emissions. Where conveyors are used, they should be of sufficient capacity to handle maximum loads and should be provided with protection against wind-whipping, for example by fitting side boards. Conveyor discharges should be arranged to minimise free fall at all times. Where dusty materials are conveyed outside buildings, above ground conveyors (or other mechanical means) should be fully enclosed and extracted to suitable arrestment plant.

Other materials which may generate airborne dust emissions, for example crushed rock, coarse aggregate, or coal should be delivered, stored and handled so as to prevent or minimise dust emissions - for example by dampening or covering.

Road vehicles or rail wagons should be loaded in such a way as to minimise airborne dust emissions. If they are loaded with dry materials, this should be carried out where local dust control measures are provided, for example extract ventilation to arrestment plant.

The packing of lime and cement into bags should be carried out using purpose-designed plant fitted with extraction equipment and the displaced air ducted to suitable arrestment plant, for example bag filters. Arrestment plant should be fitted with a failure warning device, for example a pressure drop sensor and alarm.

All spillages should be cleaned up promptly using, for example, a vacuum cleaner or vacuum system. Particular attention should be paid to preventing and cleaning up deposits of dust on support structures and roofs in order to minimise wind entrainment of deposited dust.

In designing a new process, consideration should be given to a layout, which minimises vehicle movement on site.

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Fugitives

2.3.7 Control of fugitive emissions to surface water, sewer and groundwater

Application Form
Question 2.3 (cont.)

Fugitive Emissions to Water

With the Application the Operator should:

1. supply the general Application requirements for Section 2.3 on [page 28](#) for control of fugitive emissions to air; and in addition,
2. identify, and quantify where possible quantify, significant fugitive emissions to water from all relevant sources, estimating the proportion of total emissions which are attributable to fugitive releases for each substance; these steps will be carried out as in response to [Section 3.1](#) but need to be understood here in order to demonstrate that the controls are adequate.

Indicative BAT Requirements

1. Where there are opportunities for reductions, the Permit may require the updated inventory of fugitive emissions to be submitted on a regular basis.
2. **Subsurface structures – the Operator should:**
 - establish and record the routing of all installation drains and subsurface pipework;
 - identify all subsurface sumps and storage vessels;
 - engineer systems to ensure leakages from pipes etc are minimised and where these occur, can be readily detected, particularly where hazardous (e.g. listed) substances are involved;
 - provide in particular, secondary containment and/or leakage detection for such subsurface pipework, sumps and storage vessels;
 - establish an inspection and maintenance programme for all subsurface structures, e.g. pressure tests, leak tests, material thickness checks or CCTV.
3. **Surfacing – the Operator should:**
 - describe the design(#),and condition of the surfacing of all operational areas;
 - have an inspection and maintenance programme of impervious surfaces and containment kerbs;
 - justify where operational areas have not been equipped with:
 - an impervious surface;
 - spill containment kerbs;
 - sealed construction joints;
 - connection to a sealed drainage system.

(# Relevant information may include as appropriate: capacities; thicknesses; falls; material; permeability; strength/reinforcement; resistance to chemical attack; inspection and maintenance procedures; and quality assurance procedures.)
4. **Bunds**
All tanks containing liquids whose spillage could be harmful to the environment should be banded. For further information on bund sizing and design, [see Ref. 12](#). Bunds should:
 - be impermeable and resistant to the stored materials;
 - have no outlet (i.e. no drains or taps) and drain to a blind collection point;
 - have pipework routed within banded areas with no penetration of contained surfaces;
 - be designed to catch leaks from tanks or fittings;
 - have a capacity which is the greater of 110% of the largest tank or 25% of the total tankage;
 - be subject to regular visual inspection and any contents pumped out or otherwise removed under manual control after checking for contamination;
 - where not frequently inspected, be fitted with a high-level probe and an alarm as appropriate;
 - have fill points within the bund where possible or otherwise provide adequate containment;
 - have a routine programmed inspection of bunds, (normally visual but extending to water testing where structural integrity is in doubt).

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Odour

2.3.8 Odour

Application Form
Question 2.3 (cont.)

Odour control

With the Application the Operator should:

- supply the general Application requirements for Section 2.3 on [page 28](#) for odour control; and in addition, where odour could potentially be a problem, the Operator should:
- categorise the emissions as follows:**
 - a high level release which is expected to be acknowledged in the Permit** – i.e. there will be an allowed release from the process (e.g. An odorous release from a stack or high level scrubber) and an element of BAT is adequate dispersion between source and receptor to prevent odour nuisance. The release will be allowed under the Permit but it is acknowledged that, under certain conditions, the plume may ground causing odour problems. Conditions in Permits are likely to be based on the actions to take when such events occur.
 - release should be preventable** – i.e. releases can normally be contained within the site boundary by using BAT such as containment, good practice or odour abatement.
 - release is not preventable under all circumstances** e.g. from a landfill or uncovered effluent treatment plant but potential problems are controlled by a programme of good practice measures;
- for each relevant category, demonstrate that there will not be an odour problem from the emissions under normal conditions (see odour guidance).
- for each relevant category, identify the actions to be taken in the event of abnormal events or conditions which might lead to odour, or potential odour problems (see odour guidance).
- describe the current or proposed position with regard to any techniques given below or in [Ref. 23](#).

Indicative BAT Requirements

- The requirements for odour control will be sector specific and dependant upon the sources and nature of the potential odour. In general terms:
 - where odour can be contained, for example within buildings, the Operator should ensure that the maintenance of the containment and the management of the operations are such as to prevent its release at all times;
 - Where odour releases are permitted, (see examples above):
 - for new installations or significant changes, the releases should be modelled to demonstrate a low frequency of ground level concentrations above the odour threshold (or other threshold of acceptability). For occasions where weather conditions or other incidents are liable, in the view of the Regulator, to cause exceedances of the threshold of acceptability, the Operator should take appropriate and timely action, including shutting down the operations, to prevent further annoyance,
 - for existing installations, the same principle applies, except that where experience shows there to be no odour problem such modelling and actions will not be necessary.
- For complex installations, for example where there are a number of potential sources of odorous releases or where there is an extensive programme of improvements to bring odour under control, an odour management plan should be maintained. The Regulator may incorporate the odour management plan in the Permit.

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Groundwater

Groundwater protection legislation

2.4 Emissions to Groundwater

The Groundwater Regulations came into force on 1 April 1999 (see [Appendix 2](#) for equivalent legislation in Scotland and Northern Ireland). An IPPC Permit will be subject to the following requirements under these Regulations.

- i. It shall not be granted at all if it would permit the direct discharge of a List I substance (Regulation 4(1)) (except in limited circumstances – see note 1 below).
- ii. If the Permit allows the disposal of a List I substance or any other activity which might lead to an indirect discharge (see note 2 below) of a List I substance then **prior investigation** (as defined in Regulation 7) is required and the Permit shall not be granted if this reveals that indirect discharges of List I substances would occur and in any event conditions to secure prevention of such discharges must be imposed (Regulation 4(2) and (3)).
- iii. In the case of List II substances, Permits allowing direct discharges or possible indirect discharges cannot be granted unless there has been a prior investigation and conditions must be imposed to prevent groundwater pollution (Regulation 5).
- iv. The Regulations contain further detailed provisions covering **surveillance** of groundwater (Regulation 8); conditions required when direct discharges are permitted (Regulation 9); when indirect discharges are permitted (Regulation 10); and review periods and compliance (Regulation 11).

The principles, powers and responsibilities for groundwater protection in England and Wales, together with the Agency’s policies in this regard, are outlined in the Environment Agency’s document “*Policy and Practice for the Protection of Groundwater*”(PPPG) (see [Ref. 24](#)). This outlines the concepts of vulnerability and risk and the likely acceptability from the Agency’s viewpoint of certain activities within groundwater protection zones.

- A Prior investigation** of the potential effect on groundwater of on-site disposal activities or discharges to groundwater. Such investigations will vary from case to case, but the Regulator is likely to require a map of the proposed disposal area; a description of the underlying geology, hydrogeology and soil type, including the depth of saturated zone and quality of groundwater; the proximity of the site to any surface waters and abstraction points, and the relationship between ground and surface waters; the composition and volume of waste to be disposed of; and the rate of planned disposal.
- B Surveillance** - this will also vary from case to case, but will include monitoring of groundwater quality and ensuring the necessary precautions to prevent groundwater pollution are being undertaken.

Note 1 The Regulations state that, subject to certain conditions, the discharges of List I substances to groundwater may be authorised if the groundwater is “permanently unsuitable for other uses”. Advice must be sought from the Regulator where this is being considered as a justification for such discharges.

Note 2 List I and List II refer to the list in the Groundwater Regulations and should not be confused with the similar lists in the Dangerous Substances Directive.

Application Form
Question 2.4

Identify if there may be a discharge of any List I or List II substances and if any are identified, explain how the requirements of the Groundwater Regulations 1998 have been addressed.

With the Application the Operator should:

1. confirm that there are no direct or indirect emissions to groundwater of List I or List II substances from the installation, or
2. where there are such releases, provide the information and surveillance arrangements described in A and B above.

Under these Regulations the Permit may not be granted if the situation is not satisfactory, therefore, with the application, the Operator should supply information on list I and list II substances and if necessary, prior investigation and surveillance information:

Meeting the requirements of the Groundwater Regulations

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Groundwater

List I and List II substances

List I

- 1.-(1) Subject to sub-paragraph (2) below, a substance is in list I if it belongs to one of the following families or groups of substances-
 - (a) organohalogen compounds and substances which may form such compounds in the aquatic environment;
 - (b) organophosphorus compounds;
 - (c) organotin compounds;
 - (d) substances which possess carcinogenic, mutagenic or teratogenic properties in or via the aquatic environment (including substances which have those properties which would otherwise be in list II);
 - (e) mercury and its compounds;
 - (f) cadmium and its compounds;
 - (g) mineral oils and hydrocarbons;
 - (h) cyanides.
2. A substance is not in list I if it has been determined by the Agency to be inappropriate to list I on the basis of a low risk of toxicity, persistence and bioaccumulation.

List II

- 1.-(1) A substance is in list II if it could have a harmful effect on groundwater and it belongs to one of the families or groups of substances:
 - (a) the following metalloids and metals and their compounds:

Zinc	Tin	Copper
Barium	Nickel	Beryllium
Chromium	Boron	Lead
Uranium	Selenium	Vanadium
Arsenic	Cobalt	Antimony
Thallium	Molybdenum	Tellurium
Titanium	Silver	
 - (b) biocides and their derivatives not appearing in list I;
 - (c) substances which have a deleterious effect on the taste or odour of groundwater, and compounds liable to cause the formation of such substances in such water and to render it unfit for human consumption;
 - (d) toxic or persistent organic compounds of silicon, and substances which may cause the formation of such compounds in water, excluding those which are biologically harmless or are rapidly converted in water into harmless substances;
 - (e) inorganic compounds of phosphorus and elemental phosphorus;
 - (f) fluorides;
 - (g) ammonia and nitrites
- (2) A substance is also in list II if-
 - (a) it belongs to one of the families or groups of substances set out in paragraph 1(1) above;
 - (b) it has been determined by the Agency to be inappropriate to list I under paragraph 1(2); and
 - (c) it has been determined by the Agency to be appropriate to list II having regard to toxicity, persistence and bioaccumulation.
- 3.-(1) The Secretary of State may review any decision of the Agency in relation to the exercise of its powers under paragraph 1(2) or 2 (2).
- 3.-(2) The Secretary of State shall notify the Agency of his decision following a review under sub-paragraph (1) above and it shall be the duty of the Agency to give effect to that decision.
- 4.- The Agency shall from time to time publish a summary of the effect of its determinations under this Schedule in such manner as it considers appropriate and shall make copies of any such summary available to the public free of charge.

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2.5 Waste Handling

This section relates to the management of waste produced at the installation as opposed to waste brought into any waste management installations.

The normal nature and source of the waste from each activity is given in Section 2.3 and will be confirmed in detail in the Operator's response to Section 3.1. In general the waste streams comprise:

- Cement and lime kiln dust collected in particulate abatement devices
- Materials arising from process clean outs
- Spent kiln liner bricks
- Waste oils and lubricants
- Chemical containers and general inert industrial waste.

Application Form
Question 2.5

Characterise and quantify each waste stream and describe the proposed measures for waste management storage and handling.

With the Application the Operator should:

1. identify and quantify the waste streams;
2. identify the current or proposed handling arrangements;
3. describe the current or proposed position with regard to the techniques below or any others which are pertinent to the installation;
4. demonstrate that the proposals are BAT, by confirming compliance with the indicative requirements, by justifying departures (as described in Section 1.2 and in the Guide to Applicants) or alternative measures.

Indicative BAT Requirements

1. A system should be maintained to record the quantity, nature, origin and where relevant, the destination, frequency of collection, mode of transport and treatment method of any waste which is disposed of or recovered.
2. Wherever practicable, waste should be segregated and the disposal route identified which should be as close to the point of production as possible.
3. Records should be maintained of any waste sent off-site (Duty of Care).
4. Storage areas should be located away from watercourses and sensitive boundaries e.g. adjacent to areas of public use and protected against vandalism.
5. Storage areas should be clearly marked and signed and containers should be clearly labelled.
6. The maximum storage capacity of storage areas should be stated and not exceeded. The maximum storage period for containers should be specified.
7. Appropriate storage facilities should be provided for special requirements such as for substances that are flammable, sensitive to heat or light etc., and incompatible waste types should be kept separate.
8. Containers should be stored with lids, caps and valves secured and in place. This also applies to emptied containers.
9. Storage containers, drums etc. should be regularly inspected.
10. Procedures should be in place to deal with damaged or leaking containers.
11. All appropriate steps to prevent emissions (e.g. liquids, dust, VOCs and odour) from storage or handling should be taken (see Sections 2.3.6, 2.3.7 and 2.3.8).

BAT
BREF Sections

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2.6 Waste Recovery or Disposal

The Regulations require the Regulator, in setting Permit conditions, to take account of certain general principles including that the installation in question should be operated in such a way that: “waste production is avoided in accordance with Council Directive 75/442/EEC on waste; and where waste is produced it is recovered, or where this is technically or economically impossible it is disposed of, while avoiding or reducing the impact on the environment”. The objectives of the National Waste Strategies should also be considered.

In order to meet this requirement the Regulator needs Operators to provide the information below.

Application Form
Question 2.6

Describe how each waste stream is proposed to be recovered or disposed of. If you propose any disposal, explain why recovery is technically and economically impossible and describe the measures planned to avoid or reduce any impact on the environment.

With the Application the Operator should:

1. describe, in respect of each waste stream produced by the installation, whether the waste in question is to be recovered or disposed of, and if a disposal option is planned, to justify why recovery is “technically and economically impossible” together with “the measures planned to avoid or reduce any impact on the environment”;
2. include in the description, the Operator’s view as to whether waste disposal is likely to be restricted by the implementation of the Landfill Directive;
3. describe the current or proposed position with regard to the techniques below or any others which are pertinent to the installation;
4. demonstrate that the proposals are BAT, by confirming compliance with the indicative requirements, by justifying departures (as described in Section 1.2 and in the Guide to Applicants) or alternative measures;

Indicative BAT Requirements

1. Unless agreed with the Regulator to be inappropriate, the Operator should provide a detailed assessment identifying the best practicable environmental options for waste disposal. For existing activities, this may be carried out as an improvement condition to a timescale to be approved by the Regulator.
2. The aim for all processes covered by this Note should be to prevent the creation of waste containing substances prescribed for release to land or which could cause harm. Where this is not possible, releases should be minimised by attention to raw materials and process routes, and by recycling wastes arising within the process or re-using them elsewhere.
3. The key pollutants likely to be present in releases to land can be derived from a knowledge of the process, materials of construction, corrosion/erosion mechanisms and materials related to maintenance, validated as necessary by the appropriate analytical techniques. The presence of substances created by abnormal operation should be identified, since process abnormalities can carry through substances into the solid waste that are not normally present.
4. The most significant potential solid waste from cement and lime processes is particulate matter collected in dust abatement devices. This dust tends to concentrate trace impurities in fuels and raw materials such as certain semi-volatile metals and dioxins. If calcium oxide is present in sufficient concentration (greater than 10%w/w) the waste would be classified a special waste.
5. Whether recycling is possible will depend on site-specific factors such as the particular fuels, raw materials, products and methods of operation.
6. In cement production, this material should be recycled to the production processes whenever practicable. This recycle may be directly into the kiln or kiln feed (alkali content being the limiting factor) or by blending with finished cement products. Alternative uses may be found for material that cannot be recycled. For example CKD has been used in civil engineering (soil stabilisation) and construction (lightweight aggregates and blocks).

BAT

BREF Sections

Cont.

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BAT (cont.)

7. For lime processes direct recycle of kiln dust back to the kiln process is difficult and alternative uses of the materials should be examined (similar to CKD).
8. Adequate facilities should be provided for the on-site storage, handling, loading and transportation of wastes prior to their removal from the area covered by the site Permit.
9. If no uses can be found for collected dust, then disposal to controlled landfill will be necessary.

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2.7 Energy

BAT for energy efficiency under the PPC Regulations will be satisfied provided the Operator meets the following conditions:

either

- the Operator meets the basic energy requirements in sections 2.7.1 and 2.7.2 below and is a participant to a Climate Change Agreement (CCA) or Trading Agreement with the government

or

- the Operator meets the basic energy requirements in sections 2.7.1 and 2.7.2 below and the further sector-specific energy requirements in section 2.7.3 below.

Note that even where a Climate Change Agreement or Trading Agreement is in place, this does not preclude the consideration of energy efficiency as part of an integrated assessment of Best Available Techniques in which it may be balanced against other emissions.

Further guidance is given in the Energy Efficiency Guidance Note (Ref. 14).

2.7.1 Basic energy requirements (1)

Application Form
Question 2.7 (part 1)

Provide a breakdown of the energy consumption and generation by source and the associated environmental emissions.

The requirements of this section are basic, low cost, energy standards which apply whether or not a Climate Change Agreement or Trading Agreement is in force for the installation.

With the Application the Operator should:

BAT

BREF Sections

- provide the following Energy consumption information:**

Energy consumption information should be provided in terms of delivered energy and also, in the case of electricity, converted to primary energy consumption. For the public electricity supply, a conversion factor of 2.6 should be used. Where applicable, the use of factors derived from on-site heat and/or power generation, or from direct (non-grid) suppliers should be used. In the latter cases, the Applicant shall provide details of such factors. Where energy is exported from the installation, the Applicant should also provide this information. An example of the format in which this information should be presented is given in Table 2.3 below. The Operator should also supplement this with energy flow information (e.g. "Sankey" diagrams or energy balances) showing how the energy is used throughout the process.

(Note that the Permit will require energy consumption information to be submitted annually)

Table 2.3 - Example breakdown of delivered and primary energy consumption

Energy source	Energy consumption		
	Delivered, MWh	Primary, MWh	% of total
Electricity*			
Gas			
Oil			
Other (Operator to specify)			

* specify source.

- provide the following Specific Energy consumption information**

The Operator should define and calculate the specific energy consumption of the activity (or activities) based on primary energy consumption for the products or raw material inputs which most closely match the main purpose or production capacity of the installation. The Operator should provide a comparison of Specific Energy Consumption against any relevant benchmarks available for the sector.

- provide associated environmental emissions**

This is dealt with in the Operator's response to Section 3.1.

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2.7.2 Basic energy requirements (2)

Application Form
Question 2.7 (part 2)

Describe the proposed measures for improvement of energy efficiency.

The requirements of this section are basic, low cost, energy standards which apply whether or not Climate Change Agreement or Trading Agreement is in force for the installation.

With the Application the Operator should:

1. describe the current or proposed position with regard to the **Basic, low cost energy requirements** below, and provide justifications for not using any of the techniques described;
2. provide an energy efficiency plan which appraises the costs and benefits of different energy options as described below.

Basic Energy Requirements

1. **Operating, maintenance and housekeeping measures** should be in place in the following areas, according to the checklists provided in Appendix 2 of the IPPC Energy Efficiency Guidance Note, where relevant:
 - air conditioning, process refrigeration and cooling systems (leaks, seals, temperature control, evaporator/condenser maintenance);
 - operation of motors and drives;
 - compressed gas systems (leaks, procedures for use);
 - steam distribution systems (leaks, traps, insulation);
 - space heating and hot water systems;
 - lubrication to avoid high friction losses;
 - boiler maintenance e.g. optimising excess air;
 - other maintenance relevant to the activities within the installation.
2. **Basic, low cost, physical techniques** should be in place to avoid gross inefficiencies; to include insulation, containment methods, (e.g. seals and self-closing doors) and avoidance of unnecessary discharge of heated water or air (e.g. by fitting simple control systems).
3. **Building services** energy efficiency techniques should be in place to deliver the requirements of the Building Services Section of the Energy Efficiency Guidance Note. For energy-intensive industries these issues may be of minor impact and should not distract effort **from** the major energy issues. They should nonetheless find a place in the programme, particularly where they constitute more than 5% of the total energy consumption.
4. **provide an energy efficiency plan** which:
 - identifies all techniques relevant to the installation, including those listed below and in Section 2.7.3;
 - identifies the extent to which these have been employed;
 - prioritises the applicable techniques according to the appraisal method provided in the Energy Efficiency Guidance Note which includes advice on appropriate discount rates, plant life etc.;
 - identifies any techniques that could lead to other adverse environmental impacts, thereby requiring further assessment (e.g. according to methodology, [see Ref. 6](#)).

Where other appraisal methodologies have been used, state the method, and provide evidence that appropriate discount rates, asset life and expenditure (£/t) criteria have been employed.

This should be submitted in a summary format similar to the example below, together with supporting information from any appraisal procedure carried out. The plan is required to ensure that the Operator has considered all relevant techniques. **However, where a Climate Change Agreement or Trading Agreement is in place the Regulator will only enforce implementation of those measures in categories 1-3 above.**

Cont.

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Table 2.4 - Example Format for Energy Efficiency Measures

Energy efficiency option	NPV £k	CO ₂ savings (tonnes)		NPV/CO ₂ saved £/tonne	Priority* for implementation
		annual	lifetime		
7MW CHP plant	1,372	13,500	135,000	10	high
High efficiency motor	0.5	2	14	35	medium
Compressed air	n/a	5	n/a	n/a	immediate

* Indicative only, based on cost/benefit appraisal:

Where a Climate Change Agreement or Trading Agreement is in place, the Energy Efficiency Plan should be submitted as an improvement condition to a timescale to be agreed with the Regulator but in any case within the timescale given in Section 1.1.

5. **Energy management techniques** should be in place, according to the requirements of Section 2.1 noting, in particular, the need for monitoring of energy flows and targeting of areas for reductions.

2.7.3 Further energy efficiency requirements

Application Form
Question 2.7 (part 3)

Describe the proposed measures for improvement of energy efficiency.(only where the installation is not the subject of a Climate Change Agreement or Trading Agreement).

Where there is no Climate Change Agreement or Trading Agreement in place, the Operator should demonstrate the degree to which the further energy efficiency measures identified in the implementation plan, including those below, have been taken into consideration for this sector and justify where they have not.

With the Application the Operator should:

1. identify which of the measures below are applicable to the activities, and include them in the appraisal for the energy efficiency plan in section 2.7.2.
2. describe the current or proposed position with regard to the techniques below, or any others which are pertinent to the installation;
3. demonstrate that the proposals are BAT, by confirming compliance with the indicative requirements, by justifying departures (as described in Section 1.2 and in the Guide to Applicants) or alternative measures;

Indicative BAT Requirements

The following techniques should be implemented where they are judged to be BAT based on a cost/benefit appraisal according to the methodology provided in Appendix 4 of the [Energy Efficiency Guidance note \(Ref. 14\)](#).

1. **Energy efficiency techniques**

Within IPPC it is valid to consider both the emission of direct (heat and emissions from on-site generation) and indirect (emissions from a remote power station) pollution when considering options for energy efficiency.

Cement process selection: change from conventional wet and semi-wet process to dry with multi-stage preheating and precalcination. This option is identified as BAT on new plants and major upgrades.

Improve process control: kiln optimisation is applicable to all kilns and can include many elements ranging from installation of expert control systems, instruction/training of kiln operators, raw material preparation, fuel feed control, monitoring of product quality.

Heat recovery from exhaust gases: utilise for drying of raw material, coal or intergrinding matter, generate electricity.

Cont.

BAT for energy

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BAT for energy (cont.)

Mineralised clinkers: add mineralisers such as calcium fluoride to -

- increase clinker activity and reduce the clinker content in cement products thus reducing energy use per unit mass of cement product and,
- reduce sintering zone temperature to reduce fuel input requirements.

Blended cements: reducing the clinker content in cement products reduces energy use per unit mass of cement product. Primary blending materials are blast furnace slag, hydrated lime, fly ash, cement kiln dust and pozzolans.

Clinker comminution: Install high-pressure roller press prior to grinding.

Power management systems: Install soft starter controllers to provide rapid voltage response to load for pumps, fans and compressors. For AC motors variable speed drive are applicable to pumps, fans, compressors, conveyors and machinery.

Energy efficient equipment: Install electrically efficient motors that are specifically designed for efficiency such as kiln drives.

Substitute fuels: the use of substitute fuels is not strictly speaking an energy saving technology as it simply replaces fossil fuels, nevertheless depending on the fuel used could reduce carbon emissions.

2. **Energy supply techniques**

- use of CHP;
- recovery of energy from waste;
- use of less polluting fuels.

Irrespective of whether a Climate Change Agreement or Trading Agreement is in place, where there are other BAT considerations involved, such as:

- the choice of fuel impacts upon emissions other than carbon e.g. sulphur in fuel;
- where the potential minimisation of waste emissions by recovery of energy from waste conflicts with energy efficiency requirements;
- the Operator should provide justification that the proposed or current situation represents BAT.

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2.8 Accidents and their Consequences

Guidance

IPPC requires as a general principle that necessary measures should be taken to prevent accidents which may have environmental consequences, and to limit those consequences. This section covers general areas of any installation operations which have the potential for accidental emission.

Some installations will also be subject to the Control of Major Accident Hazards Regulations 1999 (COMAH) (see [Appendix 2](#) for equivalent legislation in Scotland and Northern Ireland). There is an element of overlap between IPPC and COMAH and it is recognised that some systems and information for both regimes may be interchangeable.

The COMAH regime applies to major hazards. For accident aspects covered by COMAH, reference should be made to any reports already held by the Regulator. However, the accident provisions under IPPC may fall beneath the threshold for major accident classification under COMAH and therefore consideration should be given to smaller accidents and incidents as well. Guidance, ([see Ref. 19](#)), prepared in support of the COMAH Regulations may also be of help to IPPC Operators (whether or not they are covered by the COMAH regime) in considering ways to reduce the risks and consequences of accident.

General management requirements are covered in Section 2.1. For accident management, there are three particular components:

- **identification of the hazards** posed by the installation/activity;
- **assessment of the risks** (hazard x probability) of accidents and their possible consequences;
- implementation of **measures to reduce the risks** of accidents, and contingency plans for any accidents that occur.

Application Form
Question 2.8

Describe your documented system proposed to be used to identify, assess and minimise the environmental risks and hazards of accidents and their consequences.

With the Application the Operator should:

1. provide the accident management plan described in the indicative BAT requirements below describing the current or proposed position with regard to the techniques listed below or any others which are pertinent to the installation;
2. demonstrate that the proposals are BAT, by confirming compliance with the indicative requirements, by justifying departures (as described in Section 1.2 and in the Guide to Applicants) or alternative measures;
3. identify any issues which may be critical.

Indicative BAT Requirements

1. A structured accident management plan should be submitted to the Regulator which should:
 - a. ***identify the hazards*** to the environment posed by the installation. Particular areas to consider may include, but should not be limited to, the following:
 - transfer of substances (e.g. loading or unloading from or to vessels);
 - overfilling of vessels;
 - failure of plant and/or equipment (e.g. over-pressure of vessels and pipework, blocked drains);
 - failure of containment (e.g. bund and/or overfilling of drainage sumps);
 - failure to contain firewaters;
 - making the wrong connections in drains or other systems;
 - preventing incompatible substances coming into contact;
 - unwanted reactions and/or runaway reactions;
 - emission of an effluent before adequate checking of its composition has taken place;
 - steam main issues;
 - vandalism.

BAT for control of accidents

Cont.

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BAT for control of accidents (cont.)

- b. Assess the risks** - having identified the hazards, the process of assessing the risks can be viewed as addressing six basic questions:
1. what is the estimated probability of their occurrence? (Source frequency);
 2. what gets out and how much? (Risk evaluation of the event);
 3. where does it get to? (Predictions for the emission – what are the pathways and receptors?);
 4. what are the consequences? (Consequence assessment – the effects on the receptors);
 5. what are the overall risks? (Determination of the overall risk and its significance to the environment);
 6. what can prevent or reduce the risk? (Risk management – measures to prevent accidents and/or reduce their environmental consequences).

The depth and type of assessment will depend on the characteristics of the installation and its location. The main factors which should be taken into account are:

- the scale and nature of the accident hazard presented by the installation and the activities;
- the risks to areas of population and the environment (receptors);
- the nature of the installation and complexity or otherwise of the activities and the relative difficulty in deciding and justifying the adequacy of the risk control techniques.

c. identify the techniques necessary to reduce the risks including:

c1. the following techniques, which are relevant to most installations:

- an inventory should be maintained of substances, present or likely to be present, which could have environmental consequences if they escape. It should not be forgotten that many apparently innocuous substances can be environmentally damaging if they escape (e.g. a tanker of milk spilled into a watercourse could destroy its ecosystem). The Permit will require the Regulator to be notified of any changes to the inventory;
- procedures should be in place for checking raw materials and wastes to ensure compatibility with other substances with which they may accidentally come into contact;
- adequate storage arrangements for raw materials, products and wastes should be provided;
- to ensure that control is maintained in emergency situations, consideration should be given to process design alarms, trips and other control aspects, e.g. automatic systems based on microprocessor control and passing valve control, tank level readings such as ultrasonic gauges, high-level warnings and process interlocks and process parameters;
- preventative techniques, such as suitable barriers to prevent damage to equipment from the movement of vehicles, should be included as appropriate;
- appropriate containment should be provided, e.g. bunds and catchpots, building containment;
- techniques and procedures should be implemented to prevent overfilling of storage tanks (liquid or powder), e.g. level measurement, independent high-level alarms, high-level cut-off, and batch metering;
- installation security systems to prevent unauthorised access should be provided as appropriate and should include maintenance arrangements where necessary;
- there should be an installation log/diary to record all incidents, near-misses, changes to procedures, abnormal events and findings of maintenance inspections;
- procedures should be established to identify, respond to and learn from such incidents;
- the roles and responsibilities of personnel involved in accident management should be identified;
- clear guidance should be available on how each accident scenario should be managed, e.g. containment or dispersion, to extinguish fires or let them burn;
- procedures should be in place to avoid incidents occurring as a result of poor communication among operations staff during shift changes and maintenance or other engineering work;

Cont.

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BAT for control of accidents (cont.)

- safe shutdown procedures should be in place;
 - communication routes should be established with relevant authorities and emergency services both before and in the event of an accident. Post-accident procedures should include the assessment of harm caused and steps needed to redress this;
 - appropriate control techniques should be in place to limit the consequences of an accident, such as oil spillage equipment, isolation of drains, alerting of relevant authorities and evacuation procedures;
 - personnel training requirements should be identified and provided;
 - the systems for the prevention of fugitive emissions are generally relevant (Sections 2.3.6 and 2.3.7) and in addition, for drainage systems:
 - procedures should be in place to ensure that the composition of the contents of a bund sump, or sump connected to a drainage system, are checked before treatment or disposal;
 - drainage sumps should be equipped with a high-level alarm or sensor with automatic pump to storage (not to discharge); there should be a system in place to ensure that sump levels are kept to a minimum at all times;
 - high-level alarms etc. should not be routinely used as the primary method of level control;
- c2.** the following plus any other specific techniques identified as necessary to minimise the risks as identified in 1 and 2 above:
- adequate redundancy or standby plant should be provided with maintenance and testing to the same standards as the main plant;
 - process waters, site drainage waters, emergency firewater, chemically contaminated waters and spillages of chemicals should, where appropriate, be contained and where necessary, routed to the effluent system, with provision to contain surges and storm-water flows, and treated before emission to controlled waters or sewer. Sufficient storage should be provided to ensure that this could be achieved. There should also be spill contingency procedures to minimise the risk of accidental emission of raw materials, products and waste materials and to prevent their entry into water. Any emergency firewater collection system should also take account of the additional firewater flows or fire-fighting foams. Emergency storage lagoons may be needed to prevent contaminated firewater reaching controlled waters (see Refs. 15 and 16);
 - consideration should be given to the possibility of containment or abatement for accidental emissions from vents and safety relief valves/bursting discs. Where this may be inadvisable on safety grounds, attention should be focused on reducing the probability of the emission;

Sector specific techniques

- c3.** The following scenarios are relevant to the sector and should be addressed in the application. Consideration should be given to frequency and duration of events when carrying out this assessment.

Unplanned Shutdowns

- Power cuts and power fluctuations,
- Loss of compressed air supply,
- Mechanical failures,
- Process control failures,
- CO trips (for plants operating electrostatic precipitators),
- Ring falls (gypsum, clinker and ash),
- Process blockages (cyclones and grates and grates of pre-heater kilns),
- Raw mill stoppages.

Cont.

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BAT for control of accidents (cont.)

Loss of containment

- SLF storage and handling,
- Gas oil/diesel storage and handling,
- Lubricants storage and handling,
- LPG storage and handling,
- Process cleanouts (kilns, cyclones, hoppers etc.),
- Pneumatic conveyance,
- Fire water.

Risk of fire and explosion associated with:

- Coal/petcoke grinding, storage and firing systems,
- Substitute fuels storage and handling,
- LPG storage and handling,
- Gas oil/ diesel fuels storage and handling.

Risk of vandalism

- Site security measures

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2.9 Noise and Vibration

Within this section “noise” should be taken to refer to “noise and/or vibration” as appropriate, detectable beyond the site boundary.

The PPC Regulations require installations to be operated in such a way that “*all the appropriate preventative measures are taken against pollution, in particular through the application of BAT*”. The definition of pollution includes “*emissions which may be harmful to human health or the quality of the environment, cause offence to human senses or impair or interfere with amenities and other legitimate uses of the environment*”. BAT is therefore likely to be similar, in practice, to the requirements of the statutory nuisance legislation, which requires the use of “best practicable means” to prevent or minimise noise nuisance.

In the case of noise, “offence to any human senses” can normally be judged by the likelihood of complaints, but in some cases it may be possible to reduce noise emissions still further at reasonable costs, and this may exceptionally therefore be BAT for noise emissions.

For advice on how noise and/or vibration related limits and conditions will be determined see “*IPPC Noise – Part 1 Regulation and Permitting*”, (see Ref. 20).

Application Form
Question 2.9

Describe the main sources of noise and vibration (including infrequent sources); the nearest noise-sensitive locations and relevant environmental surveys which have been undertaken; and the proposed techniques and measures for the control of noise.

Information needed to determine BAT for noise and vibration

With the Application the Operator should:

- provide the following information for **each main source of noise and vibration** that fall within the IPPC installation:
 - the source and its location on a scaled plan of the site;
 - whether continuous/ intermittent, fixed or mobile;
 - the hours of operation;
 - its description, (e.g. clatter, whine, hiss, screech, hum, bangs, clicks, thumps or tonal elements);
 - its contribution to overall site noise emission (categorise each as high, medium or low unless supporting data is available).

A common sense approach needs to be adopted in determining which sources to include. The ones which need to be considered are those which may have environmental nuisance impact; e.g. a small unit could cause an occupational noise issue in an enclosed space but would be unlikely to cause an environmental issue. Conversely a large unit or a number of smaller units enclosed within a building could, for example, cause a nuisance if doors are left open. It must also be remembered that noise, which is not particularly noticeable during the day, may become more noticeable at night.

- provide the information required in (1) for each source plus its times of operation for **Infrequent sources of noise and vibration**, not listed above that fall within the IPPC installation: (such as infrequently operated/ seasonal operations, cleaning/maintenance activities, on-site deliveries/collections/transport or out-of-hours activities, emergency generators or pumps and alarm testing),
- identify **the nearest noise-sensitive sites** (typically dwellings, parkland and open spaces – schools, hospitals and commercial premises may be, depending upon the activities undertaken there) and any other points/boundary where conditions have been applied by Local Authority officers or as part of a planning consent, relating to:
 - the local environment:
 - provide an accurate map or scaled plan showing grid reference, nature of the receiving site, distance and direction from site boundary;
 - conditions/limits imposed which relate to other locations (i.e. boundary fence or surrogate for nearest sensitive receptor):
 - any planning conditions imposed by the Local Authority (day/evening/night*);
 - other conditions imposed by agreements, e.g. limits on operating times, technologies etc;
 - any requirements of any legal notices etc.

Cont.

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Information needed to determine BAT for noise and vibration (cont.)

- (c) the noise environment:
- background noise level, if known (day/night/evening) $L_{A,90,T}$;
 - specific noise level (day/evening/night) $L_{A,eq,T}$; and/or
 - ambient noise level (day/evening/night) $L_{A,eq,T}$, as appropriate;
 - vibration data which may be expressed in terms of the peak particle velocity (ppv) in mm s^{-1} or the vibration dose value (VDV) in $\text{m s}^{-1.75}$.

For noise these are given the meaning as defined in BS4142:1997 "Method for rating industrial noise affecting mixed residential and industrial areas", and to which reference should be made for a full description. For vibration, the appropriate standard is BS6472:1992 "Evaluation of human exposure to vibration in buildings 1 to 80 Hz". In very general terms "background" is taken to be the equivalent continuous A-weighted noise remaining when the source under investigation is not operational averaged over a representative time period, T. The "ambient" level is the equivalent continuous A-weighted combination of all noise sources far and distant, including the source under investigation and "specific noise" is the equivalent continuous A-weighted noise level produced by the source under investigation as measured at a selected assessment point. Both are averaged over a time period, T. BS4142 gives advice on the appropriate reference periods. "Worst case" situations and impulsive or tonal noise should be accounted for separately and not "averaged out" over the measurement period.

4. provide **details of any environmental noise measurement surveys**, modelling or any other noise measurements undertaken relevant to the environmental impact of the site, identifying:
 - the purpose/context of the survey;
 - the locations where measurements were taken;
 - the source(s) investigated or identified;
 - the outcomes.
5. identify any specific local issues and proposals for improvements.
6. describe the current or proposed position with regard to the techniques below, any in [Ref. 20](#) or any others which are pertinent to the installation
7. demonstrate that the proposals are BAT, by confirming compliance with the indicative requirements, by justifying departures (as described in Section 1.2 and in the Guide to Applicants) or alternative measures;

Indicative BAT Requirements

1. The Operator should employ basic good practice measures for the control of noise, including adequate maintenance of any parts of plant or equipment whose deterioration may give rise to increases in noise (eg maintenance of bearings, air handling plant, the building fabric as well as specific noise attenuation measures associated with plant, equipment or machinery).
2. In addition the Operator should employ such other noise control techniques to ensure that the noise from the installation does not give rise to reasonable cause for annoyance, in the view of the Regulator and, in particular should justify where either Rating Levels ($L_{A,eq,T}$) from the installation exceed the numerical value of the Background Sound Level ($L_{A90,T}$), or the absolute levels of 50dB $L_{A,eq}$ by day or 45 by night are exceeded. Reasons why these levels may be exceeded in certain circumstances are given in [Ref. 20](#).
3. In some circumstances "creeping background" [see Ref. 20](#) may be an issue. Where this has been identified in pre application discussions or in previous discussions with the Local Authority, the Operator should employ such noise control techniques as are considered to be appropriate to minimise problems of to an acceptable level within the BAT criteria.
4. Noise surveys, measurement, investigation (which can involve detailed assessment of sound power levels for individual items of plant) or modelling may be necessary for either new or existing installations depending upon the potential for noise problems. Operators may have a noise management plan as part of their management system. More information on such techniques is given in Part 2 of [Ref. 20](#).

Cont.

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Information needed to determine BAT for noise and vibration (cont.)

5. **Heavy machinery**
Primarily: crushers, roller & grinding mills, fan casings, motors/couplings and compressors.

Crushing and grinding of materials is inherently noisy and is usually contained indoors, but where this is insufficient to meet local needs acoustic design of the building structure and doors will be needed.

Good practice is to install vibration-dampening mounts and concrete foundations.

Compressors are normally supplied with an insulating box designed specifically by machine suppliers.

Otherwise, it may be appropriate in some cases to reduce noise by choosing a less noisy machine, but where this is not practicable noise attenuation techniques should be considered such as broad band absorptive silencing. Provision of machine cooling will be needed to dissipate heat.
6. **Air-flow generated**
Primarily stack exhausts, fan inlet/outlet or air intake and ventilation units.

Siting and location should be considered for new plant, but where this is insufficient to meet local needs install outlet silencers.
7. **Internal transport**

Within the curtilages of the site the transport of raw materials and finished products are technically associated activities. The most important consideration is roadway layout to minimise the need for reversing and preferably so it takes place in an area where the buildings shield it from current, or potential future, noise sensitive locations.

If problems persist traffic movement times will need to be limited.

Once off the site, transport is a planning issue.

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2.10 Monitoring

This section describes monitoring and reporting requirements for emissions to all environmental media. Guidance is provided for the selection of the appropriate monitoring methodologies, frequency of monitoring, compliance assessment criteria and environmental monitoring.

Application Form
Question 2.10

Describe the proposed measures for monitoring emissions, including any environmental monitoring, and the frequency, measurement methodology and evaluation procedure proposed.

With the Application the Operator should:

1. describe the current or proposed position with regard to the monitoring requirements below or any others which are pertinent to the installation for "Emissions monitoring", "Environmental monitoring", "Process monitoring" (where environmentally relevant) and "Monitoring standards" employed;
2. provide, in particular, the information described in [requirement 13](#) below;
3. provide justifications for not using any of the monitoring requirements described;
4. Identify shortfalls in the above information which the Operator believes require longer term studies to establish.

Emissions monitoring

The following monitoring parameters and frequency are normally appropriate in this sector. Generally, monitoring should be undertaken during commissioning, start-up, normal operation and shut-down unless the Regulator agrees that it would be inappropriate to do so.

Where effective surrogates are available they may be used to minimise monitoring costs.

Where monitoring shows that substances are not emitted in significant quantities, consideration can be given to a reduced monitoring frequency.

Monitoring and reporting of emissions to water and sewer

1. Cement and lime plants do not generate significant quantities of liquid effluent. Effluent can arise from site surface water run-off, deliberate washing down of surfaces and slaking processes. This effluent has the potential to be alkaline which could cause harm to controlled waters if released directly. For consented discharges, monitoring is required to demonstrate compliance with release limits typically set for flow rate, pH and suspended solids.as follows:

Parameter	Monitoring frequency
Flow rate	Continuous and integrated daily flow rate
pH	Continuous
Temperature	Continuous
Turbidity	Continuous

NB - other parameters specifically limited in the Permit should be monitored. The appropriateness of the above frequencies will vary depending upon the sensitivity of the receiving water and should be proportionate to the scale of the operations.

See section 3, Emission Benchmarks for guidance on appropriate levels.

Cont.

**Table 2-5 -
Water/sewer
emissions
monitoring**

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Emissions monitoring (cont.)

2. In addition, the Operator should have a fuller analysis carried out covering a broad spectrum of substances to establish that all relevant substances have been taken into account when setting the release limits. This should cover the substances listed in Schedule 5 of the Regulations unless it is agreed with the Regulator that they are not applicable. This should normally be done at least annually.
3. Any substances found to be of concern, or any other individual substances to which the local environment may be susceptible and upon which the operations may impact, should also be monitored more regularly. This would particularly apply to the common pesticides and heavy metals. Using composite samples is the technique most likely to be appropriate where the concentration does not vary excessively.
4. In some sectors there may be releases of substances which are more difficult to measure and whose capacity for harm is uncertain, particularly when in combination with other substances. "Whole effluent toxicity" monitoring techniques can therefore be appropriate to provide direct measurements of harm, e.g. direct toxicity assessment. Some guidance on toxicity testing is available (Ref. 21) and the Regulator will be providing further guidance in due course. Except in special circumstances toxicity testing should await that guidance.

Monitoring and reporting of emissions to air

In general:

5. Continuous monitoring would be expected where the releases are significant and where it is needed to maintain good control;
6. Where appropriate, periodic visual and olfactory assessment of releases should be undertaken to ensure that all final releases to air should be essentially colourless, free from persistent trailing mist or fume and free from droplets.
7. **Kiln exhaust gases**
The principal process emissions are usually NO_x, SO₂, oxides of carbon and particulates.

To quantify accurately the emissions, continuous measurements for the following parameters are recommended:
 - **Particulates**
 - **NO_x (as NO₂)**
 - **CO and SO₂** Dependent on the type of process (variation in adsorptive capacity of material within kiln processing system).
 - **Gas flow** should be measured, or otherwise determined, to relate concentrations to mass releases.
 - **Temperature, oxygen and water vapour content** in order to relate measurements to **reference conditions**, the following will need to be determined and recorded:
8. **Influence of fuel type**
 - A wide range of fuels are now being burned in cement (and some lime) kilns. The main fuels are coal and petroleum coke, as well as oil, LPG and gas in the lime industry. Other fuels include substitute fuels such as solvent waste residues, and substitute solid fuels such as scrap tyres, either whole or chipped.
 - Operators should note the supplementary guidance on the procedures to be followed and the considerations to be given to the use of substitute fuels in cement and lime kilns. The current guidance ([Substitute Fuels Protocol, Ref. 26](#)) covers a range of substitute fuels that can influence the process emission characteristics and specifies minimum criteria for operator monitoring at baseline conditions and maximum fuel substitution rate.

Cont.

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Emmissions monitoring (cont.)

Table 2-6 - Substances to be monitored and reported

The following tables show the monitoring frequency and reporting requirements for kilns burning hazardous wastes and kilns not burning wastes.

Substance	HWID			Other (not burning waste) ⁵			Extractive method
	Limit	Continuous	Extractive ¹	Limit	Continuous	Extractive ¹	
SO ₂	Y	Y	Y	Y	Y	Y	Agreed methodology
NO _x	Y	Y	Y	Y	Y	Y	ditto
Particulate	Y	Y	Y	Y	Y	Y	ditto
VOC	Y	Y	Y			Y ³	ditto
HCl	Y	Y	Y			Y ³	ditto
HF	Y		Y ³			Y ³	ditto
Metals	Y		Y ²	Y ⁴		Y ³	ditto
Dioxins & furans	Y		Y ²	Y		Y ³	CEN
CO	Y	Y	Y				Agreed methodology

Notes:

1. All extractive sampling to be undertaken twice per year except as indicated.
2. Samples required every two months in first year of operation.
3. When sampling has indicated that **the substance emission concentration is consistently low and the resulting off-site impact is not significant** the frequency can be reduced to one sample per year.
4. Limit values for metals may be set for those kilns burning petroleum coke.
5. Monitoring requirements for lime kilns will be dependent on a site specific assessment.

Reference Conditions

Temperature 273K, pressure 101.32Kpa, oxygen 11% and dry flue gas.

Table 2-7 - Substances to be monitored, with local records kept

Substance	HWID			Other (not burning waste) ¹			Extractive method
	Limit	Continuous	Extractive	Limit	Continuous	Extractive	
O ₂ measured at back end of kiln		Y			Y		
CO					Y		
O ₂		Y			Y		
Temperature		Y			Y		
Moisture		Y			Y ²		

Notes:

1. Monitoring requirements for lime kilns will be dependent on a site specific assessment.
2. Continuous moisture monitoring not required for those plants using extractive CEM technology, given that samples are dried prior to analysis.

Monitoring and reporting of waste emissions

9. For waste emissions the following should be monitored and recorded:
 - the physical and chemical composition of the waste;
 - its hazard characteristics;
 - handling precautions and substances with which it cannot be mixed;
 - where waste is disposed of directly to land, for example sludge spreading or an on-site landfill, a programme of monitoring should be established that takes into account the materials, potential contaminants and potential pathways from the land to groundwater surface water or the food chain.

Cont.

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Environmental monitoring

Environmental monitoring (beyond the installation)

10. The Operator should consider the need for environmental monitoring to assess the effects of emissions to controlled water, groundwater, air or land or emissions of noise or odour.

Environmental monitoring may be required, e.g. when:

- there are vulnerable receptors;
- the emissions are a significant contributor to an Environmental Quality Standard (EQS) which may be at risk of being exceeded;
- the Operator is looking for departures from standards based on lack of effect on the environment;
- to validate modelling work.

The need should be considered for:

- groundwater, where it should be designed to characterise both quality and flow and take into account short and long-term variations in both. Monitoring will need to take place both up-gradient and down-gradient of the site;
- surface water, where consideration will be needed for sampling, analysis and reporting for upstream and downstream quality of the controlled water;
- air, including odour;
- land contamination, including vegetation, and agricultural products;
- assessment of health impacts;
- noise.

Where environmental monitoring is needed the following should be considered in drawing up proposals:

- determinands to be monitored, standard reference methods, sampling protocols;
- monitoring strategy, selection of monitoring points, optimisation of monitoring approach;
- determination of background levels contributed by other sources;
- uncertainty for the employed methodologies and the resultant overall uncertainty of measurement;
- quality assurance (QA) and quality control (QC) protocols, equipment calibration and maintenance, sample storage and chain of custody/audit trail;
- reporting procedures, data storage, interpretation and review of results, reporting format for the provision of information for the Regulator.

Guidance on air quality monitoring strategies and methodologies can be found in Technical Guidance Notes M8 and M9 (see Ref. 21), for noise (see Ref. 20) and for odour (see Ref. 23).

Likely environmental monitoring requirements for this sector:

To air:

- daily visual monitoring for smoke, fugitive dust and visible plumes. CCTV surveillance is particularly appropriate for monitoring the appearance of key release points such as kiln exhaust stacks, clinker coolers and lime hydrators. Video recordings can be used as supplementary information to process records to substantiate and/ or refute pollution allegation reports.
- daily olfactory odour monitoring may be appropriate depending on local circumstances, with more extensive monitoring if nuisance is occurring or appears likely (see Ref. 23).
- fugitive dust releases are a generic problem to the sector and can result in nuisance complaints. Ambient dust monitoring combined with particle characterisation may be appropriate to attribute contributions from local sources.
- lichen surveys can be used to indicate mean winter SO₂ concentrations, though acid effects near to an installation can be masked by alkaline dust disposition.
- to validate modelling work to demonstrate compliance with standards and objectives specified in the Air Quality Strategy, see Appendix 2.

Cont.

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Environmental monitoring (cont.)

To land:

- lichen surveys can be used to indicate the effects of alkaline dust deposition in the immediate vicinity of installations.
- soil surveys for measurement of dioxin/furans and heavy metals may be appropriate to assess the cumulative impact of existing facilities; surveys should be carried out for new sites to provide baseline data.
- cement kiln dust (CKD) is the principal release. CKD which cannot be reused/ recycled is sent to purpose-designed and controlled landfill where it is monitored and alkaline leachate treated.

To groundwater:

Groundwater sampling may be needed where:

- there is uncertainty about drainage systems, especially on older sites;
- there are discharges to groundwater;
- there are any other deposits to land.

Noise:

See Section 2.9, and Ref. 20 - Noise Regulation, Measurement and Control.

Monitoring of process variables

11. The following process variables have potential environmental impact and are normally monitored in this sector. The Operator should confirm that this is so or justify any alternative arrangements.

- Raw materials and fuels: monitoring for contaminants such as sulphur, heavy metals and halogens,
- Mean time between stops: indicator of overall kiln performance,
- Raw mill downtime: can impact on cement kiln emissions if prolonged and/or frequent.

To ensure optimum kiln performance, process control strategies should be outlined in the application. In particular action levels should be addressed for the following parameters:

- Backend O₂ (1-3% excess air factor for cement manufacture),
- NO_x (as NO₂),
- SO₂: dependent on the type of process (variation in adsorptive capacity of material within kiln processing system),
- CO: burns more slowly than virtually any hydrocarbon and is therefore a good surrogate measure of effective combustion,
- Exhaust gas temperature prior to abatement: to ensure temperatures are maintained sufficiently low (ideally less than 200°C) to minimise the potential for dioxin reformation (*de novo* synthesis),
- Free lime content: indicator of product quality and kiln performance i.e. over/under burning of cement clinker and lime.

Monitoring standards (Standard Reference Methods)

Equipment standards

The Environment Agency has introduced its Monitoring Certification Scheme (MCERTS) to improve the quality of monitoring data and to ensure that the instrumentation and methodologies employed for monitoring are fit for purpose. Performance standards have been published for continuous emissions monitoring systems (CEMs) and continuous ambient monitoring systems (CAMs). Other MCERTS standards are under development to cover manual stack emissions monitoring, portable emissions monitoring equipment, ambient air quality monitors, water monitoring instrumentation, data acquisition and Operators' own arrangements. This will look at installation, calibration and maintenance of monitoring equipment, position of sampling ports and provision of safe access for manual stack monitoring.

12. As far as possible, Operators should ensure their monitoring arrangements comply with the requirements of MCERTS where available, e.g. using certified instruments and equipment, and using a registered stack testing organisation etc. Where the monitoring arrangements are not in accordance with MCERTS requirements, the Operator should provide justification and describe the monitoring provisions in detail. See Environment Agency Website (Ref. 21) for listing of MCERTS equipment

Cont.

Equipment standards MCERTS

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Monitoring standards (cont.)

Standards for sampling and analysis

BREF:
[Monitoring REF document in preparation.](#)

13. The following should be described in the application indicating which monitoring provisions comply with MCERTS requirements or for which other arrangements have been made:
- monitoring methods and procedures (selection of Standard Reference Methods);
 - justification for continuous monitoring or spot sampling;
 - reference conditions and averaging periods;
 - measurement uncertainty of the proposed methods and the resultant overall uncertainty;
 - criteria for the assessment of non-compliance with Permit limits and details of monitoring strategy aimed at demonstration of compliance;
 - reporting procedures and data storage of monitoring results, record keeping and reporting intervals for the provision of information to the Regulator;
 - procedures for monitoring during start-up and shut-down and abnormal process conditions;
 - drift correction calibration intervals and methods;
 - the accreditation held by samplers and laboratories or details of the people used and the training/competencies.

Sampling and analysis standards

14. The analytical methods given in [Appendix 1](#) should be used. In the event of other substances needing to be monitored, standards should be used in the following order of priority:
- Comité Européen de Normalisation (CEN);
 - British Standards Institution (BSI);
 - International Standardisation Organisation (ISO);
 - United States Environmental Protection Agency (US EPA);
 - American Society for Testing and Materials (ASTM);
 - Deutsches Institute für Normung (DIN);
 - Verein Deutscher Ingenieure (VDI);
 - Association Française de Normalisation (AFNOR).

Further guidance on standards for monitoring gaseous releases relevant to IPC/IPPC is given in the Technical Guidance Note 4 (Monitoring) ([see Ref. 21](#)). A series of updated Guidance Notes covering this subject is currently in preparation. This guidance specifies manual methods of sampling and analysis which will also be suitable for calibration of continuous emission monitoring instruments. Further guidance relevant to water and waste is available from the publications of the Standing Committee of Analysts.

If in doubt the Operator should consult the Regulator.

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Management	Materials inputs	Activities & abatement	Ground water	Waste	Energy	Accidents	Noise	Monitoring	Closure	Installation issues

2.11 De-commissioning

The IPPC application requires the preparation of a site report whose purpose, as described in more detail in Refs. 4 and 5 is to provide a point of reference against which later determinations can be made of whether there has been any deterioration of the site and information on the vulnerability of the site.

Application Form
Question 2.11

Describe the proposed measures, upon definitive cessation of activities, to avoid any pollution risk and return the site of operation to a satisfactory state (including, where appropriate, measures relating to the design and construction of the installation).

With the Application the Operator should:

1. supply the site report;
2. describe the current or proposed position with regard to the techniques below or any others which are pertinent to the installation;
3. for existing activities, identify shortfalls in the above information which the Operator believes require longer term studies to establish.

Indicative BAT Requirements

BAT for decommissioning

1. **Operations during the IPPC Permit**
Operations during the life of the IPPC Permit should not lead to any deterioration of the site if the requirements of the other sections of this and the specific sector notes are adhered to. Should any instances arise which have, or might have, impacted on the state of the site the Operator should record them along with any further investigation or ameliorating work carried out. This will ensure that there is a coherent record of the state of the site throughout the period of the IPPC Permit. This is as important for the protection of the Operator as it is for the protection of the environment. Any changes to this record should be submitted to the Regulator.
2. **Steps to be taken at the design and build stage of the activities**
Care should be taken at the design stage to minimise risks during decommissioning. For existing installations, where potential problems are identified, a programme of improvements should be put in place to a timescale agreed with the Regulator. Designs should ensure that:
 - underground tanks and pipework are avoided where possible (unless protected by secondary containment or a suitable monitoring programme);
 - there is provision for the draining and clean-out of vessels and pipework prior to dismantling;
 - lagoons and landfills are designed with a view to their eventual clean-up or surrender;
 - insulation is provided which is readily dismantled without dust or hazard;
 - materials used are recyclable (having regard for operational or other environmental objectives).
3. **The site closure plan**
A site closure plan should be maintained to demonstrate that, in its current state, the installation can be decommissioned to avoid any pollution risk and return the site of operation to a satisfactory state. The plan should be kept updated as material changes occur. Common sense should be used in the level of detail, since the circumstances at closure will affect the final plans. However, even at an early stage, the closure plan should include:
 - either the removal or the flushing out of pipelines and vessels where appropriate and their complete emptying of any potentially harmful contents;
 - plans of all underground pipes and vessels;
 - the method and resource necessary for the clearing of lagoons;
 - the method of ensuring that any on-site landfills can meet the equivalent of surrender conditions;
 - the removal of asbestos or other potentially harmful materials unless agreed that it is reasonable to leave such liabilities to future owners;

Cont.

INTRODUCTION		TECHNIQUES			EMISSIONS			IMPACT		
Management	Materials inputs	Main activities	Ground water	Waste	Energy	Accidents	Noise	Monitoring	Closure	Installation issues

- methods of dismantling buildings and other structures, see [Ref. 25](#) which gives guidance on the protection of surface and groundwater at construction and demolition-sites;
- testing of the soil to ascertain the degree of any pollution caused by the activities and the need for any remediation to return the site to a satisfactory state as defined by the initial site report.

(Note that radioactive sources are not covered by this legislation, but decommissioning plans should be co-ordinated with responsibilities under the Radioactive Substances Act 1993.)

For existing activities, the site closure plan may, if agreed with the Regulator, be submitted as an improvement condition.

INTRODUCTION		TECHNIQUES			EMISSIONS			IMPACT		
Management	Materials inputs	Main activities	Ground water	Waste	Energy	Accidents	Noise	Monitoring	Closure	Installation issues

2.12 Installation Wide Issues

In some cases it is possible that actions which benefit the environmental performance of the overall installation will increase the emissions from one Permit holder's activities. For example, taking treated effluent as a raw water supply will probably slightly increase emissions from that activity but could dramatically cut the total emissions from the whole installation.

Application Form
Question 2.12

Where you are not the only Operator of the installation, describe the proposed techniques and measures (including those to be taken jointly by yourself and other Operators) for ensuring the satisfactory operation of the whole installation.

With the Application the Operator should:

1. where there are a number of separate Permits for the installation (particularly where there are different Operators), **identify** any installation wide issues and opportunities for further interactions between the Permit holders whereby the performance of the overall installation may be improved; and in particular
2. describe the current or proposed position with regard to the techniques below, or any others which are pertinent to the installation;

Indicative BAT Requirements

The possibilities will be both sector and site-specific, and include:

1. communication procedures between the various Permit holders; in particular those needed to ensure that the risk of environmental incidents is minimised;
2. benefiting from the economies of scale to justify the installation of a CHP plant;
3. the combining of combustible wastes to justify a combined waste-to-energy/CHP plant;
4. the waste from one activity being a possible feedstock for another;
5. the treated effluent from one activity being of adequate quality to be the raw water feed for another activity;
6. the combining of effluent to justify a combined or upgraded effluent treatment plant;
7. the avoidance of accidents from one activity which may have a detrimental knock-on effect on the neighbouring activity;
8. land contamination from one activity affecting another – or the possibility that one Operator owns the land on which the other is situated.

BAT across the whole installation

INTRODUCTION		TECHNIQUES			EMISSIONS			IMPACT		
Benchmark comparison	Benchmark status	BOD	COD	Halogens	Heavy metals	Nitrogen oxides	Nutrients	Particulate	Sulphur dioxide	VOCs

3 EMISSION BENCHMARKS

3.1 Emissions Inventory and Benchmark Comparison

Application Form
Question 3.1

Describe the nature, quantities and sources of foreseeable emissions into each medium (which will result from the techniques proposed in Section 2).

With the Application the Operator should:

- provide a table of significant emissions of substances (except noise, vibration, odour or heat which are covered in their respective sections) that will result from the proposals in Section 2 and should include, preferably in order of significance:
 - substance (where the substance is a mixture e.g. VOCs or COD, separate identification of the main constituents or inclusion of an improvement proposal to identify them);
 - source, including height, location and efflux velocity;
 - media to which it is released;
 - any relevant EQS or other obligations;
 - benchmark;
 - proposed emissions normal/max expressed, as appropriate (see Section 3.2), for:
 - mass/unit time;
 - concentration;
 - annual mass emissions.
 - statistical basis (average, percentile etc.);
 - notes covering the confidence in the ability to meet the benchmark values;
 - if intermittent, the appropriate frequencies;
 - plant loads at which the data is applicable;
 - whether measured or calculated (the method of calculation should be provided).

The response should clearly state whether the emissions are current emission rates or those planned following improvements, and should cover emissions under both normal and abnormal conditions for:

- point source emissions to surface water, groundwater and sewer;
- waste emissions (refer to Sections 2.5 and 2.6 – Waste Management);
- point source emissions to air;
- significant fugitive emissions to all media, identifying the proportion of each substance released which is due to fugitives rather than point source releases;
- abnormal emissions from emergency relief vents, flares etc.;
- indirect and direct emission of carbon dioxide associated with energy consumed or generated.

Emissions of carbon dioxide associated with energy use should be broken down by energy type and, in the case of electricity, by source e.g. public supply, direct supply or on site generation. Where energy is generated on site, or from a direct (non-public) supplier, the Operator should specify and use the appropriate factor. Standard factors for carbon dioxide emissions are provided in the Energy Efficiency Guidance Note.

Where VOCs are released, the main chemical constituents of the emissions should be identified. The assessment of the impact of these chemicals in the environment will be carried out as in response to Section 4.1.

For waste, emissions relate to any wastes removed from the installation, or disposed of at the installation under the conditions of the Permit, e.g. landfill. Each waste should have its composition determined and the amounts expressed in terms of cubic metres or tonnes per month.

A suitable table on which to record this information is provided in the electronic version of this Guidance Note.

- compare the emissions with the benchmark values given in the remainder of this Section;
- where the benchmarks are not met, revisit the responses made in Section 2 as appropriate (see Section 1.2) and make proposals for improvements or justify not doing so.

INTRODUCTION		TECHNIQUES			EMISSIONS			IMPACT	
Benchmark Comparison	Benchmark Status	Nitrogen Oxides	Sulphur Dioxide	Particulate	Carbon Monoxide	VOCs	PCDPs & PCDFs	Heavy Metals	Waste Incineration

3.2 The Emission Benchmarks

Introduction to emission benchmarks

Guidance is given below on release concentrations or mass release rates achievable for key substances using the best combination of techniques. These BAT-based benchmarks are not mandatory release limits and reference should be made to Section 1 and the *Guide for Applicants* regarding their use.

3.2.1 Emissions to air associated with the use of BAT

The emissions quoted below are as daily averages based upon continuous monitoring during the period of operation. Standard conditions of 273 K and 101.3 kPa for the dry gas apply. No correction is applied for the oxygen content of the emission. Care should always be taken to convert benchmark and proposed releases to the same reference conditions for comparison. To convert measured values to reference conditions, see Technical Guidance Note M2 (Ref. 21) for more information

Limits in Permits may be set for mean or median values over long or short periods. The periods and limits selected should reflect:

- the manner in which the emission may impact upon the environment;
- likely variations which will arise during operation within BAT;
- possible failure modes and their consequences;
- the capabilities of the monitoring and testing system employed.

Where emissions are expressed in terms of concentrations and where continuous monitors are employed, it is recommended that limits are defined such that:

- not more than one calendar monthly average during any rolling twelvemonth period shall exceed the benchmark value by more than 10%;
- not more than one half hour period* during any rolling 24 hour period shall exceed the benchmark value by more than 50%.

* for the purpose of this limit half hourly periods commence on the hour and the half hour.

Where spot tests are employed:

- the half hour limit above shall be applied over the period of the test;
- the mean of three consecutive tests taken during a calendar year shall not exceed the benchmark value by more than 10%.

3.2.2 Emissions to water associated with the use of BAT

Wastewater treatment systems can maximise the removal of metals using sedimentation and possibly filtration. The reagents used for precipitation may be hydroxide, sulphide or a combination of both, depending on the mix of metals present. It is also practicable in many cases to re-use treated water.

Where automatic sampling systems are employed, limits may be defined such that:

- not more than 5% of samples shall exceed the benchmark value.

Where spot samples are taken:

- no spot sample shall exceed the benchmark value by more than 50%.

Examples of emissions to water associated with the use of BAT:

3.2.3 Standards and obligations

In addition to meeting the requirements of BAT, there are other national and international standards and obligations which must either be safeguarded through the IPPC Permit or, at least, taken into account in setting Permit conditions. This is particularly the case for any EC based EQSs.

EC based EQ standards

IPPC: A Practical Guide (see Ref. 4) explains how these should be taken into account and contains an annex listing the relevant standards. See [Appendix 2](#) for equivalent legislation in Scotland and Northern Ireland). They can be summarised as follows.

Air Quality

- Statutory Instrument 1989 No 317, Clean Air, The Air Quality Standards Regulations 1989.
- Statutory Instrument 1997 No 3043, Environmental Protection, The Air Quality Regulations 1997.

INTRODUCTION		TECHNIQUES			EMISSIONS			IMPACT	
Benchmark Comparison	Benchmark Status	Nitrogen Oxides	Sulphur Dioxide	Particulate	Carbon Monoxide	VOCs	PCDPs & PCDFs	Heavy Metals	Waste Incineration

Water Quality

- Directive 76/464/EEC on Pollution Caused by Dangerous Substances Discharged to Water contains two lists of substances. List I relates to the most dangerous, and standards are set out in various daughter Directives. List II substances must also be controlled. Annual mean concentration limits for receiving waters for List I substances can be found in SI 1989/2286 and SI 1992/337 the Surface Water (Dangerous Substances Classification) Regulations. Values for List II substances are contained in SI 1997/2560 and SI 1998/389. Daughter Directives cover EQS values for mercury, cadmium, hexachlorocyclohexane, DDT, carbon tetrachloride, pentachlorophenol, aldrin, dieldrin, endrin, isodrin, hexachlorobenzene, hexachlorobutadiene, chloroform, 1,2-dichloroethane, trichloroethane, perchloroethane and trichlorobenzene.
- Other waters with specific uses have water quality concentration limits for certain substances. These are covered by the following Regulations:
 - SI 1991/1597 Bathing Waters (Classification) Regulations;
 - SI 1992/1331 and Direction 1997 Surface Waters (Fishlife) (Classification) Regulations;
 - SI 1997/1332 Surface Waters (Shellfish) (Classification) Regulations;
 - SI 1996/3001 The Surface Waters (Abstraction and Drinking Water) (Classification) Regulations.

Future likely changes include:

- Some air and water quality standards may be replaced by new standards in the near future.
- The (Draft) Solvents Directive on the limitation of emissions of VOCs due to the use of organic solvents in certain activities and installations.

Other standards and obligations

Those most applicable to this sector are:

- Hazardous Waste Incineration Directive;
- Waste Incineration Directive;
- Large Combustion Plant Directive;
- Reducing Emissions of VOCs and Levels of Ground Level Ozone: a UK Strategy;
- Water Quality Objectives – assigned water quality objectives to inland rivers and water courses (ref. Surface (Rivers Ecosystem) Classification);
- The UNECE convention on long-range transboundary air pollution;
- The Montreal Protocol;
- The Habitats Directive (see Section 4.3).

3.2.4 Units for benchmarks and setting limits in Permits

Releases can be expressed in terms of:

- “**concentration**” (e.g. mg/l or mg/m³) which is a useful day-to-day measure of the effectiveness of any abatement plant and is usually measurable and enforceable. The total flow must be measured/controlled as well;
- “**specific mass release**” (e.g. kg/t product or input or other appropriate parameter) which is a measure of the overall environmental performance of the plant (including the abatement plant) compared with similar plants elsewhere;
- “**absolute mass release**” (e.g. kg/hr, t/yr) which relates directly to environmental impact.

When endeavouring to reduce the environmental impact of an installation, its performance against each of these levels should be considered, as appropriate to the circumstances, in assessing where improvements can best be made.

When setting limits in Permits the most appropriate measure will depend on the purpose of the limit. It may also be appropriate to use surrogate parameters which reflect optimum environmental performance of plant as the routine measurement, supported by less frequent check-analyses on the final concentration. Examples of surrogate measures would be the continuous measurement of conductivity (after ion-exchange treatment) or total carbon (before a guard-column in activated carbon treatment) to indicate when regeneration or replacement is required.

Regulators should consider the need to set limits on individual constituents such as sulphur, metals, chlorine and PCBs. The setting of limits on certain fuel constituents may be particularly appropriate for processed fuels.

INTRODUCTION		TECHNIQUES			EMISSIONS			IMPACT	
Benchmark Comparison	Benchmark Status	Nitrogen Oxides	Sulphur Dioxide	Particulate	Carbon Monoxide	VOCs	PCDPs & PCDFs	Heavy Metals	Waste Incineration

3.2.5 Statistical basis for benchmarks and limits in Permits

Conditions in Permits can be set with percentile, mean or median values over yearly, monthly or daily periods, which reflect probable variation in performance. In addition absolute maxima can be set.

Where there are known failure modes, which will occur even when applying BAT, limits in Permits may be specifically disapplied but with commensurate requirements to notify the Regulator and to take specific remedial action.

For Water: UK benchmarks or limits are most frequently 95 percentile concentrations or absolute concentrations, (with flow limited on a daily average or maximum basis).

For Air: benchmarks or limits are most frequently expressed as daily averages or, typically 95% of hourly averages.

3.2.6 Reference conditions for releases to air

The reference conditions of substances in releases to air from point sources are: temperature 273 K (0° C), pressure 101.3 kPa (1 atmosphere), no correction for water vapour or oxygen.

The reference conditions for combustion or incineration processes are as given in the appropriate guidance note.

These reference conditions relate to the benchmark release levels given in this Note and care should always be taken to convert benchmark and proposed releases to the same reference conditions for comparison. The Permit may employ different reference conditions if they are more suitable for the process in question.

To convert measured values to reference conditions, see Technical Guidance Note M2 ([Ref. 21](#)) for more information.

INTRODUCTION		TECHNIQUES			EMISSIONS			IMPACT		
Benchmark Comparison	Benchmark Status	Nitrogen Oxides	Sulphur Dioxide	Particulate	Carbon Monoxide	VOCs	PCDPs & PCDFs	Heavy Metals	Waste Incineration	

3.3 Oxides of Nitrogen (NOx) and other Nitrogen Compounds

Other Applicable Standards and Obligations

(Extracts from standards are quoted for ease of reference. The relevant standards should be consulted for the definitive requirements).

Statutory Instrument 1989 No 317, Clean Air, The Air Quality Standards Regulations 1989 gives limit values in air for nitrogen dioxide. Any emission from the process should not result in a breach of this standard beyond the site boundary.

Statutory Instrument 2000 No.928, Air Quality (England) Regulations 2000 gives air quality objectives to be achieved by 2005 for nitrogen dioxide.

The UNECE convention on long-range transboundary air pollution. Negotiations are now underway which could lead to a requirement further to reduce emissions of NOx.

Waste Incineration Directive - Special provisions are made for the co-incineration of waste in cement kilns for new and existing plants including a time limited exemption for wet kilns.

Benchmark Emission Values

Media	Activity	Benchmark value concentration mg/m ³ daily average	Basis for the Benchmark
To air	Cement kilns	200 to 500	BREF value range ^(Note 1)
To air	Lime kilns New plant or existing kilns with production greater than 900te/day	200 to 500	Scale of operation considered equivalent to cement manufacture
	Existing kilns with production less than 900te/day	900	Previous IPC benchmark ^(Note 2)

Note 1: The selected process has a major impact on the energy use and air emissions from the manufacture of cement clinker. The 200 to 500 mg/m³ emission range can be achieved in dry "pre-heater" and "pre-calciner" kilns by primary measures, staged combustion and selective non-catalytic reduction (SNCR). Though staged combustion and SNCR are not yet used simultaneously for NOx reduction.

Note 2: Reference should be made to [Section 2.3](#) to appreciate the dependence of NOx levels on the process characteristics and the raw materials used.

INTRODUCTION		TECHNIQUES			EMISSIONS		IMPACT		
Benchmark Comparison	Benchmark Status	Nitrogen Oxides	Sulphur Dioxide	Particulate	Carbon Monoxide	VOCs	PCDPs & PCDFs	Heavy Metals	Waste Incineration

3.4 Sulphur Dioxide (SO₂) and other Sulphur Compounds

Other Applicable Standards and Obligations

(Extracts from standards are quoted for ease of reference. The relevant standards should be consulted for the definitive requirements).

Statutory Instrument 1989 No 317, Clean Air, The Air Quality Standards Regulations 1989 gives limit values in air for sulphur dioxide.

Statutory Instrument 2000 No.928, The Air Quality (England) Regulations 2000 gives air quality objectives for sulphur dioxide to be achieved by 2004.

The UNECE convention on long-range transboundary air pollution. Under this Convention, a requirement further to reduce SO₂ emissions *from all sources* has been agreed. The second Sulphur Protocol (Oslo, 1994) obliges the UK to reduce SO₂ emissions by 80% (based on 1980 levels) by 2010.

Sulphur Content of Certain Liquid Fuels Directive 1999/32/EC. From 1 January 2003, the sulphur content of heavy fuel oil must not exceed 1% except when it is burnt in plants fitted with SO₂ abatement equipment. Sulphur levels in gas oil must not exceed 0.2% from 1 July 2000, and 0.1% from the start of 2008.

Benchmark Emission Values

Media	Activity	Benchmark value concentration mg/m ³ daily average	Basis for the Benchmark
To air	kilns	200 to 400	BREF value range ^(Note1)

Note 1: Can be achieved with a combination of primary measures, absorbent addition and wet or dry scrubbing techniques.

3.5 Particulates

Other Applicable Standards and Obligations

(Extracts from standards are quoted for ease of reference. The relevant standards should be consulted for the definitive requirements).

Air: Statutory Instrument 1989 No 317, Clean Air, The Air Quality Standards Regulations 1989 gives limit values in air for suspended particulates.

Statutory Instrument 2000 No. 928, The Air Quality (England) Regulations 2000 gives air quality objectives for PM₁₀ to be achieved by 2004.

Benchmark Emission Values

Media	Activity	Benchmark value concentration mg/m ³ daily average	Basis for the Benchmark
To air	point source emissions	20 to 30	BREF value range Achieved by electrostatic precipitators and/ or fabric filters. ^(Note 1)
To air	lime hydrators	50	Previous IPC benchmark
To air	fugitive emissions from storage and materials handling	"no visible dust" criteria may normally be appropriate	Parity with other UK industrial sector benchmarks for fugitive or low level emissions, relatively benign, nuisance dusts.

Note 1 Release concentrations will be exceeded during CO trips if electrostatic precipitators are used for abatement.

INTRODUCTION		TECHNIQUES			EMISSIONS		IMPACT		
Benchmark Comparison	Benchmark Status	Nitrogen Oxides	Sulphur Dioxide	Particulate	Carbon Monoxide	VOCs	PCDPs & PCDFs	Heavy Metals	Waste Incineration

3.6 Carbon Monoxide

Other Applicable Standards and Obligations

(Extracts from standards are quoted for ease of reference. The relevant standards should be consulted for the definitive requirements).

Statutory Instrument 2000 No. 928, *The Air Quality (England) Regulations 2000* gives air quality objectives for carbon monoxide to be achieved by 2003.

Benchmark Emission Values

Media	Activity	Benchmark value concentration mg/m ³ daily average	Basis for the Benchmark
To air	Kiln exhaust	300 to 500	Previous IPC benchmark. ^(Note 1)

Note 1: Whilst levels of 300-500mg/m³ are achievable in some cases, primary control to minimise CO may prejudice other interrelated releases, for example NO_x.

3.7 Volatile Organic Compounds (VOCs)

The term "volatile organic compounds" includes all organic compounds released to air in the gas phase.

Other Applicable Standards and Obligations

(Extracts from standards are quoted for ease of reference. The relevant standards should be consulted for the definitive requirements)

"Reducing Emissions of VOCs and Levels of Ground Level Ozone: A UK Strategy" was published by the Department of the Environment in October 1993. It sets out how the Government expects to meet its obligations under the UNECE VOCs Protocol to reduce its emissions by 30% (based on 1988 levels) by 1999, including the reductions projected for the major industrial sectors.

The UNECE convention on long-range transboundary air pollution. Negotiations are now underway which could lead to a requirement further to reduce emissions of VOCs.

Statutory Instrument 2000 No. 928, *The Air Quality (England) Regulations 2000* gives air quality objectives for 1,3 butadiene and benzene to be achieved by 2003.

3.8 Polychlorinated Dibenzodioxins and Dibenzofurans (PCDDs and PCDFs)

Benchmark Emission Values

Media	Activity	Benchmark value ng/m ³ TEQ	Basis for the Benchmark
To air	Kiln exhaust	0.1	Parity with other UK industrial sector benchmarks.

3.9 Heavy Metals

Statutory Instrument 2000 No 928, *The Air Quality (England) Regulations 2000* has air quality objectives for lead to be achieved in two stages by 2004 and 2008 respectively.

INTRODUCTION		TECHNIQUES			EMISSIONS			IMPACT	
Benchmark Comparison	Benchmark Status	Nitrogen Oxides	Sulphur Dioxide	Particulate	Carbon Monoxide	VOCs	PCDPs & PCDFs	Heavy Metals	Waste Incineration

3.10 Mandatory Waste Incineration Emission Limits

3.10.1 Hazardous Waste Incineration Directive

The Hazardous Waste Incineration Directive (HWID) was implemented in the UK early 1998 by a combination of Secretary of State Direction and Regulations (SI1998 No.767). A Regulatory Guidance Note issued 14 July 1999 provides detailed guidance and is available from the Agency on request.

The Directive recognises the burning of hazardous waste in plants not intended primarily for that purpose, such as cement and lime kilns. The Directive requires that if more than 40% of the heat input to a kiln is supplied by fuel classified as hazardous waste under Article 2(1), then the requirements in Table 3-1 must be applied. Operators should note that the hazardous waste list has been revised (Ref. 2000/532/EC), which may have the effect of extending the scope of the HWID. Further amendments to the list are planned to take effect by 1 January 2002.

If the heat obtained from burning hazardous waste is 40% or less of the total kiln heat input at any time then, in accordance with Annex II of the Directive, the emission limit values in Table 3-1 only apply to that portion of the exhaust gases generated by combustion of the waste. Overall emission limit values are based on prorating between the limits in Table 3-1, any existing authorised kiln limits based on the exhaust gas flows resulting from incinerating the waste and the flows from the kiln process when fired on non-hazardous waste fuels.

Table 3-1 - Hazardous Waste Incineration Directive: Emission limit values

Substance	Emission limits (mg/m ³)*		Monitoring requirements	Compliance conditions**
	Daily average	Half hourly average		
Particulates***	10	30 (10)	continuous	Daily averages to be less than these limits; and either all 30 min averages over a year to be less than limits; or 97% of 30 min averages over a year to be less than bracketed limits
VOCs as carbon***	10	20 (10)	continuous	
HCl***	10	60 (10)	continuous	
HF***	1	4 (2)	spot where HCl can be used as a surrogate	
SO ₂ ***	50	200 (50)	continuous	Daily averages to be less than these limits; and either all 30 min averages in 24 hours to be less than limits; or 95% of 10 min averages over a year to be less than bracketed limits
CO	50	100 (150)	continuous	
	New plants	Existing plants		
Cd and Tl in total***	0.05	0.1	Every 2 months for the first year of operation, then twice per year	All average values over the sample period (30 minutes to 8 hours) to be less than these limits
Hg***	0.05	0.1		
Pb, Cr, Cu, Mn, Ni, As, Sb, Co, V and Sn in total***	0.5	1		
Dioxins TEQ (ng/m ³)	0.1	0.1		CEN method (EN 1948, parts 1,2 and 3) sample period 6 to 8 hours

* Reference conditions are dry, temperature 273 K, pressure 101.3 kPa, 11% oxygen

** Permits usually specify half-hourly limits as all 30-minute averages over a year to be less than limits.

*** Measurements of these pollutants shall not be necessary, provided that the Permit allows the incineration of only those hazardous wastes which cannot cause average values of those pollutants higher than 10% of the emission limit values. This is important for plants burning low chlorine or low sulphur wastes.

INTRODUCTION		TECHNIQUES			EMISSIONS			IMPACT	
Benchmark Comparison	Benchmark Status	Nitrogen Oxides	Sulphur Dioxide	Particulate	Carbon Monoxide	VOCs	PCDPs & PCDFs	Heavy Metals	Waste Incineration

The Directive requirements go beyond air emission limit values. Regulators are required to:

- specify types/ quantities of hazardous waste which can be used in the process;
- set conditions for delivery/ receipt of wastes;
- set operating conditions such as minimum temperature, residence time, % oxygen;
- monitor releases as specified in the Directive.

In addition, where the hazardous waste provides 40% or less of the thermal input to the process, the Permit shall specify the minimum and maximum flow rates of hazardous wastes, minimum and maximum calorific values and the maximum concentration of pollutants, for example PCB, PCP, chlorine, fluorine, sulphur and heavy metals.

3.10.2 Waste Incineration Directive

The Waste Incineration Directive has been developed to fill the gaps between existing Directives on municipal waste incineration and hazardous waste incineration. The existing Directives will be repealed five years after the Waste Incineration Directive comes into force. It is likely that it will be given effect in UK law by a Direction from the Secretary of State to relevant enforcing authorities. Detailed guidance will be issued when details of the Direction are known.

Implementation provisions are:

- for new plant: shall comply with this Directive no later than 2 years after its entry into force;
- for existing plant: shall comply with this Directive no later than 5 years after its entry into force.

For co-incineration plants which start co-incinerating waste not later than four years after the Directive comes into force, are to be regarded as existing co-incineration plants.

As for HWID, the Directive has provisions for the co-incineration of hazardous wastes in which the 40% rule applies. Special provisions are made for the co-incineration of waste in cement kilns (Annexe II.1). The 40% rule does not apply to burning non-hazardous waste. The emission limit values and the special provisions for cement kilns are summarised in [Table 3-2](#).

Table 3-2 - Waste Incineration Directive Annex II: total emission limit values

Pollutant	Directive Requirement	
	Emission Limit (mg/m ³)*	Averaging Period
Particulates	30 ^{Note 1}	daily
VOCs (as TOC)	10 ^{Note 2}	daily
HCl	10	daily
HF	1	daily
SO ₂	50 ^{Note 2}	daily
NO _x for existing plant	800 ^{Note 3}	daily
NO _x for new plant	500	daily
CO	Set by competent authority	
Cd and Tl	total 0.05	All average values over the sample period (30 minutes to 8 hours) to be less than these limits
Hg	0.05	
Sb,As, Pb, Cr, Co, Cu, Mn, Ni and V	total 0.5	
Dioxins	0.1 ng/m ³ TEQ	CEN method (EN 1948, parts 1, 2 and 3) sample period 6 to 8 hours

* reference conditions: 273 K, 101.3 kPa, 10% O₂, dry gas.

Note 1: Until 1 January 2008, exemption for particulates may be authorised for cement kilns which burn less than three tonnes of waste per hour, provided that an emission limit of 50 mg/m³ is not exceeded.

Note 2: Exemptions may be authorised in cases where TOC and SO₂ do not result from the incineration of waste.

Note 3: Until 1 January 2008, exemptions for NO_x may be authorised for existing wet process cement kilns or cement kilns which burn less than three tonnes of waste per hour, provided that the emission limit does not exceed 1200mg/m³.

As for HWID the Waste Incineration Directive goes beyond emission limit values. Permits will be required to include an extensive range of conditions to ensure high operational standards.

4 IMPACT

4.1 Assessment of the Impact of Emissions on the Environment

The Operator should assess that the emissions resulting from the proposals for the activities/installation will provide a high level of protection for the environment as a whole, in particular having regard to EQSs etc, revisiting the techniques in Section 2 as necessary (see Section 1.2).

Application Form
Question 4.1

Provide an assessment of the potential significant environmental effects (including transboundary effects) of the foreseeable emissions.

With the Application the Operator should:

1. Provide a description, including maps as appropriate, of the receiving environment to identify the receptors of pollution. The extent of the area may cover the local, national and international (e.g. transboundary effects) environment as appropriate.
2. Identify important receptors which may include: areas of human population including noise or odour-sensitive areas, flora and fauna (i.e. Habitat Directive sites, special areas of conservation, Sites of Special Scientific Interest (SSSI or in Northern Ireland ASSI) or other sensitive areas), soil, water, i.e. groundwater (water below the surface of the ground in the saturation zone and in direct contact with the ground and subsoil) and watercourses (e.g. ditches, streams, brooks, rivers), air including the upper atmosphere, landscape, material assets and the cultural heritage.
3. Identify the pathways by which the receptors will be exposed (where not self evident).
4. Carry out an assessment of the potential impact of the total emissions from the activities on these receptors. Ref. 6 provides a systematic method for doing this and will also identify where modelling needs to be carried out, to air or water, to improve the understanding of the dispersion of the emissions. The assessment will include comparison (see IPPC A Practical Guide (Ref. 4) and Section 3.2) with:
 - community EQS levels;
 - other statutory obligations;
 - non-statutory obligations;
 - environmental action levels (EALs) and the other environmental and regulatory parameters defined in Ref. 6.

In particular it will be necessary to demonstrate that an appropriate assessment of vent and chimney heights has been made to ensure that there is adequate dispersion of the minimised emission(s) to avoid exceeding local ground-level pollution thresholds and limit national and transboundary pollution impacts, based on the most sensitive receptor, be it human health, soil or terrestrial ecosystems.

Where appropriate the Operator should also recognise the chimney or vent as an emergency emission point and understand the likely behaviour. Process upsets or equipment failure giving rise to abnormally high emission levels over short periods should be assessed. Even if the Applicant can demonstrate a very low probability of occurrence, the height of the chimney or vent should nevertheless be set to avoid any significant risk to health. The impact of fugitive emissions can also be assessed in many cases.

Consider whether the responses to Sections 2 and 3 and this assessment adequately demonstrate that the necessary measures have been taken against pollution, in particular by the application of BAT, and that no significant pollution will be caused. Where there is uncertainty about this, the measures in Section 2 should be revisited as appropriate to make further improvements.

5. Where the same pollutants are being emitted by more than one permitted activity on the installation the Operator should assess the impact both with and without the neighbouring emissions.

4.2 The Waste Management Licensing Regulations

Application Form
Question 4.2

Explain how the information provided in other parts of the application also demonstrates that the requirements of the relevant objectives of the Waste Management Licensing Regulations 1994 have been addressed, or provide additional information in this respect.

In relation to activities involving the disposal or recovery of waste, the Regulators are required to exercise their functions for the purpose of achieving the relevant objectives as set out in Schedule 4 of the Waste Management Licensing Regulations 1994. (For the equivalent Regulations in Scotland, see [Appendix 2](#). In Northern Ireland there are no equivalent regulations at the time of writing. Contact EHS for further information.)

The relevant objectives, contained in paragraph 4, Schedule 4 of the Waste Management Licensing Regulations 1994 (*SI 1994/1056 as amended*) are extensive, but will only require attention for activities which involve the recovery or disposal of waste. Paragraph 4 (1) is as follows:

- a) *“ensuring the waste is recovered or disposed of without endangering human health and without using process or methods which could harm the environment and in particular without:*
- risk to water, air, soil, plants or animals; or*
 - causing nuisance through noise or odours; or*
 - adversely affecting the countryside or places of special interest;*
- b) *implementing, as far as material, any plan made under the plan-making provisions”.*

The application of BAT is likely to already address risks to water, air, soil, plants or animals, odour nuisance and some aspects of effects on the countryside. It will, however, be necessary for you briefly to consider each of these objectives individually and provide a comment on how they are being addressed by your proposals. It is also necessary to ensure that any places of special concern which could be affected, such as SSSIs, are identified and commented upon although, again, these may have been addressed in your assessment for BAT, in which case a cross-reference may suffice.

Operators should identify any development plans made by the local planning authority, including any waste local plan, and comment on the extent to which the proposals accord with the contents of any such plan ([see Section 2.6](#)).

4.3 The Habitats Regulations

Application Form
Question 4.3

Provide an assessment of whether the installation is likely to have a significant effect on a European site in the UK and if it is, provide an assessment of the implications of the installation for that site, for the purposes of the Conservation (Natural Habitats etc) Regulations 1994 (SI 1994/2716).

Your response should cover all relevant issues pertinent to your installation, including those below. In doing so you should justify your proposals against any indicative requirements stated.

An application for an IPPC Permit will be regarded as a new plan or project for the purposes of the Habitats Regulations (for the equivalent Regulations in Scotland and Northern Ireland see [Appendix 2](#)). Therefore, Operators should provide an initial assessment of whether the installation is likely to have a significant effect on any European site in the UK (either alone or in combination with other relevant plans or projects) and, if so, an initial assessment of the implications of the installation for any such site. The application of BAT is likely to have gone some way towards addressing the potential impact of the installation on European sites and putting into place techniques to avoid any significant effects. The Operator should provide a description of how the BAT assessment has specifically taken these matters into account, bearing in mind the conservation objectives of any such site.

European sites are defined in Regulation 10 of the Habitats Regulations to include Special Areas of Conservation (SACs); sites of community importance (sites that have been selected as candidate SACs by member states and adopted by the European Commission but which are not yet formally classified); and Special Protection Areas (SPAs). It is also Government policy (set out in PPG 9 on nature conservation) that potential SPAs and candidate SACs should be considered to be European sites for the purposes of Regulation 10.

Information on the location of European Sites and their conservation objectives is available from

- English Nature (01733 455000), <http://www.english-nature.org.uk>
- Countryside Council for Wales (01248 385620), <http://www.ccw.gov.uk>
- Scottish Natural Heritage (0131 447 4784), <http://www.snh.org.uk>
- Joint Nature Conservation Committee (01733 866852), <http://www.jncc.gov.uk>
- Environment and Heritage Service, Northern Ireland, <http://www.ehsni.gov.uk>

The Regulator will need to consider the Operator's initial assessment. If it concludes that the installation is likely to have a significant effect on a European site, then the Regulator will need to carry out an "appropriate assessment" of the implications of the installation in view of that site's conservation objectives. The Regulations impose a duty on the Regulator to carry out these assessments so it cannot rely on the Operator's initial assessments. Therefore the Regulator must be provided with any relevant information upon which the Operator's assessment is based.

Note that in many cases the impact of the Habitats Regulations will have been considered at the planning application stage, in which case the Regulator should be advised of the details.

REFERENCES

For a full list of available Technical Guidance see Appendix A of the *Guide to Applicants* or visit the Environment Agency Website <http://www.environment-agency.gov.uk>. Many of the references below are being made available free of charge for viewing or download on the Website. The same information can also be accessed via the SEPA web site <http://www.sepa.org>, or the NIEHS web site www.ehsni.gov.uk. Most titles will also be available in hard copy from The Stationery Office (TSO). Some existing titles are not yet available on the Website but can be obtained from TSO.

1. IPPC Reference Document on Best Available Techniques in the Cement and Lime Industry European Commission <http://eippcb.jrc.es>
2. The Pollution Prevention and Control Act (1999) (www.uk-legislation.hms.gov.uk).
3. The Pollution Prevention and Control Regulations (SI 1973 2000) (www.uk-legislation.hms.gov.uk).
4. IPPC: A Practical Guide (for England and Wales) (or equivalents in Scotland and Northern Ireland) (www.environment.detr.gov.uk).
5. IPPC Part A(1) Installations: Guide for Applicants (includes Guidance on the Preparation of a Site Report) (EA Website).
6. Assessment methodologies:
 - E1 BPEO Assessment Methodology for IPC
 - E2 Methodology for IPPC BAT Determinations
 - IPPC Environmental Assessments for BAT (in preparation as H1)
7. Management system references:
 - Sector specific
8. Waste minimisation support references:
 - Environment Agency web site. Waste minimisation information accessible via: www.environment-agency.gov.uk/epns/
 - Waste Minimisation – an environmental good practice guide for industry (helps industry to minimise waste and achieve national environmental goals). Available free to companies who intend to undertake a waste reduction programme (tel 0345 33 77 00)
 - Profiting from Pollution Prevention – 3Es methodology (emissions, efficiency, economics). Video and A4 guide aimed at process industries. Available from Environment Agency, North East region (tel 0113 244 0191, ask for regional PIR)
 - Waste Minimisation Interactive Tools (WIMIT). Produced in association with the ETBPP and the BOC Foundation (a software tool designed for small and medium businesses.). Available free from The Environmental Helpline (tel 0800 585794)
 - Environmental Technology Best Practice Programme – ETBPP. A joint DTI/DETR programme, with over 200 separate case studies, good practice guides, leaflets, flyers, software tools and videos covering 12 industry sectors, packaging, solvents and the generic areas of waste minimisation and cleaner technology. The ETBPP is accessible via a FREE and confidential helpline (tel 0800 585794) or via the web site www.envirowise.com
 - ETBPP, Increased Profit Through Improved Materials Additions: Management/Technical Guide, GG194/195
 - Waste Management Information Bureau. The UK's national referral centre for help on the full range of waste management issues. It produces a database called Waste Info, which is available for online searching and on CD-ROM. Short enquiries are free (tel 01235 463162)
 - Institution of Chemical Engineers Training Package E07 – Waste Minimisation. Basic course which contains guide, video, slides, OHPs etc. (tel 01788 578214)
9. Water efficiency references:
 - ETBPP, Simple measures restrict water costs, GC22
 - ETBPP, Effluent costs eliminated by water treatment, GC24
 - ETBPP, Saving money through waste minimisation: Reducing water use, GG26
 - ETBPP Helpline 0800 585794
10. Environment Agency (1998) Optimum use of water for industry and agriculture dependent on direct abstraction: Best practice manual. R&D technical report W157, WRc Dissemination Centre, Swindon (tel 01793 865012)
11. Releases to air references:
 - BREF on Waste Water and Waste Gas Treatment.
 - A1 Guidance on effective flaring in the gas, petroleum etc industries, 1993, ISBN 0-11-752916-8
 - A2 Pollution abatement technology for the reduction of solvent vapour emissions, 1994, £5.00, 0-11-752925-7
 - A3 Pollution abatement technology for particulate and trace gas removal, 1994, £5.00, 0-11-752983-4
 - Landfill gas flaring
 - Part B PG1/3 Boilers and Furnaces 20-50 MW net thermal input (ISBN 0-11-753146-4-7)
 - Part B PG1/4 Gas Turbines 20-50 MW net thermal input (ISBN 0-11-753147-2)
12. Releases to water references:
 - BREF on Waste Water and Waste Gas Treatment
 - A4 Effluent Treatment Techniques, TGN A4, Environment Agency, ISBN 0-11-310127-9 (EA website)

REFERENCES

- Environment Agency, Pollution Prevention Guidance Note – Above-ground oil storage tanks, PPG 2, gives information on tanks and bunding which have general relevance beyond just oil (EA website)
 - Mason, P. A, Amies, H. J, Sangarapillai, G. Rose, Construction of bunds for oil storage tanks, Construction Industry Research and Information Association (CIRIA), Report 163, 1997, CIRIA, 6 Storey's Gate, Westminster, London SW1P 3AU. Abbreviated versions are also available for masonry and concrete bunds (www.ciria.org.uk online purchase)
13. Dispersion Methodology Guide D1 (EA website - summary only)
 14. IPPC Energy Efficiency Guidance Note (the consultation version, available on the website should be used until the final version is published)
 15. BS 5908: Code of Practice for Fire Precautions in the Chemical and Allied Industries
 16. Environment Agency, Pollution Prevention Guidance Note – Pollution prevention measures for the control of spillages and fire-fighting run-off, PPG 18, gives information on sizing firewater containment systems (EA website)
 17. Investigation of the criteria for, and guidance on, the landspreading of industrial wastes – final report to the DETR, the Environment Agency and MAFF, May 1998
 18. Agency guidance on the exemption 7 activity (proposed)
 19. COMAH guides
 - A Guide to the Control of Major Accident Hazards Regulations 1999, Health and Safety Executive (HSE) Books L111, 1999, ISBN 0 07176 1604 5
 - Preparing Safety Reports: Control of Major Accident Hazards Regulations 1999, HSE Books HS(G)190, 1999
 - Emergency Planning for Major Accidents: Control of Major Accident Hazards Regulations 1999, HSE Books HS(G)191, 1999
 - Guidance on the Environmental Risk Assessment Aspects of COMAH Safety Reports, Environment Agency, 1999 (EA website)
 - Guidance on the Interpretation of Major Accidents to the Environment for the Purposes of the COMAH Regulations, DETR, 1999, ISBN 753501 X, available from the Stationery Office
 20. Assessment and Control of Environmental Noise and Vibration from Industrial Activities (joint Regulator's guidance in preparation)
 21. Monitoring Guidance (EA website)
 - M1 Sampling facility requirements for the monitoring of particulates in gaseous releases to atmosphere, March 1993, £5.00, ISBN 0-11-752777-7
 - M2 Monitoring emissions of pollutants at source January 1994, £10.00, ISBN 0-11-752922-2
 - M3 Standards for IPC Monitoring Part 1: Standards, organisations and the measurement infrastructure, August 1995, £11.00, ISBN 0-11-753133-2
 - M4 Standards for IPC Monitoring Part 2 : Standards in support of IPC Monitoring, revised 1998
 - MCERTS approved equipment link via <http://www.environment-agency.gov.uk/epns> "Guidance for Business and Industry";
 - Direct Toxicity Assessment for Effluent Control: Technical Guidance (2000), UKWIR 00/TX/02/07.
 22. The Categorisation of Volatile Organic Compounds, DOE Research Report No DOE/HMIP/RR/95/009 (EA website)
 23. Odour Assessment and Control – Guidance for Regulators and Industry (joint agencies guidance in preparation)
 24. "Policy and Practice for the Protection of Groundwater" (PPPG) (EA website)
 25. Working at Construction and Demolition-sites (PPG 6) (EA website)
 26. Substitute Fuels Protocol for use on cement and lime processes. Agency guidance.
 27. Draft Entec report (shortly to be issued). Solid Waste Derived Fuels in Cement and Lime Kilns – An International Perspective.

DEFINITIONS

BAT	Best Available Techniques
BAT Criteria	The criteria to be taken into account when assessing BAT, given in Schedule 2 of the PPC Regulations
CKD	Cement Kiln Dust
CO	Carbon Monoxide
EA	Environment Agency (for England and Wales)
EFTA	European Free Trade Association
EPs	Electrostatic Precipitators
EMS	Environmental Management System
ITEQ	International Toxicity Equivalents
LPG	Liquefied Petroleum Gas
NIEHS	Northern Ireland Environment and Heritage Service
NO _x	Oxides of Nitrogen
PCB	Polychlorinated byphenols
PCDD	Polychlorinated dibenzo dioxins
PCDF	Polychlorinated dibenzo furans
PCP	Polychlorophenol
PFA	Pulverised Fuel Ash
PM	Particulate matter
RMC	Ready Mixed Concrete
SCR	Selected Catalytic Reduction
SECp	Specific Energy Consumption
SEPA	Scottish Environmental Protection Agency
SLF	Substitute Liquid Fuels
SNCR	Selective Non Catalytic Reduction
SO ₂	Sulphur Dioxide
SS	Suspended Solids
STW	Sewage treatment works
TEQ	International Toxicity Equivalents
TOC	Total Organic Carbon
VOC	Volatile Organic Compounds

APPENDIX 1 - MONITORING AND SAMPLING METHODS

TABLE A1-1 - CONTINUOUS MONITORING TECHNIQUES FOR CEMENT AND LIME PROCESSES

Source	Pollutant	Suitable technique	Comments on best practice
In kiln	O ₂	Extractive Paramagnetic Electrochemical	<ul style="list-style-type: none"> These techniques have proven to be effective but because of the high temperatures (1000-1300°C), very high dust loading (up to 100mg/m³) and corrosive conditions (sulphur and nitric acids) the sample train becomes more complicated. Best practice, for example, would incorporate: <ul style="list-style-type: none"> - the use of water-cooled probes - acid resistant materials - the use of shock chillers to condense out sulphur acids - additional filters to improve performance and reduce cleaning/replacement frequency - housings for analysers and electronics to be kept away from high temperature areas
	CO	Non Dispersive Infra-Red (NDIR)	
	NO _x	Non Dispersive Ultra-Violet (NDUV) Chemiluminescence	
Kiln flue exhaust	PM	Cross-duct opacity	<ul style="list-style-type: none"> Cross-duct systems e.g. Erwin Sick are generally regarded as more accurate than triboelectric devices, and most suitable for kiln flue gases. Back scatter devices have not proven to be successful for these emissions. Opacity measurement should be separate from the monitoring of any other species. Post EP abatement, triboelectric techniques are not suitable for this application because of interference from charged particles.
	O ₂	Paramagnetic/ Electrochemical/ zirconium oxide cell	<ul style="list-style-type: none"> Paramagnetic devices perform best on dry gas streams, and are best suited to dry kiln systems. ZnO devices are better designed for wet kiln exhaust gases.
	SO ₂	NDIR/NDUV	<ul style="list-style-type: none"> Some NDIR devices have been prone to interference with chlorine, but on the whole this should not preclude the use of CEM techniques for SO_x and NO_x measurement.
	NO _x	NDIR/NDUV	
	HC	Extractive Flame Ionisation Detector (FID)	<ul style="list-style-type: none"> The FID technique is well proven although there is still some debate about the best type of sample train. The USEPA considers hot probes to be best practice, although they have caused problems with line blocking and just as reliable results have been obtained by cold probes.
	HCl	Gas Filter Correlation Infra-Red (GCF IR); Fourier Transform Infra-Red (FTIR); Ion selective electrode	<ul style="list-style-type: none"> These techniques for continuously measuring HCl are widely used in the incineration sector, but there is little evidence of their application to cement processes. This is due more to their cost than technical inapplicability. There is no technical reason why these techniques could not be used on cement processes.
	Metals	No techniques have been found which can effectively monitor metals on a continuous basis.	
Clinker coolers	PM	Cross-duct opacity triboelectric	<ul style="list-style-type: none"> Triboelectric devices would be the preferred equipment for these emissions because of the lower temperature of the gases than in kiln exhausts, and the generally lower particulate loadings.

Measurement uncertainty is defined as total expanded uncertainty at 95% confidence interval calculated in accordance with the Guide to the Expression of Uncertainty in Measurement, ISBN 92-67-10188-9, 1th Ed., Geneva, Switzerland, ISO 1993.

APPENDIX 2 - EQUIVALENT LEGISLATION IN SCOTLAND & NORTHERN IRELAND

The legislation referred to in the text is that for England and Wales. The following are the equivalents for Scotland and Northern Ireland.

Table A.2.1 - Equivalent Legislation

<i>England and Wales</i>	<i>Scotland</i>	<i>Northern Ireland</i>
PPC Regulations (England and Wales) 2000	PPC (Scotland) Regulations 2000; SI 200/323	
Waste Management Licensing Regulations SI:1994 1056	Waste Management Licensing Regulations SI:1994 1056	No NI equivalent
The Water Resources Act 1991	COPA 1974 (S30A-30E equiv to Part III WRA91) Natural Heritage (Scotland) Act 1991(Part II equiv to Part I WRA91)	The Water (NI) Order 1999
SI 1989 No 317: Clean Air, The Air Quality Standards Regulations 1989	SI 1989/317: Clean Air, The Air Quality Standards Regulations 1989	The Air Quality Standards Regulations (Northern Ireland) 1990. Statutory Rules of Northern Ireland 1990 No 145
SI 1997 No 3043: Environmental Protection, The Air Quality Regulations 1997	SSI 2000/97 The Air Quality (Scotland) Regs	No NI equivalent
SI 1989 No 2286 and 1998 No 389 the Surface Water (Dangerous Substances Classification) Regulations. (Values for List II substances are contained in SI 1997/2560 and SI 1998/389)	SI 1990/126 Surface Water (Dangerous Substances) (Classification) (Scotland) Regs	Surface Waters (Dangerous Substances) (Classification) Regulations 1998. Statutory Rules of Northern Ireland 1998 No 397 SI1991/1597:
SI 1991/1597: Bathing Waters (Classification) Regs.	SI 1991/1609 Bathing Waters (Classification) (Scotland) Regs	The Quality of Bathing Water Regulations (NI) 1993
SI 1992/1331 and Direction 1997 Surface Waters (Fishlife) (Classification) Regs.	SI 1997/2471 Surface Waters (Fishlife) (Classification) Regs	The Surface Water (Fishlife) (Classification) Regulations (NI) 1997
SI1997/1332 Surface Waters (Shellfish) (Classification) Regs.	SI 1997/2470 Surface Waters (Shellfish) (Classification) Regs	The Surface Water (Shellfish) (Classification) Regulations (NI) 1997
SI1994/2716 Conservation (Natural Habitats etc) Regulations 1994	SI 1994/2716 Conservation (Natural Habitats etc) Regs	Conservation (Natural Habitats etc) Regulations (Northern Ireland) 1995
Control of Major Accident Hazards Regulations 1999 (COMAH)	SI 1999/743 Control of Major Accident Hazards Regs	Control of Major Accident Hazard Regulations (Northern Ireland) 2000

APPENDIX 3 - SUMMARY OF CLINKER CAPACITY

Company	Plant Site	Process	Capacity (te/day)	Substitute fuel
Blue Circle	Aberthaw	dry	1700	SLF planned
	Cauldon	dry (pre-calciner)	2800	tyres
	Cookstown	semi-dry	1150	tyres planned
	Dunbar	dry (pre-calciner)	3000	SLF, tyres planned
	Hope	dry	1900	tyres planned
		dry	1900	
	Northfleet	semi-wet	1800	
		semi-wet	1800	
	Weardale	semi-dry	1050	
		semi-dry	1050	
	Westbury	wet	950	tyres planned
wet		950		
Rugby	South Ferriby	semi-dry	1100	
		semi-dry	1100	
	Barrington	wet	770	SLF, Dycal planned
	New Rugby	semi-wet (calciner)	4000	
Castle	Ketton	dry	1060	tyres & SLF, nappy off-cuts planned
		dry (pre-calciner)	3100	SLF, commercial solid wastes, tyres planned
	Ribblesdale	wet	1000	SLF
		wet	1000	SLF
		dry (pre-calciner)	2500	SLF (planned)
	Padeswood	dry (long kiln)	840	
		wet	420	
		wet	420	
Buxton Lime	Tunstead	wet	750	
Sean Quinn	Fermanagh*	dry	1500	

* Plant shut down but not decommissioned.

APPENDIX 4 - SUMMARY OF UK LIME PRODUCTION

Table A4-1 - Commercial Lime Production

Company	Plant Site	Kiln Type	Number	Capacity (te/day)	Substitute fuel
Lhoist	Hindlow	Maerz	2	300	
Buxton Lime	Hindlow	Maerz Parallel-flow regenerative	2	2 x 300	
	Tunstead	Rotary	2	2 x 240	
		Shaft	8 (only 5 operational)	(5 x 200)	
Hansons Aggregates	Cheddar	Rotary	1	552	
Lafarge Redland Aggregates	Thrislington	Rotary	3	2 x 624, 1 x 1920	SLF
	Whitwell	Rotary	2	2 x 960	SLF
Singleton Birch	Melton Ross	Maerz twin shaft vertical	4	4 x 300	

Table A4-2 – In-house Lime Production

Company	Plant Site	Kiln Type	Number	Capacity (te/day)	Substitute fuel
Steel Production					
Corus UK	Shapfell	Maerz (3 x twin shaft, 1 x three shaft)	4	4 x 300	
Speciality Products					
Speciality Minerals	Lifford	Multi chamber vertical shaft	1	100	
Sugar Refining					
British Sugar	Allscott	Shaft	1	96	
	Bardney	Shaft	1	264	
	Bury St Edmunds	Shaft	2	2 x 168	
	Cantley	Shaft	1	120	
	Ipswich	Shaft	1	144	
	Kidderminster	Shaft	1	168	
	Newark	Shaft	1	768	
	Wissington	Shaft	2	364, 144	
	York	Shaft	2	144, not available	
Soda Ash Production					
Brunner Mond	Winnington	Shaft	8	8 x 160	
	Lostock	Shaft	4	4x 228	

APPENDIX 5 - RAW MATERIALS USED

The following information has been extracted from a Cembureau publication entitled "Best Available Techniques for the Cement Industry" dated December 1999.

The raw materials used in clinker manufacturing typically consists of:

- Calcareous components rich in calcium, e.g. greater than 75% of carbonates (limestone, chalk, marble, calcareous marl).
- Argillaceous components rich in aluminium, silicon and iron (marl, marly clay, shale, clay) and
- Corrective components specifically enriched in one of the four main elements (bauxite, iron ore, sand, high-grade limestone, etc.). Correctives are used in small quantities only to adjust the chemical composition of the raw mix to the required quality targets.

Table A5-1 - Chemical and mineralogical composition of Portland Cement clinker

Components	(% by weight)
SiO ₂	19.71 – 24.25
Al ₂ O ₃	3.76 – 6.78
TiO ₂	0.21 – 0.52
P ₂ O ₅	0.02 – 0.27
Fe ₂ O ₃	1.29 – 4.64
Mn ₂ O ₃	0.03 – 0.68
CaO	63.8 – 70.14
SO ₃	0.00 – 4.51
MgO	0.20 – 2.07
K ₂ O	0.31 – 1.76
Na ₂ O	0.03 – 0.33
Na ₂ O - equivalent	0.31 – 1.34
Loss on ignition	0.09 – 1.56
CO ₂	0.03 – 0.83
H ₂ O	0.04 – 1.11
Moduli	
LS	90.5 – 104.1
SR	1.6 – 4.1
Ar	1.4 – 3.7
GS	34.8 – 188.5
Bogue Clinker Phases (%)	
C ₃ S	51.5 – 85.2
C ₂ S	0.2 – 27.1
C ₃ A	6.8 – 15.6
C ₄ AF	4.0 – 16.2
CaO _{free}	0.08 – 5.58

Table A5-2 - Chemical composition of primary raw materials, correctives, coal ash and raw meal for the production of Portland Cement clinker

Components	Primary raw materials			Correctives			Coal Ash ¹	Raw Meal
	Limestone	Calcareous marl	Clay	Sand	Iron ore	Bauxite ¹		
SiO ₂	0.5 - 3	3 - 50	37 - 78	80 - 99	4 - 11	2.9	44.3	12 - 16
Al ₂ O ₃ + TiO ₂	0.1 - 1	1 - 20	7 - 30	0.5 - 3	0.2 - 3	57.5	32.3	2 - 5
Fe ₂ O ₃ + Mn ₂ O ₃	0.1 - 0.5	0.5 - 10	2 - 15	0.5 - 2	19 - 95	22.8	4.8	= 5
CaO	52 - 55	5 - 52	0.5 - 25	0.1 - 3	0.1 - 34	2.4	7.8	40 - 45
MgO	0.5 - 5	0.5 - 5	= 5	= 0.5	= 1.5	0.04	1.2	0.3 - 3
K ₂ O	= 0.3	= 3.5	0.5 - 5	= 1	traces	0.04	0.56	0.2 - 1.4
Na ₂ O	= 0.1	= 0.2	0.1 - 0.3	= 0.5	traces	0.02	0.15	= 0.3
SO ₃	= 0.1	0.1 - 4	= 3	= 0.5	traces	0.12	5.5	= 1.2
Loss on ignition: CO ₂ + H ₂ O	40 - 44	2 - 42	1 - 20	= 5	0.1 - 30	13.5	2.0	32 - 36

(All values are given in % by weight)

Note 1: Single analysis

Table A5-3 - The Chemical Composition of Mineral Additions

Components	Granulated Blast Furnace Slag	Burnt oil shale	Natural Pozzolan ("Trass")	Pulverised Fly Ash
SiO ₂	32.3 - 40.5	34.3 - 36.7	53.9 - 63.2	40 - 55
Al ₂ O ₃	7.1 - 14.0	11.3 - 11.4	15.2 - 20.4	24 - 30
TiO ₂	0.3 - 1.9	0.6 - 0.6	0.6 - 1.2	0.7 - 1.3
P ₂ O ₅	0.0 - 0.2	0.2 - 0.2	0.1 - 0.2	0.1 - 1.5
Fe ₂ O ₃	0.2 - 2.4	7.3 - 10.4	5.2 - 7.9	5 - 15
Mn ₂ O ₃	0.2 - 1.7	0.1 - 0.1	0.1 - 0.3	0.1 - 0.4
CaO	35.3 - 45.9	27.3 - 31.6	2.7 - 8.5	1.5 - 8
MgO	0.0 - 11.7	1.8 - 2.0	1.1 - 2.7	1.5 - 3.5
SO ₃	0.1 - 0.3	10.1 - 11.2	0.0 - 0.3	0.4 - 2.5
K ₂ O	0.2 - 1.1	2.0 - 2.1	1.5 - 6.0	1.0 - 4.5
Na ₂ O	0.2 - 0.6	0.3 - 0.3	1.5 - 4.3	0.4 - 1.5
LOI	0.1 - 1.9	4.2 - 8.0	7.1 - 11.6	0.8 - 5.0
CO ₂	0.1 - 1.3	2.6 - 7.0	0.6 - 4.8	-
H ₂ O	0.1 - 1.1	1.0 - 1.7	-	-
S ²⁻	0.9 - 2.1	0.1 - 0.2	-	-
CaO _{free}	-	-	-	0.1 - 1.5

(All values are given in % by weight)