

Guidelines for co-processing of alternative fuels and raw materials and treatment of organic hazardous wastes in cement kilns

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Guidelines for treatment of hazardous wastes and co-processing of AFRs in cement kilns

The fundamental and overarching principle of these guidelines is to prevent that cement kilns are abused for treatment of inappropriate wastes, nor shall increased emissions, non compliance with regulations or inferior practise be tolerated.

These guidelines recommend external auditing, transparent information disclosure of performance and the implementation of a continuous improvement system.



Stockholm Convention recommendations for general measures for management of co-processing of hazardous wastes in cement kilns

- ❑ Legislative and regulatory framework (permits, communication, transparency, community advice etc.)
- ❑ Emission monitoring is obligatory;
- ❑ Hazardous waste from trustworthy parties only (traceability);
- ❑ Transport, handling and storage must be monitored and controlled;
- ❑ Health and safety must have highest standards;

Stockholm Convention recommendations for general measures for management of co-processing of hazardous wastes in cement kilns

- ❑ Site must be suitable and with adequate infrastructure;
- ❑ Control and abatement of gross air emissions;
- ❑ Environmental monitoring, audit and reporting;
- ❑ Demonstration of performance (test burn);
- ❑ Qualification and training.

Policy elements

These Guidelines recommends that a national policy on waste management is in place and that strategies, legislation, guidelines, plans, treatment options and other elements of waste management will be developed and implemented following internationally recognised guiding principles.

Internationally recognised guiding principles

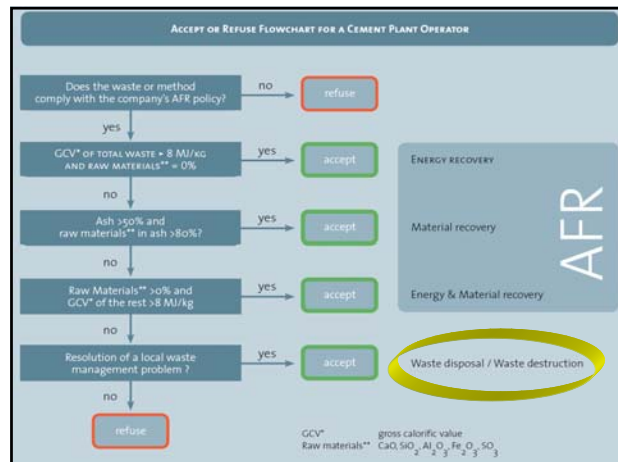
- ❑ Hazardous wastes are a major environmental problem and priority should be given to prevention of dangerous impacts on human, the environment and the ecosystem;
- ❑ The prevention and reduction of hazardous waste generation is the most beneficial approach to hazardous waste management and should be given priority;
- ❑ A hazardous waste minimisation strategy comprising waste prevention, cleaner production, reuse and recovery of materials and energy should be established;

Choice of waste management options should be based on the following hierarchy/priority:

- a) Avoidance, prevention and minimisation;
- b) Reuse and recycling to the highest degree possible;
- c) Recovery of energy and resources;
- d) Disposal, treatment and destruction;
- e) Final environmental sound and safe treatment.

Policy elements vs. Cement Kilns

- ❑ Cement kilns shall primarily be used for recovering energy and materials, i.e. for co-processing alternative fuels and raw materials which can substitute fossil fuel and virgin raw materials;
- ❑ In lack of available treatment options and urgent needs, a certified cement kiln can be used for treatment of organic hazardous constituents provided that this is done under strict Government control and guidance. Such activities must have a special permit and should comply with these guidelines.



International Conventions

- ❑ The national policy should aim for sustainable resource and energy consumption as well as integrating all relevant elements of and complying with the Montreal Protocol aimed at eliminating ozone-depleting substances (1987), the Basel Convention on the Control of Transboundary Movements of hazardous Wastes and their Disposal (1989), the Convention on Biological Diversity (1992), the Aarhus Protocol on Persistent Organic Pollutants (1998), the Rotterdam Convention on the Prior Informed Consent Procedures for Certain hazardous Chemicals and Pesticides in International Trade (1998) and the Stockholm Convention on Persistent Organic Pollutants (POPs) (2004).

Risk factors

The largest potential risks with the treatment of hazardous wastes and co-processing of AFRs in cement kilns are connected to possible accidents, spills and exposure during:

- a) collection and transport of hazardous wastes to the plant;
- b) handling/pre-treatment, preparation and feeding;
- c) emissions to air;
- d) contamination of the product.

Risk reduction

Certain requirements and prerequisites should be in place to prevent and reduce the risks to the greatest extent possible prior to commencing on with treatment of hazardous wastes in cement kilns on a routine basis.

Limitations of the guidelines

These guidelines cover "all" aspects of co-processing of AFRs and treatment of hazardous wastes in cement kilns by describing international recommendations and environmentally sound management principles.

These principles must however be adapted to local circumstances, i.e. regulation, waste types and characteristics, pre-processing facility, and the co-processing at the local cement plant.

Limitations of the guidelines

The final co-processing and treatment at the cement plant will be determined by the local raw material and fuel chemistry, by the availability of AFRs and waste materials, by the infrastructure and the cement production process, by the availability of equipment for controlling, handling and feeding the waste materials, and finally by site specific health, safety and environmental issues.

Many of these aspects are to a certain degree site specific and will vary from plant to plant, that is why only general principles and international recommendations are applicable.

Limitations of the guidelines

The final details of the pre-processing and co-processing practise must therefore be described in the local permit/licence; the recommended content of such a co-processing permit/licence is outlined in chapter 14. The recommendations of these guidelines should however be integrated in the permit.

Recommended requirements for cement plants

1. An approved EIA and all necessary national/local licenses;
2. Compliance with all relevant national and local regulations;
3. Compliance with the Basel and the Stockholm Convention;

Requirements and prerequisites

4. An approved location, technical infrastructure and processing equipment;
5. Reliable and adequate power and water supply;
6. Adequate air pollution control devices and continuous emission monitoring ensuring compliance with regulation and permits - **needs to be verified through regular baseline monitoring and reporting;**

Requirements and prerequisites

7. Exit gas conditioning/cooling and low temperatures (<200°C) in the air pollution control device to prevent dioxin formation;
8. Clear management and organisational structure with unambiguous responsibilities, reporting lines and feedback mechanism;

Requirements and prerequisites

9. An error reporting system for employees;
10. Qualified and skilled employees to manage hazardous wastes and health, safety and environmental issues;
11. Adequate emergency and safety equipment and procedures, and regular training;

Requirements and prerequisites

12. Authorised and licensed collection, transport and handling of hazardous wastes;
13. Safe and sound receiving, storage, preparation and feeding of hazardous wastes;

Requirements and prerequisites

14. Adequate laboratory facilities and equipment for hazardous waste acceptance and feeding control;
15. Demonstration of hazardous wastes destruction performance through test burns;

Requirements and prerequisites

16. Adequate record keeping of hazardous wastes and emissions;
17. Adequate product quality control routines;
18. An environmental management and continuous improvement system certified according to ISO 14001, EMAS or similar;

Requirements and prerequisites

19. Regular independent audits, emission monitoring and reporting;
20. Regular stakeholder dialogues with local community and authorities, and for responding to comments and complaints;
21. Open disclosure of performance reports on a regular basis.

2. General considerations

This chapter summarise general measures and considerations, which needs to be in place when introducing treatment of hazardous wastes in cement plants.

2.1 Compliance with regulations

Relevant and appropriate legislative and regulatory framework has to be in place to guarantee a high level of environmental protection.

The cement plant operator must:

- a) Identify all relevant laws, regulations, standards relating to safety, health, environment, and quality control, and review compliance continually;
- b) Share this information with the employees and make sure that they are aware of their responsibilities under them.

2.2 Location, health and safety aspects

Site location and suitability should be carefully considered as this may avoid risks associated with proximity to populations of concerns, impact of releases, logistics, transport, infrastructure, as well as having in place technical solutions for vapours, odours, infiltration into environmental media, etc.

2.2 Location, health and safety aspects Sites must:

- a) Develop robust emergency procedures as well as procedures for operation and maintenance that cover safety of workers and installations;
- b) Operations and maintenance procedures must be systematically reviewed.

2.3 Training

The pre-processing facility and cement plant operator must develop and implement appropriate and documented training programs for employees on operation, safety, health, and environment and quality issues relevant to their jobs.

2.3 Training

Train new employees during an induction process and personnel reporting to work on a site for the first time should be trained through a site induction program.

Keep training records on file.

The training program should include the following:

- a) General and job specific safety rules;
- b) Safe operation of all equipment;
- c) Compliance with existing permits for working with hazardous waste;
- d) Details of the site emergency plan and procedures;

- e) Procedures for handling hazardous wastes and alternative fuels and raw materials as well as detection of warning indicators such as barrel expansion, smoke from stockpiles, spillages or leaks;
- f) Use and maintenance of personal protective equipment (PPE);

- g) Waste labelling (composition, storage requirements and risks) and requirements for segregation of incompatible wastes (such as minimum distances, firewalls and containment cells).

Such training programs should also be given to contractors and, in some instances, suppliers.

2.4 Involvement and communication

Adequate documentation and information are mandatory, providing an informed basis for openness and transparency about health and safety measures and standards, and ensuring that employees and authorities have such information well before starting any use of wastes.

All relevant authorities must be involved during the permitting process, and the cement plant operator must:

2.4 Involvement and communication cont.

- a) Establish credibility through open, consistent, and continuous communication with the authorities and other involved stakeholders. All necessary information must be provided to allow stakeholders to understand the purpose of the treatment of hazardous wastes in a cement kiln, the context, the function of the parties involved and decision-making procedures;
- b) Provide necessary information to ensure that authorities are able to evaluate the treatment of hazardous wastes;
- c) A stakeholder engagement plan should be established for working with the local community and authorities, including procedures for responding to community interests, comments, or complaints; feedback should be given promptly.

2.5 Reporting performance

Building trust with stakeholders requires both transparency and accountability in the cement plant operator and its site operations.

The production of regular reports on performance in all areas of interest helps to provide key stakeholders with the information they need to make a fair and balanced judgment of the company's or site's activities and performance.

2.6 Environmentally sound management

Environmentally sound management (ESM) is a policy concept that more broadly applies to hazardous wastes within the Basel and Stockholm Convention.

In its article 2, paragraph 8, the Basel Convention (1989; 2006) defines ESM of hazardous wastes or other wastes as *“taking all practicable steps to ensure that hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against adverse effects which may result from such wastes.”*

2.6 Environmentally sound management

To comply with the ESM criteria, a number of legal, institutional and technical conditions must be met, in particular that:

- a) A regulatory and enforcement infrastructure ensures compliance with applicable regulations;
- b) The facility should be authorized and have an adequate standard of technology and pollution control to deal with hazardous wastes;

c) The facility should have an applicable environmental management system (EMS) in place;

d) The facility should take sufficient measures to safeguard occupational and environmental health and safety;

e) The facility should have an adequate monitoring, recording and reporting programme;

f) People involved in the management of hazardous wastes are capable and adequately trained in their capacity.

g) That the facility should have an adequate emergency plan; and

h) The effects of the activities needs to be monitored and appropriate action should be taken in cases where monitoring gives indications that the management of hazardous wastes has resulted in unacceptable releases.

2.7 Environmental management system

The pre-processing facility and cement plant operator should have an environmental management system (EMS) in place, ensuring continuous improvement of its performance.

The two most frequently used guidelines for EMS design are the international standard, ISO 14001, and the European standard, EMAS.

2.7 Environmental management system

ISO 14001 provides guidelines that can be implemented by almost any type of organization in any country and was designed primarily to improve management. EMAS, on the other hand, is designed to bring about changes in environmental performance.

Preparing for and complying with ISO 14001 involves several steps:

- a) Conducting an initial environmental review;
- b) Identifying environmental aspects and impacts;
- c) Setting an environmental policy;
- d) Understanding and complying with local environmental legislation and regulations and other standards to which the organization subscribes;
- e) Setting environmental objectives and targets;
- f) Setting and implementing an environmental management program;
- g) Setting and implementing environmental procedures;
- h) Establishing environmental training and awareness;
- i) Establishing an environmental communication system;
- j) Establishing a system for document and operational control;
- k) Installing an emergency preparedness and response plan;
- l) Monitoring and measuring;
- m) Understanding non-conformance and implementing correction and prevention;
- n) Having an audit, and
- o) Management review and control.

3. Initial waste and impact evaluation by the cement plant

The aim of the initial acceptance procedures is to set the outer boundaries and limits for wastes, which can be accepted by a particular kiln, and the conditions and requirements for their preparation and delivery specification.

Any waste fed to a cement kiln should:

- a) Be homogenous;
- b) Have stable heat and moisture content;
- c) Have stable chemical and physical composition;
- d) Have a pre-specified size distribution.

In real-life, a cement plant operator usually receives wastes from various producers with various waste characteristics and to fulfil the requirements mentioned above wastes must be pre-processed prior to delivering to the cement plant.

The cement plant operator must however specify their requirements for waste acceptance with the waste owner and the pre-processing facility prior to any deliverables.

3.1 Waste evaluation

Accept only wastes from trustworthy parties throughout the supply chain, with traceability ensured prior to reception by the facility and with unsuitable wastes refused.

The pre-processing facility and cement plant operator must develop an evaluation and acceptance procedure that includes the following features:

- a) To evaluate possible impacts before delivering it to the cement plant or pre-processing facility, each waste supplier must prepare a representative sample.

This must include a datasheet detailing the chemical and physical properties, information on relevant health, safety, and environmental considerations during transport, handling, and use of the material.

It must also specify the source of the particular shipments being made;

- b) Test and check the sample's physical and chemical characteristics against specifications.

3.2 Assessment of possible impacts

When the cement plant operator and the pre-processing facility have received information about the waste, he must:

- a) Assess the potential impact of transporting, unloading, storing, and using the material on the health and safety of employees, contractors, and the community. Ensure that equipment or management practices required to address these impacts are in place;
- b) Assess what personal protective equipment will be required for employees to safely handle the waste on site;
- c) Assess the compatibility of wastes; reactive or non-compatible wastes must not be mixed;

- d) Assess the effect the waste may have on the process operation.

Chlorine, fluorine, sulphur, and alkali content in wastes may build up in the kiln system, leading to accumulation, clogging, and unstable operation; excess in chlorine or alkali may produce cement kiln dust or bypass dust (and may require installation of a bypass) which must be removed, recycled or disposed of responsibly.

The heat value is the key parameter for the energy provided to the process. Wastes with high water content may reduce the productivity and efficiency of the kiln system and the ash content affects the chemical composition of the cement and may require an adjustment of the composition of the raw materials mix;

- e) Assess the potential impact on process stability and quality of the final product;
- f) Assess the effect the waste may have on plant emissions and whether new equipment or procedures are needed to ensure that there is no negative impact on the environment;
- g) Determine what materials analysis data the waste supplier will be required to provide with each delivery, and whether each load needs to be tested prior to off-loading at the site.

3.3 Commonly restricted wastes

Develop a uniform list of restricted wastes valid for the plant based on the previous impact assessment and the plants raw material and fuel composition.

Certain cement companies choose not to treat the following wastes and materials:

- a) Electronic waste;
- b) Entire Batteries;
- c) Infectious and biological active medical waste;
- d) Mineral acids and corrosives;
- e) Explosives;
- f) Asbestos;
- g) Radioactive waste;
- h) Unsorted municipal waste;
- i) Unknown/unidentified wastes.

3.3 Commonly restricted wastes

Individual companies may exclude additional materials depending on local circumstances and company policy.

Shipments crossing international boundaries and classified as hazardous waste under the Basel Convention must meet with the requirements of the Convention.

3.3.1 Risky wastes

When the waste composition cannot be described in detail (e.g. small amounts of pesticides or laboratory chemicals), the cement plant operator and the pre-processing facility may agree with the waste producer on specific packaging requirements, making sure that the waste will not react during transport, or within containers.

For example, risks may arise from:

- a) Wastes with phosphides;
- b) Wastes with isocyanates;
- c) Waste with peroxides;
- d) Wastes with alkaline metals (e.g., or other reactive metals);
- e) Cyanide with acids;
- f) Wastes forming acid gases during combustion;
- g) Wastes with mercury and thallium.

3.4 Check list for acceptance control

Delivered wastes must generally undergo specific admission controls, whereby the previously received declaration by the waste producer provides the starting point.

After comparison by visual and analytical investigations with the data contained in the declaration, the waste is either accepted and allocated to the appropriate pre-processing and/or storage area, or rejected in the case of significant deviations.

Prior to signing any commercial contract, the cement plant operator must make sure that:

- a) The waste generator, collector, pre-processing facility provides adequate information on composition and risks of the material;
- b) They do not accept any substances, compounds or preparations which are not allowed or on the “negative list”;

c) They prohibit blending of incompatible materials and perform compatibility tests if needed;

d) They perform sampling on the site of the generator, collector or the pre-processing facility and analysis before acceptance of commercial contracts. Sampling and analysis can be done by own or external, certified laboratories;

e) They do not start transportation to plant site before completion of the acceptance process. This acceptance process does not replace sampling and analysis of waste deliveries at the plant sites;

f) They communicate the inherent safety and health risks indicated by the waste generator, collector, pre-processor or identified by the sample analysis to the downstream operations (transport, pre- and co-processing) to ensure that PPE and installations are adapted accordingly;

- g) They provide simple, clear and practical handling procedures, based on the material properties, to each person who will work with the waste;
- h) They provide the commercial employees with adequate training in chemistry to allow them to enforce the waste acceptance criteria.

4. Waste collection and transport

Waste transport, handling and storage must be effectively monitored, and be in full compliance with existing regulatory requirements; only qualified, authorised and licensed transport companies shall be used.

4.1. Waste collection and handling

The main concerns when handling hazardous wastes are human exposure, accidental release to the environment and contamination of other waste streams. Hazardous wastes should be handled separately from other waste types in order to prevent contamination and recommended practices for this purpose include:

- a) Inspecting drums and containers for leaks, holes, rust, and high temperature;
- b) Handling hazardous wastes at temperatures below 25 °C, if possible, due to the increased volatility at higher temperatures;

- c) Ensuring that spill containment measures is adequate and would contain liquid wastes if spilled;
- d) Placing plastic sheeting or absorbent mats under containers before opening containers if the surface of the containment area is not coated with a smooth surface material (paint, urethane, epoxy);
- e) Removing liquid hazardous wastes either by removing the drain plug or by pumping with a peristaltic pump and Teflon or silicon tubing;

- f) Using dedicated pumps, tubing and drums, not used for any other purpose, to transfer liquid wastes;
- g) Cleaning up any spills with cloths, paper towels or absorbent;
- h) Triple rinsing of contaminated surfaces with a solvent such as kerosene to remove all of the residual hazardous wastes;
- i) Treating all absorbents and solvent from triple rinsing, disposable protective clothing and plastic sheeting as hazardous wastes.

4.2 Waste transport

Wastes consisting of, containing or contaminated with hazardous materials must be packaged prior to transport. Liquid hazardous wastes should be placed inter alia in double-bung steel drums. Regulations governing transport often specify containers of a certain quality (e.g. 16-gauge steel coated inside with epoxy). Therefore, containers used for storage should meet transport requirements in anticipation that they may be transported in the future.

Drums

Drums may be placed on pallets for movement by forklift truck and for storage, but must be strapped to the pallets prior to movement.

All drums and containers must be clearly labeled with both a hazard warning label and a label that gives the details of the drum. The details include the contents of the drum, the type of waste, and the name and telephone number of the responsible person.

Only authorised and licensed transport companies shall be used for collection and transport of hazardous wastes, and the plant operator should ensure that:

- a) Vehicles are fit for operation according to local regulations and waste specifications;
- b) Vehicles are clean (no spillage or residues);
- c) Drivers have received appropriate training in the transport of waste/hazardous substances including emergency response, based on local regulations (at a minimum).
- d) Drivers have been instructed to refuse to load and transport barrels, big bags or other waste packages which are damaged, leaking or showing other conspicuous warning signs (e.g. barrel expansion from pressure build-up, elevated temperature etc.).

5. Waste reception and handling

Wastes received in drums at the pre-processing facility and cement plant must be packed, labelled and loaded properly to ensure that waste material reaches the plant in good condition.

The transport of packed waste, typically waste in drums should present detailed instructions on the types of material.

All wastes received at the plant should initially be treated as being unknown and hazardous until compliance with specifications has been positively verified.

Vehicles carrying wastes must stop upon arrival and make the necessary identifications. Such vehicles should be:

- a) Weighed in and out of the site and deliveries must be recorded;
- b) Documents relating to vehicles carrying hazardous waste must be checked and the compliance with site acceptance specifications and regulations determined;
- c) Document checks should cover waste certificates, transport certificates, etc.;
- d) Instructions for unloading, including safety and emergency instructions, should be provided in due time to vehicle drivers.
- e) A vehicle found not to comply should not be allowed to enter the site.

5.1.1 Management for non-compliant deliveries

Make written instructions available that describe measures to be implemented in case of non-compliance with specifications set for hazardous wastes. The producer of hazardous waste must be informed about non-compliant deliveries. If non-compliance cannot be cleared with producer, the shipment must be rejected and if required in the permit, authorities must be notified.

Deliveries should be evaluated for each producer on a statistical basis in order to assess the performance and reliability of the hazardous waste producers; periodically review contracts accordingly.

5.2 Checking, sampling and testing incoming wastes – general considerations

Delivered wastes must undergo specific admission controls, whereby the previously received declaration by the waste producer provides the starting point.

Sample and analyze vehicle loads once on site according to the frequency and protocol defined in the site control plan; check agreement with site specifications according to the plan of control.

Accept wastes once their properties are confirmed to agree with specifications.

5.2.1 Assess incoming wastes

Apply a suitable regime for the assessment of incoming waste. Such assessment must reveal:

- a) That the wastes received are within the range suitable for the installation;
- b) Whether the wastes need special handling/storage/treatment/removal for off-site transfer;
- c) Whether the wastes are as described by the supplier (for contractual, operational or legal reasons).

5.2.2 Techniques for checking

The techniques adopted vary from simple visual assessment to full chemical analysis. The extent of the procedures adopted will depend upon:

- a) Nature and composition of waste;
- b) Heterogeneity of the waste;
- c) Known difficulties with wastes (of a certain type or from a certain source);

- d) Specific sensitivities of the installation concerned (e.g. certain substances known to cause operational difficulties);
- e) Whether the waste is of a known or unknown origin (should be avoided);
- f) Existence or absence of a quality controlled specification for the waste;
- g) Whether the wastes have been dealt with before and the plants experiences with it.

5.2.3 Inspection

The following inspection scheme should be applied:

- a) Control and comparison of data in the declaration list in comparison with delivered waste;
- b) Sampling/analysis of all bulk tankers;
- c) Random checking of drummed loads;
- d) Unpacking and checking of packaged loads;

- e) Assessment of combustion parameters;
- f) Blending tests on liquid wastes prior to storage;
- g) Control of flashpoint for wastes in the bunker;
- h) Screening of waste input for elemental composition e.g. by XRF and/or other appropriate techniques.

5.2.4 Detectors for radioactive materials

The inclusion of radioactive sources or substances in waste, can lead to operational and safety problems.

Very low "background" levels of radioactivity are present throughout the natural environment and will be found in wastes – such levels do not require specific measures for their detection and control.

However, some wastes are at risk of containing higher levels.

5.2.4 Detectors for radioactive materials

Radioactive materials can often be detected using specific detectors situated at, for example, the entrance to the plant.

Tests of waste loads that may have a higher risk of contamination can be carried out.

Plastic scintillation detectors are one type of detector used; these measure photons from gamma emitting radionuclides and to a lesser extent from beta emitters.

5.3 Reception and handling

There should be written procedures and instructions in place for the unloading, handling, and storage of the solid and liquid hazardous wastes used on site, i.e.:

- a) Designated routes for vehicles carrying specified hazardous wastes should be clearly identified within the site;
- b) Relevant employees should be trained in the company's operating procedures, and compliance with such procedures should be audited regularly;
- c) Appropriate signs indicating the nature of hazardous wastes should be in place at storage, stockpiling, and tank locations;
- d) Storage facilities should be operated in such a way as to control emissions to air, water, and soil.

5.3.1 Labelling

In general, waste delivery is accompanied by a suitable description of the waste; an appropriate assessment of this description and the waste itself forms a basic part of waste quality control. An indicative list of the most important parameters for labelling includes:

- a) Name and address of the deliverer;
- b) Origin of the waste;
- c) Volume;
- d) Water and ash content;
- e) Calorific value;
- f) Concentration of chlorides, fluorides, sulphur and heavy metals.

6. Waste pre-processing

The use of wastes must not detract from smooth and continuous cement kiln operation, product quality, or the site's normal environmental performance implying that wastes used in cement kilns must be homogenous and have a stable chemical composition and heat content, and a pre-specified size distribution.

Pre-processing and preparation with the objective of providing a more homogeneous feed and more stable combustion conditions may therefore be necessary.

Waste pre-processing

Such pre-processing can include drying, shredding, grinding or mixing depending on the type of waste.

Pre-processing is usually done in a purpose made facility, which may be located outside or inside the cement plant.

If the alternative fuel is prepared outside the cement plant, the fuels only need to be stored at the cement plant and then proportioned for feeding them to the cement kiln.

6.1 Alternative fuels

Alternative fuels can be subdivided into five classes:

1. Gaseous alternative fuels, for example coke oven gases, refinery waste gas, pyrolysis gas, landfill gas, etc.
2. Liquid alternative fuels, for example low chlorine spent solvents, lubricating as well as vegetable oils and fats, distillation residues, hydraulic oils, insulating oils, etc. Some equipment can be sealed under a nitrogen blanket to reduce fire and explosion risks when handling liquids.
3. Pulverized, granulated or fine crushed solid alternative fuels, for example ground waste wood, sawdust, planer shavings, dried sewage sludge, granulated plastic, animal flours, agricultural residues, residues from food production, fine crushed tyres, etc.

4. Coarse crushed solid alternative fuels, for example crushed tyres, rubber/plastic waste, waste wood, re-agglomerated organic matter, etc.
5. Lump alternative fuels, for example whole tyres, plastic bales, material in bags and drums, etc.

Mixing and homogenisation of wastes will generally improve feeding and combustion behaviour. Mixing of wastes can involve risks and should be carried out according to a prescribed recipe.

6.2 Pre-processing and mixing of alternative fuels

Techniques used for waste pre-processing and mixing are wide ranging, and may include:

- a) Mixing and homogenising of liquid wastes to meet input requirements, e.g. viscosity, composition and/or heat content;
- b) Shredding, crushing, and shearing of packaged wastes and bulky combustible wastes, e.g. tyres;
- c) Mixing of wastes in a bunker using a grab or other machine (e.g. sprelling machines for sewage sludge);
- d) Production of refuse derived fuel (RDF), usually produced from source separated waste and/or other non hazardous waste.

Mixing and homogenisation

Solid heterogeneous wastes (e.g. packaged hazardous wastes) can be mixed in a bunker or a pit prior to loading into feed systems.

In bunkers, the mixing involves blending of wastes using cranes and the crane operators can identify potentially problematic loads (e.g. baled wastes, discrete items that cannot be mixed or will cause loading/feeding problems) and ensure that these are removed, shredded or directly blended (as appropriate) with other wastes.

Crane capacity must be designed so that it is sufficient to allow mixing and loading at a suitable rate.

6.3 Segregation of waste types for safe processing

Waste acceptance procedures and storage depend on the chemical and physical characteristics of the waste. Appropriate waste assessment is an essential element in the selection of storage and input operations and is strongly related to the checking, sampling and assessment of incoming wastes.

The segregation techniques applied vary according to the type of wastes received at the plant. Segregation relates to maintaining separation of materials so that hazardous mixtures are avoided. Extensive procedures are required to separate chemically incompatible materials.

Proper labelling of the wastes (e.g. in accordance with the European Waste Catalogue) that are delivered in containers, assists their identification and traceability, and ensures:

- a) Knowledge of waste content, which is required for choice of handling/processing operations;
- b) The operators ability to trace sources of problems and then to take steps to eliminate or control them;
- c) The ability to demonstrate conformance with restrictions on waste types and quantities received/processed.

Bar code systems and scan readers can be used for packaged and liquid wastes. The costs of such systems are low in relation to the benefits.

6.4 General design considerations

Carefully consider plant layout to ensure access for day-to-day operations, emergency escape routes, and maintainability of the plant and equipment.

Apply recognized standards to the design of installations and equipment. Any modification to installations and equipment should meet requirements set in the standards. Thoroughly evaluate existing equipment refitted for a different service from a safety and performance standpoint before resuming commercial production. Document any modifications to installations and equipment.

6.4 General design considerations

Assess operations for health and safety risks or concerns to ensure that equipment is safe and to minimize risks of endangering people or installations, or damaging the environment.

Use appropriate procedures to assess risks or hazards for each stage of the design process.

Only competent and qualified personnel should undertake or oversee such hazard and operability studies.

6.4.1 Design for reception and storage of hazardous wastes

Establish suitable and safe transfer systems from transportation to the storage area to avoid risks from spillage, fugitive emissions or vapour. Suitable vapour filtration and capture equipment should be in place to minimize impact to the reception point and surrounding areas from unloading activities.

Transfer and storage areas must be designed to manage and contain accidental spills into rainwater or firewater, which may be contaminated by the materials. This requires appropriate design for isolation, containment, and treatment as follows:

6.4.1 Design for reception and storage of hazardous wastes

- a) All ground area within diked, storage areas must be sealed so that spills will not penetrate the ground;
- b) Sealed concrete surfaces with well controlled drainage are recommended;
- c) All leaks, spills, rainwater etc. should be easily collected and saved for destruction;

6.4.1 Design for reception and storage of hazardous wastes

- d) No runoff water from the waste chemical storage area should be discharged to sewers. Any such runoff should be redirected into storage tank for subsequent high temperature destruction in the kiln;
- e) Leak free design should be specified whenever possible;
- f) Methods to contain and recover piping leaks without environmental contamination should be provided;
- g) Adequate alarms for abnormal conditions should be provided.

6.4.1 Design for reception and storage of hazardous wastes

Monitoring systems capable of detecting volatile organic vapours should be placed at key process locations to signal accidental waste fuel leaks. Periodic monitoring for volatile organic compound emissions should be provided.

All volatile organic emissions from hazardous waste storage and handling facilities could be exhausted to the cement kiln for complete destruction. Alternatively, a closed vapour line between the storage tank vents and the tank trucks should be provided to return the displaced volatile organic vapours from the storage tanks to the tank truck, when loading the tanks.

A back up carbon adsorption vapour control system could be provided to control volatile organic compound storage tank breathing emissions. Explosion proof safety valves should be used.

6.4.2 Housekeeping

General tidiness and cleanliness contribute to an enhanced working environment and can allow potential operational problems to be identified in advance. The main elements of good housekeeping are:

- a) The use of systems to identify and locate/store wastes received according to their risks;
- b) The prevention of dust emissions from operating equipment;
- c) Effective waste water management;
- d) Effective preventive maintenance.

7. Waste storage

Limit waste volume in storage and waste storage time to a minimum, i.e. maximum allowed waste storage need to be based on installed fire protection systems (which should include early warning sensors like temperature and smoke detectors).

Limits for waste and processed wastes storage times per type of material have to be formally defined and respected, taking into consideration the corresponding health and safety risks (toxicity, reactivity, flammability/explosion potential, and storage conditions) and local regulations.

Waste storage

Assure that storage facilities fit their purpose. In general, the storage of wastes needs, additionally, to take into account the unknown nature and composition of wastes, as this gives rise to additional risks and uncertainties.

In many cases, this uncertainty means that higher specification storage systems are applied for wastes than for well-characterised raw materials.

A common practice is to ensure, as far as possible, that hazardous wastes are stored in the same containers (drums) that are used for transport; thus avoiding the need for additional handling and transfer.

Waste storage

Good communication between the waste producer and the waste manager help to ensure wastes are stored and transferred, etc., such that risks all along the chain are well managed.

It is also important that only well characterised and compatible wastes are stored in tanks or bunkers.

7.1 Liquid and solid wastes

Appropriate waste assessment is an essential element in the selection of storage and loading options. Some issues to note are:

- For the storage of solid hazardous waste, many plants are equipped with a bunker from where the waste is fed into the installation by cranes or feed hoppers;
- Liquid hazardous waste and sludge's, these are usually stored in a tank farm. Some tanks have storage under an inert (e.g. N₂) atmosphere. Liquid waste is pumped via pipelines to the kiln. Sludge's can be fed by using special "viscous-matter" pumps. Appropriate storage for liquids should meet relevant safety and design codes for storage pressures and temperatures and should have adequate secondary containment;

Appropriate waste assessment is an essential element in the selection of storage and loading options. Some issues to note are:

- Some kilns are able to feed certain substances, such as toxic, odorous liquids, by means of a direct injection device, directly from the transport container into the kiln.

Hazardous wastes should be stored in an isolated area, preferable well fenced and locked, to provide good security from intruders and vandals.

Incompatible wastes must be kept separate. The waste liquid storage sump area should be enclosed and all vent gases from such area and storage tank should be vented to an emission control system. Solid materials handling systems should have adequate dust control systems.

7.2 Storage time

Storage design should be appropriate to maintain the quality and storage time of the materials. The design should prevent build-up of old materials for solids and apply mixing or agitation to prevent settlements in liquids.

Storage of hazardous waste should be for as brief a period as possible and in accordance with the permit and regulation. Recommended maximum storage times are:

- 10 days for waste mixtures, and hazardous wastes;
- 21 days for hazardous waste impregnated substrates;
- For non-hazardous AFR, storage time is limited by the designed storage capacity and installed fire suppression systems.

7.3 Storage of solid waste

Solid and un-pumpable pasty hazardous waste that has not been degassed and does not smell can be stored temporarily in bunkers. Storage and mixing areas can be separated in the bunker. This can be achieved through several design segments. The bunker must be designed in such a way that ground emissions can be prevented.

The bunker and container storage must be enclosed unless health and safety reasons (danger of explosion and fire) exist. The air in the bunker is usually removed and ducted to the kiln. In anticipating fires, monitors such as heat-detecting cameras are used, in addition to constant monitoring by personnel (control room, operator).

7.3.1 Storage of pumpable hazardous waste

Larger amounts of fluid and pumpable pasty wastes are temporarily stored in tanks that must be available in sufficient numbers and sizes to accommodate reacting liquids separately (danger of explosion, polymerisation).

Tanks, pipelines, valves, and seals must be adapted to the waste characteristics in terms of construction, material selection, and design. They must be sufficiently corrosion-proof, and offer the option of cleaning and sampling. Flat bed tanks are generally only deployed for large loads.

7.3.1 Storage of pumpable hazardous waste

It may be necessary to homogenise the tank contents with mechanical or hydraulic agitators. Depending on the waste characteristics, some tanks must be heated indirectly and insulated.

Tanks are set in catch basins that must be designed for the stored material, with bund volumes chosen so that they can hold the liquid waste in the event of leakage.

7.4 Storage for containers and tank containers

For safety reasons, hazardous waste is often accumulated in special containers, which can be delivered directly to the plant. Delivery is also taken of bulk liquids.

The delivered containers may be stored or the contents transferred. In some cases, according to a risk assessment, the waste may be directly injected via a separate pipeline into the kiln. Heated transfer lines may be used for wastes that are only liquid at higher temperatures.

Storage areas for containers and tank containers are usually located outside, with or without roofs. Drainage from these areas is generally controlled, as contamination may arise.

7.5 Safety aspects of storage

The following measures will strengthen safety:

- a) Storage areas should be kept clear of uncontrolled combustible materials;
- b) Clear safety warnings, no smoking, fire, evacuation route, and any procedures signs should be clearly posted;
- c) An emergency shower and eye washing station should be clearly marked and located near the storage of liquid alternative fuels;

7.5 Safety aspects of storage

- d) A fire protection system must be available at all times and should meet all standards and specifications from local authorities (e.g. local fire department);
- e) Adequate alarms should be provided to alert all personnel about emergency situations;
- f) Communications equipment should be maintained at the site so that the control room and the local fire department can be contacted immediately in case of a fire;
- g) Equipment should be grounded and appropriate anti-static devices and adequate electrical devices selected (e.g. motors, instruments, etc.).

7.5.1 The use of fire detection and control systems

Automatic fire detection systems are used in waste storage areas as well as for fabric and static filters, electrical and control rooms, and other identified risk areas.

Automatic fire control systems are applied in some cases, most commonly when storing flammable liquid waste although also in other risk areas.

Foam and carbon dioxide control systems provide advantages in some circumstances e.g. for the storage of flammable liquids. Foam nozzles are commonly used in MSW incineration plants in the waste storage bunker. Water systems with monitors, water cannons with the option to use water or foam, and dry powder systems are also used. Nitrogen blanketing may be used in fixed coke filters, fabric filters, tank farms, or for the pre-treatment and kiln loading facilities for hazardous wastes.

7.5.1 The use of fire detection and control systems

Continuous automatic measurement of temperature can be carried out on the surface of wastes stored in the bunkers. Temperature variations can be used to trigger an acoustic alarm. There are also other safety devices, such as:

- a) Nozzles above the waste feed hoppers;
- b) Fire resistant walls to separate transformers and retention devices under transformers;
- c) Gas detection above gas distribution module.

When ammonia is used, its storage requires specific safety measures, i.e. NH₃ detection and water spray devices to absorb releases.

8. Best available techniques and best environmental practise (BAT/BEP)

Technological advancement of the cement industry will concentrate on the further development of new technology, on the utilization of secondary materials and other supplementary cementitious materials.

Best available techniques and best environmental practise (BAT/BEP)

In recent years, improvement of cement production lines with precalcining systems includes the new homogenization technology, new preheating and precalcining systems with the capacity of up to ten thousand tons of cement per day, various new types of crushing and grinding systems, new operation and management systems, new environmental protection measures such as the use of new bag dust collector and low NOx burner.

The utilization of secondary materials and supplementary cementitious materials may save huge amounts of natural resources.

8.1 BAT/BEP for cement production

Dry preheater/precalciner kilns are regarded to be the best available techniques (BAT) and to constitute the Best Environmental Practise (BEP). These technologies are also the most economically feasible option, which constitutes a competitive advantage and thereby contributes to gradually phase out older, polluting and less competitive technologies.

For new plants and major upgrades the best available techniques for the production of cement clinker is a dry process kiln with multi-stage preheating and precalcination.

A smooth and stable kiln process, operating close to the process parameter set points, is beneficial for all kiln emissions as well as the energy use.

8.1 BAT/BEP for cement production

This can be obtained by applying:

- Process control optimisation, including computer-based automatic control systems;
- The use of modern fuel feed systems;
- Minimising fuel energy use by means of preheating and precalcination to the extent possible, considering the existing kiln system configuration.

Careful selection and control of substances entering the kiln can reduce emissions and when practicable, homogenous raw materials and fuels with low contents of sulfur, nitrogen, chlorine, metals and volatile organic compounds should be selected.

8.1 BAT/BEP for cement production

PCDD/PCDF control in cement production becomes a simultaneous effort to reduce the precursor and/or organic concentrations, preferably by finding a combination of optimum production rate and optimum gas temperatures and oxygen level at the raw material feed end of the kiln, and reducing the APCD temperature.

8.1 BAT/BEP for cement production

Feeding of alternative raw materials as part of raw material mix should be avoided if it includes elevated concentrations of organics and no alternative fuels should be fed during start-up and shut down.

The most important measure to avoid PCDD/PCDF formation in long dry and wet kilns seems to be quick cooling of the kiln exhaust gases to lower than 200 °C. Modern preheater and precalciner kilns have this feature already inherent in the process design and have APCD temperatures less than 150 °C. Operating practices such as minimising the build-up particulate matter on surfaces can assist in maintaining low PCDD/PCDF emissions.

8.3 Conventional fuels

Three different types of conventional or fossil fuels are used in cement kiln firing in decreasing order of importance:

- Pulverized coal and petcoke;
- Fuel oil (heavy);
- Natural gas.

8.3 Conventional fuels

In order to keep heat losses at minimum, cement kilns are operated at lowest reasonable excess oxygen factors. This requires highly uniform and reliable fuel metering as well as the fuel being present in a form which allows for easy and complete combustion (fuel preparation process and fuel storage).

These conditions are fulfilled by all pulverized, liquid and gaseous fuels, be it conventional or alternative fuels.

The main fuel input (65 – 85%) has therefore to be of this type whereas the remaining 15 – 35% may be fed in coarse crushed or lumpy form.

8.3 Conventional fuels

Fuel feed points to the cement kiln system are via the:

- Main burner at the rotary kiln outlet end;
- Feed chute at the transition chamber at the rotary kiln inlet end (for lump fuel);
- Fuel burners to the riser duct;
- Precalciner burners to the precalciner;
- Feed chute to the precalciner (for lump fuel);
- Mid-kiln valve to long wet and dry kilns (for lump fuel).

8.3 Conventional fuels

The fuel introduced via the main burner to the hot zone of the rotary kiln therein produces the main flame with flame temperatures around 2000° C.

For process optimisation reasons the flame has to be adjustable within limits.

The flame is shaped and adjusted by the so-called primary air (10 – 15% of total combustion air) through interaction of the outer axial air ring channel as well as of the conical inner air ring channel of the (main) burner.

9. Co-processing of alternative fuels

Conventional fuels are today increasingly substituted by non-conventional, non-fossil (gaseous, liquid, pulverized, coarse crushed) alternative (or secondary) fuels for resource efficiency and economical reasons.

9. Co-processing of alternative fuels

Many regulations do not restrict the use of AFRs / hazardous wastes to certain categories or concentration limits; some focus on emissions limits only. Other regulations specify an explicit list of acceptable AFRs with maximum and/or minimum values for various parameters, e.g. heavy metals, chlorine, calorific value etc. called the "positive" list and some regulations specify a negative list with waste categories not allowed.

Independent of concept chosen, it will be the local raw material and fuel chemistry, the infrastructure and the cement production process, the availability of equipment for controlling, handling and feeding the waste materials, and finally site specific health, safety and environmental issues which determines the waste categories to be accepted at the specific plant.

9.1 Input control – general rules

Use hazardous wastes only after the supplier, and the chemical and physical properties and specifications of the materials have been clearly identified.

Consistent long-term supply of appropriate hazardous waste is required to maintain stable conditions during operation.

Content of sulphur, nitrogen, chlorine, metals and volatile organic compounds needs to be specified and carefully controlled. Limitations with respect to the product and/or the process should be established.

Feeding of waste to the kiln must ensure:

- a) Sufficient temperature;
- b) Sufficient retention time;
- c) Sufficient mixing conditions;
- d) Sufficient oxygen.

Feeding of waste to the kiln must ensure:

The waste type and composition will determine the adequate feeding point; i.e. the main burner or the secondary burner in precalciner/preheater will ensure temperature > 900 °C. No waste feed as part of raw mix feed if it includes organics, and no waste feed during start-up and shutdown.

Handling and feed systems should be appropriate to the hazardous waste used and must ensure stable and controlled input to the kiln. The operator should assess risks from fugitive emissions; equipment failure modes and appropriate safeguards should be incorporated into the design to prevent environmental pollution, health, and safety problems.

Feeding control

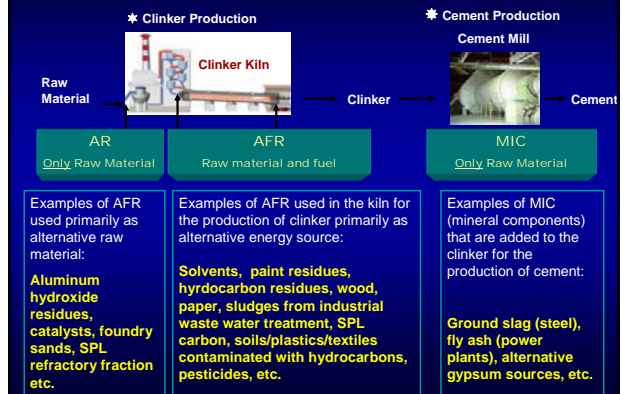
Automated monitors should be employed to alert operators in the event of a waste handling problem. A pressure transducer located in the waste piping at the entrance of the kiln should be provided to turn off the waste fuel pump automatically in the event of a sudden pressure drop due to pipe rupture or pump failure.

Interlocks should be provided to stop the flow of waste automatically if either normal fuel supply or combustion air flow is interrupted, or if carbon monoxide levels indicate less than 99.9% combustion efficiency.

9.2 Selection of feed point

The use of AFRs should not detract from smooth and continuous kiln operation, product quality, or the site's normal environmental performance. Therefore, a constant quality and feed rate of the waste materials must be ensured.

Wastes co-processed in the cement industry



9.2 Selection of feed point

The feed point for hazardous wastes into the kiln should be selected according to the nature (and, if relevant, hazardous characteristics) of the hazardous wastes used.

Gaseous, liquid, and finely pulverized alternative fuels can be fed to the kiln system via any of the feed points mentioned in the previous chapter. Coarse crushed and lump fuels can be fed to the transition chamber or to the mid-kiln valve only (with some exceptions).

9.2 Selection of feed point

Hazardous wastes should be introduced in the high-temperature combustion zone of the kiln system, i.e. the main burner, the precalciner burner, the secondary firing at the preheater, or the mid-kiln (for long dry and wet kilns).

9.2 Selection of feed point

The following is valid:

- Persistent organic pollutants and highly chlorinated organic compounds should be introduced at the main burner to ensure complete combustion due to the high combustion temperature and long retention time. Other feed points are appropriate only where test have shown high destruction and removal efficiency rates;
- Alternative raw materials with volatile organic components should not be introduced with other raw materials in the process, unless tests have shown that undesired emissions at the stack do not occur; such raw materials can be fed through a double or triple flap arrangement into the kiln inlet;

9.2 Selection of feed point

- Mineral inorganic wastes free of organic compounds can be added to the raw meal or raw slurry preparation system. Mineral wastes containing significantly quantities of organic components are introduced via the solid fuels handling system, i.e. directly to the main burner, to the secondary firing or, rarely, to the calcining zone of long wet or dry kilns;
- Mineral additions such as granulated blast furnace slag, fly ash from thermal power plants or industrial gypsum can be fed to the cement mill.

9.3 Operations and process control

Operating requirements should be developed to specify the acceptable composition of the waste feed, including acceptable variations in the physical and/or chemical properties of the hazardous waste. For each hazardous waste, the operating requirements should specify acceptable operating limits for feed rates, temperatures, retention time, oxygen etc.

For start-up, shutdown, or upset conditions of the kiln, written instructions should be issued, describing conditions of use of wastes. Kiln operators should know and understand these instructions.

9.3 Operations and process control

The general principle of good operational control of the kiln system using conventional fuels and raw materials should be applied.

In particular, all relevant process parameters should be measured, recorded and evaluated continuously and should cover:

- a) Free lime;
- b) Oxygen concentration;
- c) Carbon monoxide concentration.

9.3.1 Kiln operation and feeding of wastes

The plant should characterize a good operation and use this as a basis to improve other operational performance.

Having characterized a good kiln, establish reference data by adding controlled doses of waste, and look at changes and required controls and practice to control emissions.

The impact of hazardous wastes on the total input of circulating volatile elements such as chlorine, sulphur, or alkalis must be assessed carefully prior to acceptance as they may cause operational troubles in the kiln system.

9.3.1 Kiln operation and feeding of wastes

The kiln process must be operated to achieve stable conditions, which may be achieved by applying process control optimization (including computer-based automatic control systems) and use of modern, gravimetric solid fuel feed systems.

Input limits and operational set points for these components should be set individually by the site based on the process type and on the specific site conditions.

9.3.1 Kiln operation and feeding of wastes

Procedures for stopping hazardous waste feed in the event of an equipment malfunction or other emergency must be implemented and the set points for each operating parameter that would activate feed cut-off must be specified. The waste feed must also be cut off when operating conditions deviate from limits established in the permit.

No hazardous waste burning should take place unless the cement kiln is operating at normal temperatures in the range of 1100 oC to 1600 oC and instrumentation must be provided to record continuously the rate of flow of these wastes.

9.3.1 Kiln operation and feeding of wastes

Feeding of hazardous wastes should not be permitted during periods of kiln start-up, shutdown, major upset or conventional (coal) fuel interruption.

Kiln coating temperature should be measured by a recording optical pyrometer and conventional (coal) fuel flow should be continuously measured and recorded.

9.3.1 Kiln operation and feeding of wastes

Examples of system controls and set points, which could provide for automatic shutdown of introduction of hazardous wastes in the event any of the following conditions occur:

- a) Cement kiln temperatures fall below 1100 °C;
- b) Conventional raw meal and fuel flow interruption;
- c) Kiln speed decrease to below 60 RPH;
- d) Loss of draft in the firing hood and main fan stoppage;
- e) The kiln should be operated at all times in an oxidizing atmosphere. Oxygen in the kiln exhaust gases must be maintained at a level of not less than 1.5% and be continuously recorded;

9.3.1 Kiln operation and feeding of wastes

- f) If the outside skin temperature of the kiln exceeds 500°C, the feed of hazardous wastes should be stopped and shutdown should be initiated for repair of the refractory.

Reintroduction of hazardous wastes should not take place until such lining repairs are completed;

- g) Waste introduction into the kiln should cease in the event of kiln ring formation;

9.3.1 Kiln operation and feeding of wastes

- h) Hazardous wastes must not be used during failure of the air pollution control devices. The kiln exhaust gases must be quickly conditioned and cooled the lower than 200 °C to avoid formation and release of dioxins and other POPs;
- i) Fugitive emissions must be prevented and controlled and the off-gas dust from the filters should be fed back into the kiln to the maximum extent practicable, in order to reduce issues related to treatment and emissions. Dust that cannot be recycled should be managed in a manner demonstrated to be safe.

9.4 Laboratory and quality control

The plant needs an adequate laboratory, with sufficient infrastructure, sampling equipment, instrumentation and test equipment.

Inter-laboratory tests should be carried out periodically in order to check and improve the performances and maintenance of the laboratory.

Personnel must be competent and should be trained according to their specific needs and to the nature of the hazardous wastes used

9.4 Laboratory and quality control

Fuels, raw materials, and any AFRs or wastes entering, being processed or produced at the site, should be controlled regularly.

A plan should provide detailed instructions for:

- a) Personnel assignment;
- b) Sampling;
- c) Frequency of sampling and analysis;
- d) Laboratory protocols and standards;
- e) Calibration procedures and maintenance;
- f) Recording and reporting protocol.

10. Cement quality

The cement plant must carry out chemical and physical analysis for all relevant parameters concerning cement quality and potential clinker contamination on a routine basis and all data must be kept recorded.

Co-processing of AFRs shall not affect the cement quality and this must be documented. The operator must be aware that fluorine, phosphate and zinc influences setting time and strength development of the cement, that chlorine, sulphur and alkalis affect overall product quality and that chromium may cause allergic reactions in sensitive users.

10. Cement quality

The classification of cements in terms of their strength-giving properties has been practised for many years. It is impractical for cement producers to test the cements they make with all the many different sands and aggregates and in the wide range of mix proportions they are likely to meet in practice.

Standard test procedures have therefore been developed to enable manufacturers to control their production.

10. Cement quality

The strength-giving characteristics of cements can take the form of assessments at early (2- 3 days) or late (28 days) ages or both.

The European ENV 197-1 places primary emphasis upon the 28-day strength and for this purpose introduces three classes, 32.5, 42.5 and 52.5 representing the minimum characteristic strength, in N/mm², which the cement is required to achieve at 28 days from tests made in accordance with the test method described in European Standard EN 196-1.

11. Emission monitoring

Emission monitoring is obligatory in order to demonstrate compliance with existing laws, regulations, and agreements.

Emission monitoring is also needed for controlling the input of conventional materials and their potential impacts.

Sulphides in raw materials may result in the release of SO₂ and organic carbon in raw materials will result in CO, CO₂ and volatile organic compound (VOC) emissions.

Heavy metals in fuel and raw material, especially volatile heavy metals, which are not completely captured in the clinker, must be assessed, monitored and controlled.

11.1 Emission limit values for cement kilns in Europe

For emissions to air, cement kilns co-processing AFR and treating hazardous wastes in the EU must comply with the Directive 2000/76/EC and must meet the emissions limits in flue gases given in table 2 below, corrected to 273 K, 101.3 kPa, 10% O₂ and dry gas.

11.2 Continuous emission measurements

To monitor the process and accurately quantify the emissions, continuous emission measurements are recommended for the following parameters:

- a) Exhaust volume;
- b) Humidity;
- c) Temperatures;
- d) Particulate matter;

11.2 Continuous emission measurements

- e) O₂;
- f) NO_x;
- g) SO₂;
- h) CO;
- i) Volatile organic compounds (VOC);
- j) HCl;
- k) Pressure.

11.3 Regular monitoring

Periodical monitoring should be conducted for the following substances on a regular basis:

- a) Metals and their compounds;
- b) Total organic carbon;
- c) HF;
- d) NH₃;
- e) PCDD/PCDF;
- f) Chlorobenzenes, HCB and PCBs including coplanar congeners and chloronaphthalenes.

11.4 Occasional monitoring

Measurements of the following substances may be required occasionally under special operating conditions:

- a) Demonstration of the destruction and removal efficiency (DRE) and the destruction efficiency (DE);
- b) Benzene, toluene and xylene;
- c) Polycyclic aromatic hydrocarbons;
- d) Other organic pollutants.

It is especially important to measure metals when wastes with higher metal content are used as raw materials or fuels.

11.5 Additional measures for exit gas cleaning

Activated carbon filter has high removal efficiency for trace pollutants (> 90%). Pollutants such as sulphur dioxide (SO₂), organic compounds, metals, ammonia (NH₃), ammonium (NH₄⁺) compounds, hydrogen chloride (HCl), hydrogen fluoride (HF) and residual dust may also be removed from the exhaust gases by adsorption on activated carbon.

Selective catalytic reduction can be applied for NO_x control. The process reduces NO and NO₂ to N₂ with the help of NH₃ and a catalyst at a temperature range of about 300 °- 400 °C, which imply heating of the exhaust gases.

12. Test burn and performance verification

Test burns are recommended for the demonstration of the destruction and removal efficiency (DRE) and the destruction efficiency (DE) of certain principal organic hazardous compounds (POHC) in a cement kiln (see Annex 2). The DRE is calculated on the basis of mass of the POHC content fed to the kiln, minus the mass of the remaining POHC content in the stack emissions, divided by the mass of the POHC content within the feed.

Test burn and performance verification

The DRE considers emissions to air only. The DE considers all out-streams (liquid and solids) in addition to the air emissions and is the most comprehensive way of verifying the performance.

Test burns with hazardous compounds require professional supervision and independent verification.

Test burn and performance verification

The following conditions should be fulfilled in a test burn:

- a) The destruction and removal efficiency for hazardous compound should be at least 99.99%. Chlorinated aromatic compounds should be chosen as a test compound if available because they are generally difficult to destroy. For POPs, a DRE/DE of ≥99.9999% should be achieved.
- b) The cement kiln should meet an emissions limit for PCDDs/PCDFs of 0.1 ng TEQ/Nm³ both under baseline and test burn conditions.
- c) The cement kiln should comply with existing emission limit values.

Test burn and performance verification

Test burns with non-hazardous hazardous waste are usually not a regulatory requirement but are sometimes done to evaluate the behaviour of the process and the influence on main gaseous emissions and the cement clinker quality when feeding waste to the kiln.

Such simplified tests are usually conducted by process engineers at the cement plant using already installed on-line monitoring equipment and process operational data.

13. On-site security and safety

Adequate systems and procedures should be in place to minimize the risk of unauthorized access to hazardous wastes used on-site. An emergency response plan should be in place, which:

- a) Identifies potential spill or contamination areas;
- b) Defines clean-up procedures;
- c) Identifies areas of high risk on site or in the local community;

On-site security and safety

- d) Provides written instructions in the event of an emergency;
- e) Documents equipment required in the event of an emergency;
- f) Assigns responsibilities to employees and local officials;
- g) Details emergency response training requirements;
- h) Describes reporting and communication requirements both within the company and with interested external stakeholders.

On-site security and safety

The emergency response plan may be reviewed with relevant external emergency services and emergency drills should be arranged with the local community emergency response services to ensure a coordinated response under emergency conditions.

Safety and emergency instructions, such as Material Safety Data Sheets, must be provided to employees and contractors in due time, and should be easily understandable. Hazards relating to new materials should be reviewed with operating staff prior to using such materials in the facility.

Conducting a job safety analysis is one approach to identifying hazards and potential exposures, along with appropriate control practices and techniques. Automated handling equipment should be used wherever possible.

13.1 Personal protective and emergency equipment

Adequate personal protective equipment should be made available to employees and contractors, and to individuals visiting the installation. Its use should be required. This includes but is not limited to:

- a) Helmet;
- b) Glasses;
- c) Gloves;
- d) Hearing protection;

13.1 Personal protective and emergency equipment

- e) Safety shoes;
- f) Respiratory protection;
- g) Other protective equipment specified in the Material Safety Data Sheets.

13.1 Personal protective and emergency equipment

Emergency equipment, such as fire extinguishers, self contained breathing masks, sorbent materials and shower stations should be sited in the immediate vicinity of the waste chemical storage area. Employees should be trained in their proper use.

The plant needs to have specially trained and authorized personnel at the storage and pumping site for unloading and storage of hazardous wastes. When authorized operating personnel are not on site, the storage and pumping area should be made sufficiently secure to prevent site access and operation of the storage and unloading system.

13.1 Personal protective and emergency equipment

Wherever a contact risk such as infection or skin irritation exists, the company should provide appropriate facilities for operators to take required hygiene precautions.

Maintenance work should be authorized by plant management, and carried out once a supervisor has checked the area and necessary precautions have been taken.

Special procedures, instructions, and training should be in place for such routine operations as:

13.1 Personal protective and emergency equipment

- h) Working at height, including proper tie-off practices and use of safety harnesses;
- i) Confined space entry where air quality, explosive mixtures, dust, or other hazards may be present;
- j) Electrical lock-out, to prevent accidental reactivation of electrical equipment undergoing maintenance;
- k) "Hot works" (i.e. welding, cutting, etc.) in areas that may contain flammable materials.

14. Content of a co-processing permit/licence

Any pre-processing facility or cement plant co-processing AFRs or treating organic hazardous wastes must have a permit or licence issued by the national competent authority.

Such a permit must describe requirements and restrictions of operation and should be developed in close cooperation with local competent authorities, with the pre-processing facility and the cement plant.

14. Content of a co-processing permit/licence

The permit should allow certain flexibility to allow for future development and adjustments, but needs to reflect the technical feasibility, infrastructure and its equipment, location, types of AFRs, as well as health, safety and environmental issues.

The pre-processing facility and the cement plant should have separate permits. The following chapters suggest and list crucial elements of a possible permit for a cement plant.

14.1 Plant organisation and components

A permit document should provide a short description of the plant, its history, ownership, its location and its background and intentions for co-processing of AFRs and/or treatment of hazardous wastes, as well as more detailed information of:

- a) Organisational structure (also for AFR), management, employees, training;
- b) Environmental management system, audits, emission monitoring and reporting;
- c) Environmental impact assessment, current and previous permits and its compliance;
- d) Laboratory facilities and product quality control routines;

14.1 Plant organisation and components

- e) Clinker process technology, e.g. rotary kiln(s), pre-heaters, pre-calciner, burners, stacks and process control system;
- f) Raw material quarrying (expected lifetime), transport, preparation, storage and feeding;
- g) Fuel sources, preparation, storage and feeding;
- h) Conveying facilities, crushers, mills, coolers;
- i) Baseline emissions, continuous emission monitoring equipment, exit gas conditioning and cooling, air pollution control devices;

14.1 Plant organisation and components

- j) Modes of operation, e.g. drying of raw material in the raw mill with the exit gas etc.
- k) AFR equipment, receiving, storage and pre-processing, feeding and control;
- l) Health, environment, emergency and safety issues;
- m) Cement production and dispatch;
- n) Water and power sources and reliability;
- o) Noise and if relevant, sewage water treatment;
- p) On-site control, security and safety.

14.2 Application documents

The information above should be documented properly, e.g. by:

- Plant pictures, topographical and geographical maps also indicating nearby resources;
- Description of the operation of the plant with name and make of equipments;
- Constructions documents for AFR and hazardous waste activities;
- Description of the intended AFRs and hazardous waste, i.e. sources, generation, processing, installation, supply, quality control and assurance system;
- Available alternative treatment options for hazardous waste, and pro-et-cons for selecting this plant;

14.2 Application documents

- f) An EIA and an evaluation of general environmental issues, the performance of the APCD and the emission situation;
- g) An impacts evaluation of the use of AFRs/hazardous wastes on the surroundings, on the process stability, product quality, air pollution emission prognosis (e.g. dust, NO_x, SO₂, heavy metals, VOC, HCl, PCDD/PCDFs etc.), odour and noise;
- h) Procedures for the implementation and maintenance of pollution prevention and occupational health and safety standards;
- i) Involvement with stakeholders and public information.

14.3 Plant data

A table describing all necessary information in short on plant fact essentials, as name, address, phone and fax, web address, names of plant managers, contact details to closest hospital, fire and police, transport access gates, water and power supply.

14.4 AFR / hazardous wastes acceptance

Some regulations do not restrict the use of AFRs or organic hazardous wastes to certain categories or concentration limits; they focus on emissions limits values only, i.e. implying that the co-processing practise shall not affect or increase the emissions.

The Directive 2000/76/EC on the incineration of waste in the European Union specify that if “in a co-incineration plant more than 40% of the resulting heat release comes from hazardous waste (unspecified), the emission limit values for incinerators must apply”.

14.4 AFR / hazardous wastes acceptance

Some regulations specify an explicit list of acceptable AFRs with maximum and/or minimum values for various parameters, e.g. heavy metals, chlorine, heat content/calorific value etc., often called the “positive” list. Annex 1 list some constraints and recommendations for certain input parameters. Some regulations specify a “negative” list with waste categories not allowed, e.g. as described in chapter 3.3.

A combination of emissions limit values and a negative waste list may be the easiest to practice for the cement companies and the controlling authorities. If properly enforced, this concept has shown to constitute a satisfactory regulatory concept.

14.4 AFR / hazardous wastes acceptance

A permit must contain details of the AFRs / hazardous wastes permitted /not permitted to be used at the particular plant and should provide the following information:

- a) Concept for acceptance of AFRs / hazardous wastes, i.e. negative or positive list;

14.4 AFR / hazardous wastes acceptance

For each of the categories of alternative fuel, alternative raw material and hazardous waste permitted to use at the plant the following information should be described in the permit:

- b) Types, volumes/masses, percentage of input, quality and characteristics (gross chemical composition, chlorine, heat and water content etc.);
- c) Origin and main suppliers;

14.4 AFR / hazardous wastes acceptance

- d) Special requirements for collection and transport and specification of documents that must follow deliveries;
- e) Requirements and procedures for control, sampling and analysis at the point of recipient;
- f) Procedures to follow when deliverables are in non-compliance;
- g) Requirements and procedures for chemical and physical analysis, testing compatibility or other tests, as well as requirements for keeping and storing samples of the AFR/hazardous waste;

14.4 AFR / hazardous wastes acceptance

- h) Requirements for pre-processing and preparation;
- i) Requirements and conditions for storage;
- j) Requirements and conditions for feeding to the process, on start up and shut down as well as requirements for interlocks and set points for stopping waste feed;
- k) Procedures and requirements for collection and analysis of process and environmental samples as well as health checks of employees;

14.5 Monitoring and control of combustion

The cement plant must provide input limits and operational set points for each of the categories of alternative fuel, alternative raw material and hazardous waste permitted to use. The permit must describe:

- a) Normal good and stable kiln/process operation without feeding of AFRs/hazardous wastes, i.e. description of the baseline conditions;
- b) Normal readings of the continuous emission monitoring equipment (CEM) and CO-levels without feeding of AFRs/hazardous wastes;

14.5 Monitoring and control of combustion

- c) Normal values for cement quality without feeding of AFRs/hazardous wastes;
- d) Stable smooth kiln/process operation with controlled and separate feeding of AFRs/hazardous wastes, i.e. description of the normal co-processing conditions;
- e) Readings of the CEM and CO-levels with controlled and separate feeding of AFRs/hazardous wastes;

14.5 Monitoring and control of combustion

- f) Values for cement quality with controlled and separate feeding of AFRs/hazardous wastes;
- g) Operational modes, i.e. differences in direct compound mode when it comes to emissions;
- h) Emission limit values/window for the CEMs, O₂ and for CO-levels;
- i) Conventional raw meal and fuel feed requirements;

14.5 Monitoring and control of combustion

- j) Kiln production and kiln speed requirements (if relevant);
- k) Maximum kiln coating temperatures (if relevant);
- l) Minimum kiln inlet and outlet temperatures;
- m) Minimum retention time at specific temperatures;
- n) Minimum kiln inlet and outlet oxygen concentration (CEM);
- o) Procedures for operation of the air pollution control devices and its maximum "down-time", as well as requirements for exhaust gas conditioning;

14.5 Monitoring and control of combustion

- p) Operation procedures when loss of draft in the firing hood or fan stoppage (if relevant);
- q) Operation procedures in the event of kiln ring formation or cyclone blockage (if relevant);
- r) Operation procedures in the event of major fugitive emissions (if relevant);
- s) Operation procedures for recycling of dusts.

14.6 Air pollution control

All exit gases must be cleaned and discharged via stacks with sufficient height and dispersion capability. Requirements of local regulation must be included in the permit.

14.7 Monitoring of emissions

The competent authority must describe requirements for the installation and operation of continuous emission monitoring equipment, as well as requirements and conditions for periodical monitoring and test burns.

Emission measurements must be conducted on a regular basis, be representative and always converted to standardized conditions (dry gas, pressure, temperature and oxygen concentration), i.e. be comparable, and possible to evaluate and verify. The regulated air pollutants and the subsequent emission limit values must be provided by the National regulation and the competent authority, which also needs to specify the conditions for compliance.

14.8 Qualified laboratories

To ensure a uniform measurement practice, representative measurement results and comparable quality procedures, independent third party qualified laboratories with satisfactory sampling, analysis and calibration procedures should be used.

The location and configuration of the sampling point(s) must be coordinated with the competent authorities.

14.9 Excerpts of the Directive 2000/76/EC on the incineration of waste in the European Union - Article 4 - Application and permit

Excerpts of the Directive 2000/76/EC on the incineration of waste in the European Union - Article 4 - Application and permit

1. Without prejudice to Article 11 of Directive 75/442/EEC or to Article 3 of Directive 91/689/EEC, no incineration or co-incineration plant shall operate without a permit to carry out these activities.
2. Without prejudice to Directive 96/61/EC, the application for a permit for an incineration or co-incineration plant to the competent authority shall include a description of the measures which are envisaged to guarantee that:

Excerpts of the Directive 2000/76/EC on the incineration of waste in the European Union - Article 4 - Application and permit

- (a) the plant is designed, equipped and will be operated in such a manner that the requirements of this Directive are taking into account the categories of waste to be incinerated;
- (b) the heat generated during the incineration and co-incineration process is recovered as far as practicable e.g. through combined heat and power, the generating of process steam or district heating;
- (c) the residues will be minimized in their amount and harmfulness and recycled where appropriate;
- (d) the disposal of the residues which cannot be prevented, reduced or recycled will be carried out in conformity with national and Community legislation.

Excerpts of the Directive 2000/76/EC on the incineration of waste in the European Union - Article 4 - Application and permit

3. The permit shall be granted only if the application shows that the proposed measurement techniques for emissions into the air comply with Annex III and, as regards water, comply with Annex III paragraphs 1 and 2.
4. The permit granted by the competent authority for an incineration or co-incineration plant shall, in addition to complying with any applicable requirement laid down in Directives 91/271/EEC, 96/61/EC, 96/62/EC, 76/464/EEC and 1999/31/EC:

Excerpts of the Directive 2000/76/EC on the incineration of waste in the European Union - Article 4 - Application and permit

- (a) list explicitly the categories of waste which may be treated. The list shall use at least the categories of waste set up in the European Waste Catalogue (EWC), if possible, and contain information on the quantity of waste, where appropriate;
- (b) include the total waste incinerating or co-incinerating capacity of the plant;
- (c) specify the sampling and measurement procedures used to satisfy the obligations imposed for periodic measurements of each air and water pollutants.

Excerpts of the Directive 2000/76/EC on the incineration of waste in the European Union - Article 4 - Application and permit

5. The permit granted by the competent authority to an incineration or co-incineration plant using hazardous waste shall in addition to paragraph 4:

- (a) list the quantities of the different categories of hazardous waste which may be treated;
- (b) specify the minimum and maximum mass flows of those hazardous wastes, their lowest and maximum calorific values and their maximum contents of pollutants, e.g. PCB, PCP, chlorine, fluorine, sulphur, heavy metals.

Excerpts of the Directive 2000/76/EC on the incineration of waste in the European Union - Article 4 - Application and permit

6. Without prejudice to the provisions of the Treaty, Member States may list the categories of waste to be mentioned in the permit which can be co-incinerated in defined categories of co-incineration plants.

7. Without prejudice to Directive 96/61/EC, the competent authority shall periodically reconsider and, where necessary, update permit conditions.

Excerpts of the Directive 2000/76/EC on the incineration of waste in the European Union - Article 4 - Application and permit

8. Where the operator of an incineration or co-incineration plant for non-hazardous waste is envisaging a change of operation which would involve the incineration or co-incineration of hazardous waste, this shall be regarded as a substantial change within the meaning of Article 2(10)(b) of Directive 96/61/EC and Article 12(2) of that Directive shall apply.

9. If an incineration or co-incineration plant does not comply with the conditions of the permit, in particular with the emission limit values for air and water, the competent authority shall take action to enforce compliance.