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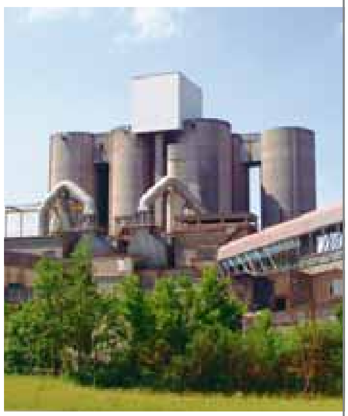
Guidelines on co-processing Waste Materials in Cement Production

The GTZ-Holcim Public Private Partnership





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Important Notice

These Guidelines are addressed to stakeholders and decision makers from the private and public sectors engaged in waste management and cement production. The document offers guiding principles and gives a general orientation concerning the conditions in which co-processing can be applied. They make certain recommendations and provide certain country-specific experiences, but cannot and should not be used as a template. Each person, legal entity or country, in engaging in waste co-processing, must develop its own standards based on international conventions and national and local conditions and must harmonize them with its legal framework. These Guidelines shall not be legally binding nor shall they be construed as constituting any obligation, representation or warranty on the part of the authors or the sender or any technical, commercial, legal or any other advice.

While all reasonable care has been taken to ensure accuracy of the information contained in these Guidelines, none of **Holcim Group Support Ltd** and **Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (GTZ)** and/or any of its respective affiliates, directors, officers, employees, consultants, advisers and/or contractors accepts any responsibility or liability for any errors, or omissions in or otherwise in relation to these Guidelines. Nor does the information imply an opinion on the part of or any endorsement by such entities or persons.

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About these Guidelines

One of the major objectives of these Guidelines is to help make waste management more efficient by offering objective information about co-processing of waste in the cement industry. This ambitious report is based on intensive dialogues and working sessions.

These Guidelines have been prepared by experts from **Holcim** and **GTZ**. Support and advice were given by a variety of external experts from public and private sector as well as from the cement industry and from organizations working in international development cooperation. The elaboration of the document was coordinated by the **Institute for Ecopreneurship (IEC) of the University of Applied Sciences Northwestern Switzerland (FHNW).**

The Management Team of this initiative wishes to express sincere thanks to the collaborating experts from Holcim and GTZ and all who participated by sharing their time, information and insights.

Participants of the start-up event in September 2003 in Bonn, Germany

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Foreword

These Guidelines result from a joint initiative by the Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (GTZ) and Holcim Group Support Ltd (Holcim), to promote the co-processing of waste in cement kilns – that is, the use of wastes along with other materials in kilns to produce cement. Holcim *(→ www.holcim.com)* is a worldwide leading supplier of cement and aggregates as well as value-adding activities such as ready-mix concrete and asphalt, including services. GTZ *(→ www.gtz.de)* is a government owned corporation for international co-operation for sustainable development with worldwide operations. The findings and recommendations are based on experiences from industrialized and developing countries, as well as from the public and private sectors.

The Guidelines are also based on initiatives of bilateral or multilateral organizations to improve waste management at national and local levels, as well as attempts by the cement industry to reduce the negative environmental impacts of cement production.

We have paid special attention to the work of the Cement Sustainability Initiative (CSI) of the World Business Council for Sustainable Development (WBCSD), which looks at options for improving environmental performance and increasing corporate social responsibility.

Using waste co-processing in cement production will help in achieving the targets set in Agenda 21 of the "Earth Summit" in Rio de Janeiro (1992), the Johannesburg Declaration on Sustainable Development (2002) and the Millennium Development Goals.

We prepared the Guidelines taking into consideration all related international conventions such as the Basel and the Stockholm Conventions and the UN Framework Convention on Climate Change (Kyoto Protocol).

Avoiding the creation of wastes and reducing their quantities are the best ways of dealing with current waste problems all over the world. Wherever possible, the concepts of resource efficiency, cleaner production (CP), recycling and reuse must be given first priority. Co-processing of wastes does not conflict with the waste hierarchy, as it can be classified as a technology for energy and material recovery.

These Guidelines are based on an approach that aims to reduce existing waste problems in developing countries and at the same time to encourage the use of waste as an alternative source for primary energy and virgin raw materials in cement kilns.

Close collaboration and co-operation between the public and the private sectors are the key to achieving the maximum benefit from co-processing of waste in cement kilns. Innovative techniques and technical know-how are available and will be further developed by the private sector, whereas the public sector should ensure that environmental standards are maintained and health and safety regulations are applied and enforced.

There is general agreement that co-processing of waste in cement kilns requires:

- → the observation of and compliance with all applicable laws and regulations (in some jurisdictions the legislation in relation to waste processing has yet to be put in place or is in the process of being amended in line with regulatory or technical developments)
- → facility personnel and government regulators/inspectors knowledgeable and experienced in waste combustion, including toxic/hazardous waste
- → a proper enforcement of the legal framework for all waste management activities, combined with monitoring by the authorities and the strict enforcement of regulations
- → the establishment of local emergency preparedness and response programs, in addition to any national programs
- → health and safety programs for personnel who may come into contact with toxic or hazardous waste
- → a "corporate responsibility" approach on the parts of the private and public sectors alike
- → transparency in terms of information and communications.

Thus ethical conduct, good governance and social responsibility are prerequisites for successfully implementing the Guidelines.

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1.0 Executive Summary

Different types of wastes have been successfully co-processed as alternative fuels and raw materials (AFR) in cement kilns in Europe, Japan, USA, Canada and Australia since the beginning of the 1970s.

These Guidelines are meant to gather the lessons of that experience and offer it particularly to developing countries that need to improve approaches to waste management. Some developing countries will need capacity building help before launching AFR programs.

The Guidelines, meant for all of the cement industry and all of its stakeholders, result from a public-private partnership between **Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (GTZ)** *(→ www.gtz.de)* and **Holcim Group Support Ltd.** *(→ www.holcim.com)*. These findings and recommendations are based on experiences from industrialized and developing countries, as well as from the public and private sectors. They are also based on initiatives of bilateral and multilateral organizations to improve waste management at national and local levels, as well as attempts by the cement industry to reduce environmental degradation resulting from cement production. They reflect international laws and conventions.

The use of AFR can decrease the environmental impacts of wastes, safely dispose of hazardous wastes, decrease greenhouse gas emissions, decrease waste handling costs and save money in the cement industry. It will help in achieving the targets set in Agenda 21 of the "Earth Summit" in Rio de Janeiro (1992), the Johannesburg Declaration on Sustainable Development (2002) and the Millennium Development Goals. However, there are some basic rules and principles that should be observed.

AFR use should respect the waste hierarchy, be integrated into waste management programs, support strategies for resource efficiency and not hamper waste reduction efforts. Following certain basic rules assures that the use of AFR does not have negative impacts on cement kiln emissions. Co-processing should not harm the quality of the cement produced. Countries considering co-processing need appropriate legislative and regulatory frameworks. National laws should define the basic principles under which co-processing takes place and define the requirements and standards for co-processing. Regulators and operators should conduct baseline tests with conventional fuels and materials so they can compare AFR results to these. Some wastes should never be co-processed; these range from unsorted municipal garbage and certain hospital wastes to explosives and radioactive waste. Other wastes will need pre-processing before they can be used, and approaches to AFR use should take account of the need to effectively regulate and manage these pre-processing plants.

Following certain basic rules assures that the use of AFR does not change the emissions of a cement kiln stack. These include feeding alternative fuels into the most suitable zones of the kiln, feeding materials that contain a lot of volatile matter into the high temperature zone only, and avoiding materials that contain pollutants kilns cannot retain, such as mercury. Emissions must be monitored, some only once a year and others continuously. Environmental impact assessments (EIA) should be done to confirm compliance with environmental standards; risk assessments can identify any weaknesses in the system, and material flux and energy flow analyses help to optimize the use of resources.

Cement plant operators using AFR shall ensure their traceability from reception up to final treatment. Transport of wastes and AFR must comply with regulations. Plants must have developed, implemented and communicated to employees adequate spill response and emergency plans. For start-up, shut-down and conditions in between, strategies for dealing with AFR must be documented and available to plant operators. Plants need well-planned and functioning quality control systems, as well as monitoring and auditing protocols.

Risks can be minimized by properly locating plants in terms of environmental setting, proximity to populations and settlements, and the impact of logistics and transport. Plants will require good infrastructure in terms of technical solutions for vapors, odors, dust, infiltration into ground or surface waters, and fire protection. All aspects of using AFR must be well documented, as documentation and information are the basis for openness and transparency about health and safety measures, inside and outside the plant.

1.0 Executive Summary

Management and employees must be trained in handling and processing of AFR. Hazardous operations training for new workers and subcontractors should be completed before starting with co-processing. Periodic re-certification should be done for employees and subcontractors. Induction training should be included for all visitors and third parties. Understanding risks and how to mitigate them are keys to training. Training authorities is the basis for building credibility.

Introducing AFR requires open communications with all stakeholders. Provide all the information stakeholders need to allow them to understand the purposes of co-processing, the context, the functions of parties involved, and decision-making procedures. Open discussions about good and bad experiences are part of transparency, leading to corrective actions. Be credible and consistent, cultivating a spirit of open dialogue and respect for differing cultures.

In these Guidelines the bar has been kept high in terms of environmental, social and health and safety standards, but they are realistic and achievable. Ambitious targets are needed in order to achieve goals (e.g. the Millennium Development Goals). However, one cannot expect that the public sector in any country or each and every cement plant operator or waste handling company anywhere in the world can implement all the proposed standards straight away. To achieve the proposed standards, a stepwise and country specific (phasing) program or action plan is required, which ideally represents a consensus (reflecting the enhanced cooperation) between the public and private sector.

As populations increase in the developing world, so do waste management problems, and so does the need for more cement and concrete for housing and the infrastructure of development. The properly managed use of wastes as fuels and raw materials in cement kilns can help manage wastes while contributing to the sustainable development of our world.

2.0 Introduction

Greenhouse gases and global warming, the efficient use of non-renewable fossil fuels, toxic residues, and the contamination of water and soil resources are in the forefront of ecological concerns and public discussions. Cost competitiveness, global competition and profitability are the concerns of business. The challenge facing today's society is to balance environmental protection and economic interest.

The cement industry consumes a significant amount of natural resources and energy. It also contributes worldwide to the development and modernization of cities and infrastructure. The cement industry and its associations continuously try to improve environmental performance by optimizing the use of natural resources and reducing its overall energy consumption.

Cement consumption is increasing, especially in developing countries and countries in transition. Worldwide cement production in 2003 was 1.94 billion tons (metric tons), increasing from 1.69 billion tons in 2001 with a steady increase of an estimated 3.6% yearly due to the strong demand in developing countries and countries in transition. Europe's share of consumption is 14.4%; USA, 4.7%; the rest of the Americas, 6.6%; Asia, 67.5% (China, 41.9%); Africa, 4.1%, and the rest of the world 2.7%. Estimated cement consumption in 2004 was 260 kg per capita (Source: Cembureau[1]).

Whenever possible, best available technology (BAT) should be used[2] and can usually achieve significant reductions in energy consumption. Over the past 20 years, the European cement industry has reduced its energy consumption by about 30%, equivalent to saving approximately 11 million tons of coal per year.

Substituting fossil fuel and virgin raw material by waste (**A**lternative **F**uels and **R**aw materials – **AFR**) will further reduce overall CO_2 emissions if the waste material being used would instead have been burned or disposed without energy recovery.

The cement industry presents a mixed picture. International companies, whose market share is increasing, usually adopt their own internal standards throughout the world, using best available technologies when building new facilities. From a technical point of view, all kiln types are suited for co-processing. However, older, polluting, and less integrated technologies are gradually being phased out due to stricter standards and/or voluntary best practices. Older cement plants may fall short of both best available technology standards and standards related to business ethics, labor rights, health, safety and environment. The situation varies in different countries due to the cement market structure and the state of regulations.

Poor waste management is a challenge in developing countries and in countries in transition. In most of those countries, waste is discharged to sewers, buried or burned on company premises, illegally dumped at unsuitable locations, or taken to landfills that fail to meet requirements for the environmentally sound final disposal of waste. This can cause contamination of soil, water resources, and the atmosphere, leading to the sustained deterioration of the living conditions and health of the adjacent populations. Toxic substances and persistent compounds escape into the environment, are spread through the air over large areas, and can enter the food chain, affecting human and animal health.

Several factors can cause these problems:

→ Not all developing countries have an integrated waste management strategy and only a few can offer an appropriate technical infrastructure for disposing of waste in a controlled and environmentally sound manner
→ Although in many cases laws concerning the controlled handling of waste exist, they are often not properly enforced
→ Uncontrolled disposal is usually the cheapest way to get rid of the waste, and the waste generators tend to be unwilling to pay much for adequate disposal

1 Cembureau, based in Brussels, is the representative organization of the cement industry in Europe and includes 25 members
2 Useful information on BAT can be found in the following two documents:
- Cembureau, 1999. Best Available Technology for the cement industry
- Integrated Pollution Prevention and Control (IPPC) 2001. Reference document on Best Available Technology in the Cement and Lime manufacturing industries

2.0 Introduction

→ Policy makers rarely pay enough attention to the subject of waste management, and may know little about the consequences for human health or the high cost of the remediation of the damage caused by uncontrolled waste disposal.

There is general agreement that there is an urgent need to improve waste management, and different solutions are being discussed. Waste avoidance, cleaner production, producer responsibility, supply chain management or sustainable use of natural resources are only a few of the strategies being promoted. In spite of technological progress and an increasing social and political awareness, the problem of growing waste streams persists. The "zero waste society" is a worthy vision, but we are far from realizing it.

Modern incineration plants and secure landfills are common disposal options in OECD countries but have high investment and operating costs and need qualified personnel. An efficient cement kiln can provide an environmentally sound, and cost-effective treatment/recovery option for a number of wastes.

Different types of wastes have been successfully used as AFR in cement kilns or similar plants in Europe, Japan, USA, Canada and Australia since the beginning of the 1980s *[→ see **Annex 2**: Utilization of alternative fuels in the European and Japanese cement industry]*.

→ ***Table 1*** gives an overview of energy substitution through AFR in the cement industry in selected countries.

Industrialized countries have had more than 20 years of positive experiences with AFR *[→ see **Annex 3**: AFR development in Germany]*. Why then are wastes not being used routinely as AFR in the cement plants of developing countries, and why has co-processing not been better promoted as an ecologically beneficial form of energy and material recovery? The main reasons are limited knowledge of the potential of AFR and of legislative and institutional requirements related to co-processing, political reservations, legal uncertainties and concerns of the public and NGOs over environmental and health damage.

Co-processing of hazardous waste in cement production has been recognized as an environmentally sound disposal method in the context of the Basel Convention[3]. This addresses the suitability of co-processing of hazardous waste in cement production and the conditions to which it should be subject.

These Guidelines are intended to make decision makers from public authorities, the cement industry and the interested public aware of co-processing as a tool in waste management and to increase the quality of discussion and decision making in waste management.

Location	Percentage of thermal energy substituted by AFR	Year
France	32%	2003
Germany	42%	2004
Norway	45%	2003
Switzerland	47%	2002
USA	25%	2003

Table 1: Share of AFR in the total fuel demand in the cement industry in selected countries (Source: CEMBUREAU, SINTEF)

3 The 'Basel Convention Technical Guidelines on Incineration on Land', SBC, 1995 (paragraphs 26-27)

– The 'General technical Guidelines for the environmentally sound management of wastes consisting of, containing or contaminated with persistent organic pollutants', SBC, 2004 (section G.2.c) –

3.0 Purpose, Target Groups and Boundaries of the Guidelines

We have tried to make these Guidelines valid for all countries, independent of location or level of industrialization. However they focus mainly on the use of waste material as AFR in cement production in developing countries and countries in transition, thereby offering an environmentally sound and financially feasible alternative use for some waste material. One of our major objectives is to help reduce the deficiencies in waste management. We aim to offer **objective information** about co-processing of waste in the cement industry.

[A comprehensive list of literature and Internet links is attached as ***Annex 1*** *]*

The Guidelines are meant to provide various target groups with **relevant information** on (i) technical and legal conditions, (ii) environmental, safety and health standards, and (iii) professional requirements needed to ensure that co-processing of waste does not have negative environmental or human health impacts.

The Guidelines offer an overview of **strategies** for communication and stakeholder engagement and recommendations for the legal framework needed to guide the permitting process and the control and enforcement procedures.

The Guidelines offer links to organizations, institutions, and companies active in the field of co-processing and propose ways and means for **capacity building** at all levels to ensure sound application of the technology. They give references to relevant international environmental agreements.

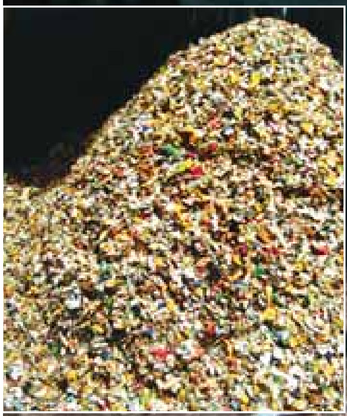
Beside these **core objectives** the Guidelines are also meant to help:

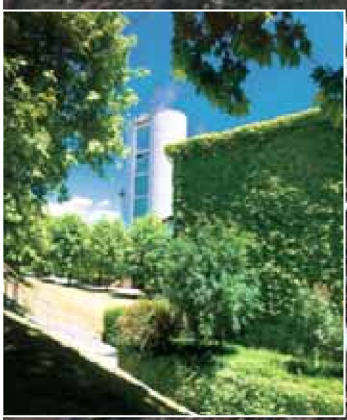
→ to promote dialogue among public authorities, private enterprises, and civil society, leading to a better-informed discussion among the various groups
→ to raise awareness and build technical know-how, which can have positive effects across the entire waste management sector
→ to show that waste can be an alternative resource for energy and material recovery.

The **topics** of the Guidelines include the preparation of AFR before feeding them into the kiln (pre-processing) and their use as an energy source and raw material in the kiln itself (co-processing). They also consider topics such as storage, transport, and environmental awareness. The Guidelines do not cover quarry issues and the re-use of concrete.

The Guidelines are aimed at the following **target groups:**

→ government organizations and public institutions
→ local communities
→ non-governmental organizations
→ the cement industry, their associations and federations as well as the concrete industry
→ operators of waste handling facilities
→ laboratories involved in waste quality control
→ waste generators.



4.0 General Definitions and Principles of Co-processing

These Guidelines use the following definitions:

→ **Waste:** The EC Framework Waste Directive 75/442/EEC, Article 1 defines waste as "any substance or object, which (a) the holder discards or intends or is required to discard or (b) has to be treated in order to protect the public health or the environment." Waste material can be solid, liquid, or pasty. Any waste material can be defined by its origin (industry, agriculture, mining etc), hence a proper list should always be established at national level to help create a common understanding and define a legal framework. Where no specific list has been defined, the EC Waste Catalogue might serve as a reference.

→ **Hazardous and non-hazardous waste:** The EC Directive 91/689/EC on Hazardous Waste defines hazardous waste by reference to two Annexes that evaluate the level of danger of a material (harmful, irritating, combustible...). However, legislation can vary greatly between countries (except within the EU), leading to differences in determining whether a waste is hazardous or not. For countries where no classification of waste exists, either the Waste List of the Basel Convention[4] or the EC Waste Catalogue[5] is recommended.

→ **Co-processing:** This refers to the use of waste materials in industrial processes, such as cement, lime, or steel production and power stations or any other large combustion plants. Even though the EU calls this process co-incineration, for the purpose of these Guidelines, co-processing means the substitution of primary fuel and raw material by waste. It is a recovery of energy and material from waste. Co-processing is further explained in → *see* ***chapter 5.***

→ **AFR (Alternative Fuel and Raw Materials):** This refers to waste materials used for co-processing. Such wastes typically include plastics and paper/card from commercial and industrial activities (e.g. packaging waste or rejects from manufacturing), waste tires, waste oils, biomass waste (e.g. straw, untreated waste wood, dried sewage sludge), waste textiles, residues from car dismantling operations (automative shredder residues - ASR), hazardous industrial waste (e.g. certain industrial sludges, impregnated sawdust, spent solvents) as well as obsolete pesticides, outdated drugs, chemicals and pharmaceuticals.

→ **Pre-processing:** Transforming waste to AFR requires certain standards. AFR does not always consist of a specific waste stream (such as tires or solvents) but must be prepared from different waste sources before being used as fuel or raw material in the cement plant. The preparation process is needed to produce an AFR stream that complies with the technical and administrative specifications of cement production and to guarantee that environmental standards are met.

4 http://www.basel.int/text/con-e-rev.pdf
5 http://www.vrom.nl/get.asp?file=/docs/milieu/eural_engelse_versie.pdf

4.0 General Definitions and Principles of Co-processing

The following general principles should be followed:

Principle I	**Co-processing respects the waste hierarchy:** → Co-processing does not hamper waste reduction efforts, and waste shall not be used in cement kilns if ecologically and economically better ways of recovery are available. → Co-processing shall be regarded as an integrated part of modern waste management, as it provides an environmentally sound resource recovery option for the management of wastes. → Co-processing is in line with relevant international environmental agreements, namely the Basel and Stockholm Conventions.
Principle II	**Additional emissions and negative impacts on human health must be avoided:** → To prevent or keep to an absolute minimum the negative effects of pollution on the environment as well as risks to human health. → On a statistical basis, emissions into the air shall not be higher than those from cement production with traditional fuel.
Principle III	**The quality of the cement product remains unchanged:** → The product (clinker, cement, concrete) shall not be abused as a sink for heavy metals. → The product should not have any negative impact on the environment as e.g. demonstrated with leaching tests. → The quality of cement shall allow end-of-life recovery.
Principle IV	**Companies engaged in co-processing must be qualified:** → Have good environmental and safety compliance track records and to provide relevant information to the public and the appropriate authorities. → Have in place personnel, processes, and systems demonstrating commitment to the protection of the environment, health, and safety. → Assure that all requirements comply with applicable laws, rules and regulations. → Be capable of controlling inputs and process parameters required for the effective co-processing of waste materials. → Ensure good relations with the public and other actors in local, national and international waste management schemes.
Principle V	**Implementation of co-processing has to consider national circumstances:** → Country specific requirements and needs must be reflected in regulations and procedures. → A stepwise implementation allows for the build-up of required capacity and the set-up of institutional arrangements. → Introduction of co-processing goes along with other change processes in the waste management sector of a country.

Waste shall be co-processed only if there is no financially and ecologically better way of waste avoidance and recycling. The integration of co-processing into the waste hierarchy is shown in → ***Figure 1** on the right.*
The waste management hierarchy is defined as follows:

- → **Avoidance or prevention** of waste is the ideal solution. This can be achieved only through a strict product policy that ensures that certain materials do not appear as residues at all.
- → **Minimization or reduction** of waste, in particular by the application of the cleaner production concept or changes in consumer habits related to packaging.
- → **Recovery** of waste material by means of direct recycling and reuse of primary materials (e.g. metal to metal or paper to paper). It also includes other technologies like composting or anaerobic digestion.
- → **Co-processing** – recovery of energy and materials from waste as a substitute for fossil energy and virgin raw materials.
- → **Incineration** is primarily a disposal technology to reduce waste volumes, to reduce the potential negative impact of the waste material and to a certain extent recover energy.
- → **Chemical-physical pre-treatment** is a procedure to stabilize waste materials before final disposal.
- → **Controlled landfilling** is the common method for the final disposal of non-recyclable waste.

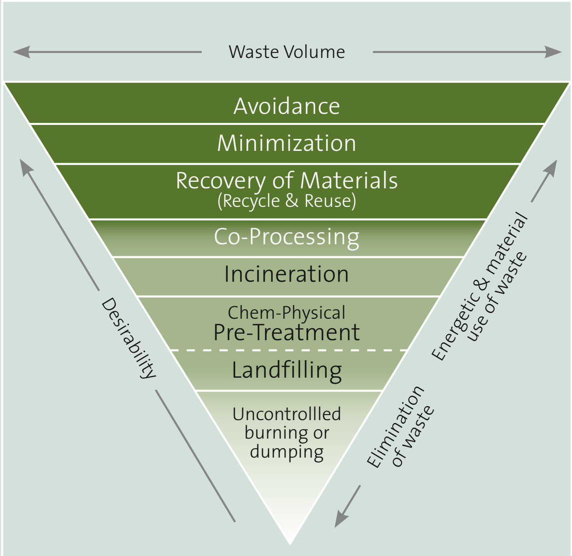


Figure 1: Waste management hierarchy

- → **Uncontrolled burning and dumping,** often accompanied by open burning, is still the most common method of waste disposal in developing countries, where these pose a major threat to natural resources and human health. This form of waste disposal should be avoided.

The waste hierarchy has to be respected for any waste disposal option, including co-processing. Co-processing should be considered as a treatment alternative within an integrated waste management concept. Whenever possible, waste should be avoided or used for energy and material recovery, as from the ecological and economical point of view this is the most appropriate solution for any country. However, it may take time to fully implement this approach in developing countries.

Eco-balance or Life Cycle Analysis (LCA) is a tool which can be used to judge the advantages of different waste management solutions. It provides information about impacts on the environment when comparing different reuse, recycling and disposal options. LCA enables governmental authorities to find the best alternatives for different wastes, so that they can develop a waste management strategy that takes into consideration the local environmental situation, social interests, and economical conditions. The criteria for determining the most appropriate treatment option will vary from country to country and depend very much on the scale of industry and the given infrastructure. Using LCA in the environmental management system, in accordance with the ISO14001 series, can help companies evaluate the potential for continuous improvement and assess proposed steps.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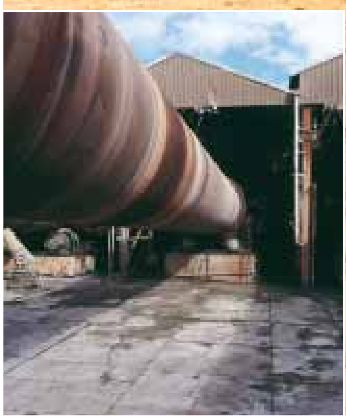


5.0 Main Characteristics of co-processing in the Cement Industry

5.1 Cement Manufacturing

Cement manufacturing is a material-intensive process. After mining, grinding and homogenization of raw materials, the next step in cement manufacturing is calcination of calcium carbonate, followed by sintering the resulting calcium oxide with silica, alumina, and iron oxide at high temperatures to form clinker. The clinker is then ground or milled with gypsum and other constituents to produce cement. Naturally occurring calcareous deposits such as limestone, marl, or chalk provide the source for calcium carbonate. Silica, iron oxide and alumina are found in various ores and minerals, such as sand, shale, clay, and iron ore. However, process residues are more and more used as replacements for the natural raw materials. Producing one ton of clinker requires an average of 1,5 – 1,6 tons of raw materials. Most of the material is lost from the process as carbon dioxide emissions to air in the calcination reaction ($CaCO_3 \rightarrow CaO + CO_2$).

Cement production also has high energy requirements, which typically account for 30-40% of the production costs (excluding capital costs). Traditionally, the primary fuel has been coal, but a wide range of other fuels is also used, including petroleum coke, natural gas and oil. In addition to these fuels, various types of waste are used as fuel. Clinker is burned in a rotary kiln that can be part of a wet or dry long kiln system, a semi-wet or semi-dry grate preheater (Lepol) kiln system, a dry suspension preheater kiln system, or a preheater/precalciner kiln system[6]. The best available technique for the production of cement clinker is a dry process kiln with multi-stage suspension preheating and precalcination. Modern cement plants have an energy consumption of 3,000-3,300 MJ per ton of clinker, whereas the wet process with long kilns consumes up to 6,000 MJ per ton.

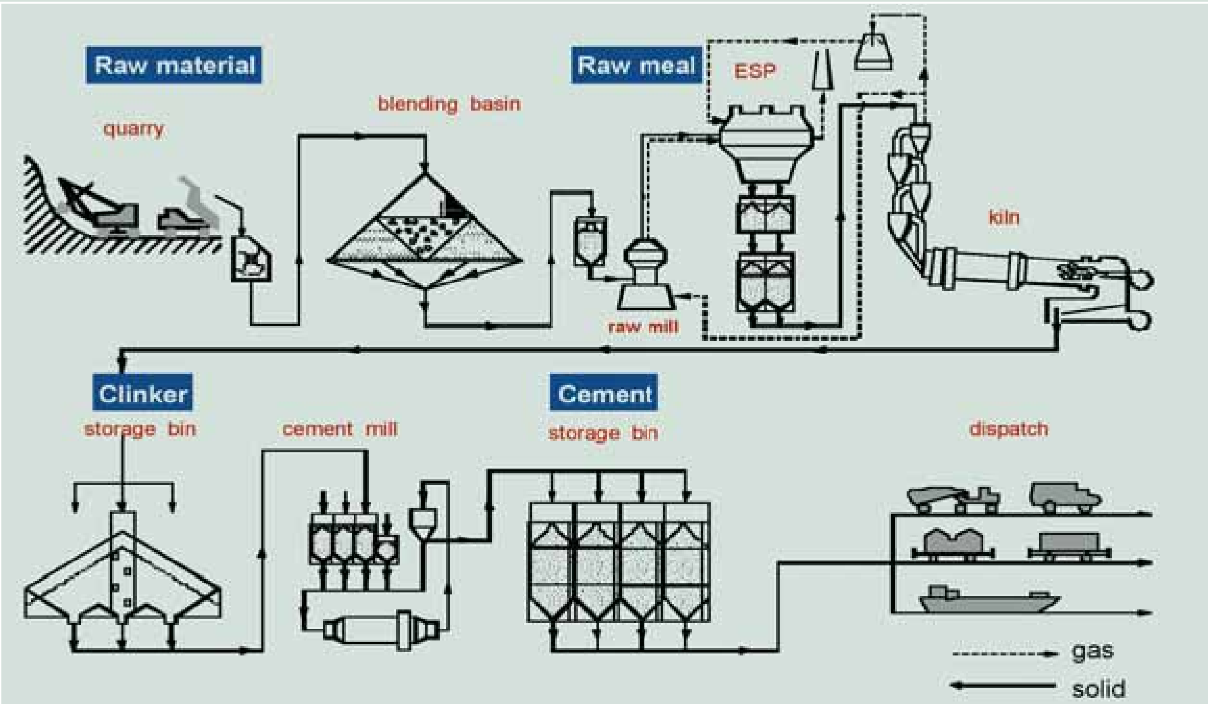


Figure 2: The process of cement production (Source: VDZ)

6 A detailed description of the different kiln types is given in the chapters 3.4 & 3.5 of the CEMBUREAU BAT document (2000). The document can be downloaded under: http://www.cembureau.be/Documents/Publications/CEMBUREAU_BAT_Reference_Document_2000-03.pdf

5.0 Main Characteristics of co-processing in the Cement Industry

The emissions from cement plants that cause the greatest concern are nitrogen oxides (NO_X), sulfur dioxide (SO_2), and dust. Other important emissions to be considered are carbon oxides (CO, CO_2), volatile organic compounds (VOC), dioxins (PCDDs) and furans (PCDFs), and metals. The emission values depend mainly on input materials (raw material and fuel), the temperature level, and the oxygen content during the combustion stages. In addition, kiln emissions can be influenced by flame shape and temperature, combustion chamber geometry, the reactivity of the fuel, the presence of moisture, the available reaction time, and the burner design.

Although high temperature at the main burner is the main reason for the formation of thermal NO_X, this heat is also able to completely destroy unwanted organic substances present in the input material, a great environmental advantage.

Characteristics	Temperature and time
Temperature at main burner	>1450°C: material >1800°C: flame temperature.
Residence time at main burner	>12-15 sec and >1200°C >5-6 sec and >1800°C
Temperature at precalciner	>850°C: material >1000°C: flame temperature
Residence time at precalciner	>2 - 6 sec and >800°C

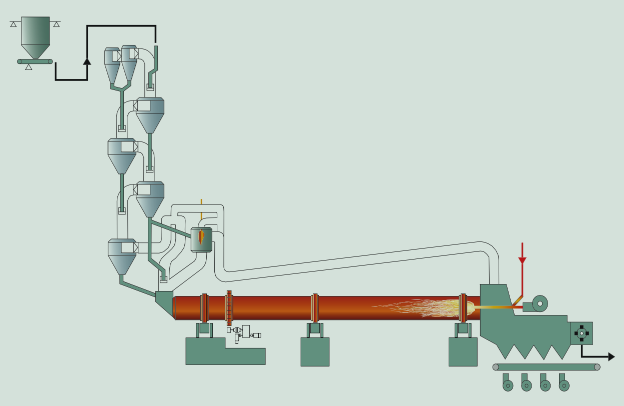


Table 2: Temperature and residence time during cement production

Dust is released from cement production processes either as point source dust (kiln stack, cooler stack, cement mill stack) or as fugitive (dispersed dust from stockpiles, material transfer points, and road transportation). Most of the dust is pure pulverized raw material. Second in importance is clinker and cement mill dust. The cement production process does not (with a few local exceptions) produce liquid effluents. All water consumed (mainly for gas cooling purposes) is released to the atmosphere as water vapor. Surface water quality might be impaired if storm waters flush large quantities of settled dust out of a dusty plant and directly into adjacent small surface waters.

The optimization of the clinker burning process and the continuous development and introduction of abatement techniques (such as dust filters, desulphurization, or selective non-catalytic reduction) have lowered certain cement kiln emissions considerably.

The process, the best available technologies, and environmental impacts are described comprehensively in the reference document produced under the EC Integrated Pollution and Prevention process[7] and in the BAT-BEP Guidelines on Best Available Technology and provisional guidance on best environmental practices[8]. In addition, the Cement Sustainability Initiative of the WBCSD has come up with Guidelines on co-processing that reflect a consensus of the private sector.

7 http://eippcb.jrc.es
8 for example the BAT-BEP on best environmental practices relevant to Article 5 and Annex C of the Stockholm Convention can be found under http://www.pops.int/documents/batbep_advance/default.htm

5.2 Co-processing in the Cement Industry

5.2.1 The process and its application

Co-processing refers to the use of waste materials in industrial processes, such as cement, lime, or steel production and power stations or any other large combustion plants. Co-processing means the substitution of primary fuel and raw material by waste, recovering energy and material from waste. Waste materials used for co-processing are referred to as alternative fuels and raw materials (AFR).

Different feed points can be used to insert AFR into the cement production process. The most common ones are:

→ via the main burner at the rotary kiln outlet end
→ via a feed chute at the transition chamber at the rotary kiln inlet end (for lump fuel)
→ via secondary burners to the riser duct
→ via precalciner burners to the precalciner
→ via a feed chute to the precalciner (for lump fuel)
→ via a mid kiln valve in the case of long wet and dry kilns (for lump fuel).

*[→ see **Case Study 1**: Selection of adequate feed points- The example of Lägerdorf, Holcim Germany]*

Alternative raw materials are typically fed to the kiln system in the same way as traditional raw materials, e.g. via the normal raw meal supply. Alternative raw materials containing components that can be volatilized at low temperatures (for example, hydrocarbons) have to be fed into the high temperature zones of the kiln system.

Co-processing has the following characteristics during the production process:

→ The alkaline conditions and the intensive mixing favor the absorption of volatile components from the gas phase. This internal gas cleaning results in low emissions of components such as SO_2, HCl, and, with the exception of mercury and thallium, this is also true for most of the heavy metals.
→ The clinker reactions at 1450°C allow incorporation of ashes and in particular the chemical binding of metals to the clinker.
→ The direct substitution of primary fuel by high calorific waste material causes a higher efficiency on energy recovery in comparison to other "waste to energy" technologies

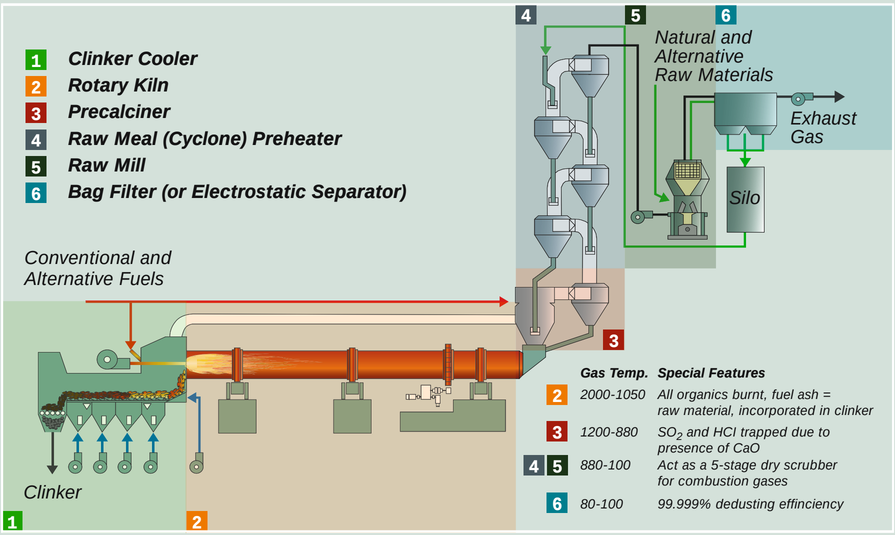


Figure 3: Clinker process and special characteristics (example: pre-calciner kiln)

5.2.2 Co-processing and waste management

Co-processing of waste in cement kilns offers advantages for the cement industry as well as for the authorities responsible for waste management. Cement producers can save on fossil fuel and raw material consumption, contributing to a more eco-efficient production. One of the advantages for authorities and communities is that this waste recovery method uses an existing facility, eliminating the need to invest in a new, purpose-built incinerator or secure landfill site.

Co-processing should be considered in any approach to waste management. A detailed systems approach, comparing individual waste technologies and looking at the interface of combined processes (collection, storage, recycling and disposal) will help to optimize waste management from ecological, social and economical points of view. Tools to be applied for this approach are material and energy flux analyses and eco-balances.

*[→ See **Case Study 2**: An integrated waste management concept – The example from Cartago, Costa Rica]*

Municipal waste is a heterogeneous material and consists in developing countries mainly of a native organic (kitchen refuse, green cut), an inert (sand, ash) and a post-consumer (packing material, electronic goods) fraction. Valuable recycling material such as cardboard, hard plastic, glass or metal are often sorted out by the informal (rag pickers) or formal (cooperatives) sector. In some cases the organic fraction is used for biogas production (anaerobic digestion) or for composting. What is valid for industrial waste holds also true for municipal waste: only sorted waste with a known composition and defined calorific value is suitable for processing as AFR. The selection has to be based on the waste hierarchy and the social impacts of waste recycling as income generation for the urban poor. Whenever possible the informal sector should be incorporated in collection and sorting activities.

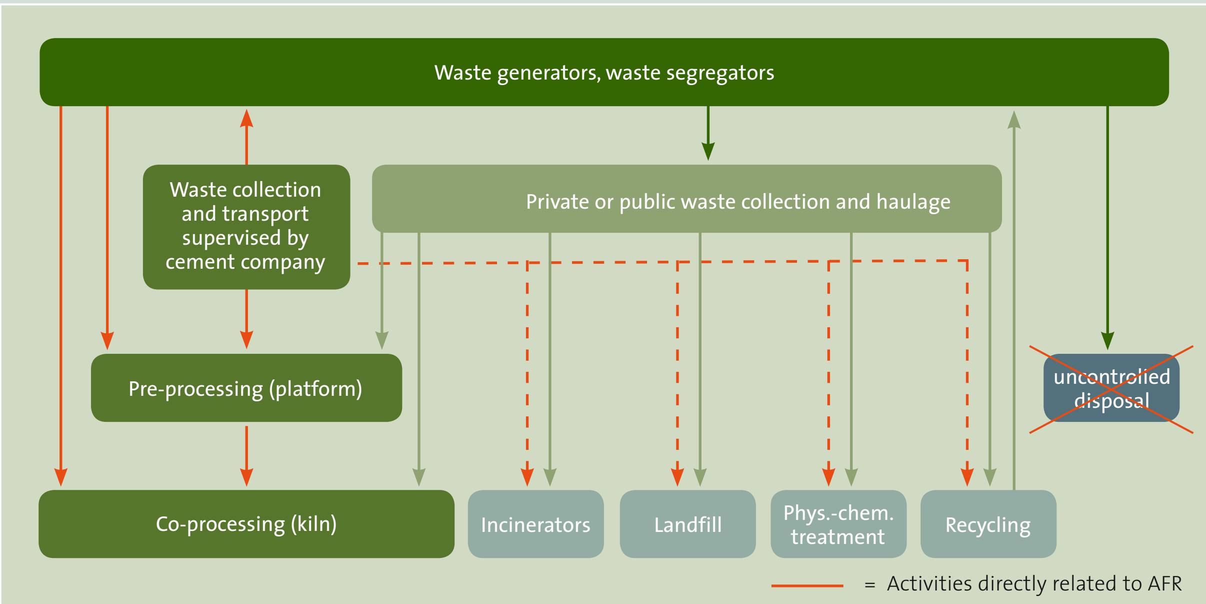


Figure 4: Waste treatment and co-processing: The AFR chain

Compounds	Waste material	Industrial sources
Clay mineral / Al_2O_3	→ Coating residues → Aluminum recycling sludge	→ Foundries → Aluminum industry
Limestone / $CaCO_3$	→ Industrial lime → Lime sludge	→ Neutralization process → Sewage treatment
Silicates / SiO_2	→ Foundry sand → Contaminated soil	→ Foundries → Soil remediation
Iron-oxide / Fe_2O_3	→ Roasted pyrite → Mechanical sludge → Red sludge	→ Metal surface treatment → Metal industry → Industrial waste water treatment
Si-Al-Ca-Fe	→ Fly ashes → Crushed sand	→ Incinerator → Foundries
Sulfur	→ Gypsum from gas desulphurization → Chemical gypsum	→ Incineration → Neutralization process
Fluorine	→ CaF_2 filter sludge	→ Aluminum industry

Table 3: Group classification of alternative raw materials (Source: VDZ)

As cement kiln emissions are site-specific, depending on production processes and the input material, a control and monitoring system for the incoming waste materials and for the optimization of the feeding points is an important aspect to be considered.

Co-processing is not only the use of waste in place of traditional fuels, but can also recover valuable raw materials. → ***Table 3*** above gives some examples on raw material recovery from different wastes. For more information on waste selection → *see* ***chapter 6.1.4.***

5.2.3 Pre-processing: From waste to AFR

Wastes occur in different forms and qualities. The transformation of waste to AFR requires certain standards. Some types of waste cannot be used directly as AFR, but must undergo a preparation process. This step produces a waste product with defined characteristics that complies with the technical specifications of cement production and guarantees that environmental standards are met.

AFR pre-processing plants usually store incoming materials and contain grinding, mixing, and homogenization processes. They must have all the required permits and monitoring systems, for example for dust, odor, VOC, water and noise.

*[→ see **Case Study 3**: Pre-processing of waste material - The example of Energis, Holcim Group, in Albox, Spain]*

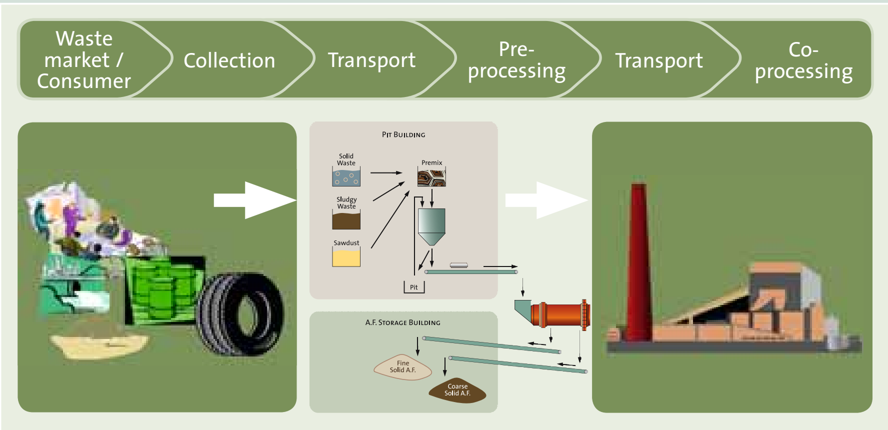


Figure 5: From waste to AFR: Pre-processing operations

5.2.4 Financing of waste services and the polluter-pays principle

The polluter-pays principle must be the basis for the economical and financial analysis of co-processing. This means that those who are producing waste (e.g. industry) or are responsible for its handling (e.g. municipality) have to take care for its best, environmentally sound management. The costs for this duty depend on the different treatment options available on the market, the energy or material value of the waste itself, the required technical standards and the stipulated directives of a country-specific environmental policy.

Co-processing means additional costs to the cement company of the collection, pre-processing, storage and feeding of AFR to the kiln and of quality control and reporting. These costs are in general composed of running costs (staff and equipment), amortization, interests and business risk. As supply chain structures and monitoring systems improve, costs decrease.

The market value of the waste material (positive or negative) fluctuates and depends on the price for fossil fuel and primary raw materials, market competition and the costs of alternative treatments. Normally the overall costs for pre- and co-processing of waste are higher than the energy and material savings so that a waste fee has to be levied. In only a few cases can the waste material reach a profitable market value. This occurs when the sum of the production and investment costs for AFR is lower than the market price for fossil energy and raw material.

Much environmental pollution and inadequate waste handling comes from incorrect pricing of services and goods. In order to assure that waste disposal is not only driven by financing criteria but also follows ecological concerns, market-based instruments (MBIs) such as environmental taxes, incentives or compensation schemes should be applied. The MBIs have to go hand in hand with strict enforcement and penalties.

5.3 Requirements for the Implementation of co-processing

5.3.1 Institutional challenges for co-processing

Co-processing AFR presents challenges for cement plant operators and regulators. The operators need to understand and control all impacts that co-processing will have on the production process, on the final product, on the environment, and on the health and safety of the workers. Regulators should understand all these issues in order to fulfill their roles in controlling environmental impacts and impacts on health and safety. Both operators and regulators should understand the concerns of the public over possible negative effects of co-processing, and they should establish efficient communication processes in order to explain their activities and to avoid conflicts.

In some places the challenges are more complex. Environmental legislation does not exist in all countries. In others, the regulatory framework may exist, but there is no enforcement because of lack of human capacity, awareness or resources. Most developing countries lack information on the methodology of emission analysis and on the evaluation of analytical data from continuous emissions monitoring. Waste statistics are more or less nonexistent, and documentation systems for tracing waste are not known. The lack of waste management plans does not allow for a financially and ecologically optimized handling of waste streams. Thus capacity building is required for the regulatory body to ensure environmentally sound and efficient co-processing.

5.3.2 Areas for capacity building

The following are baseline questions when considering a capacity-building process:

- → Is the existing legislative and regulatory environmental framework appropriate for co-processing?
- → Are regulations available for the safe pre-processing of waste? Do the authorities have sufficient regulatory capacities?
- → Does an integrated waste management plan exist that includes the optimized use of waste material for the given local circumstances? Do national and local waste management policies need further development or updating?
- → Do the industry and authorities understand and use the concept of waste hierarchy?
- → Are the authorities qualified to authorize, control, and monitor co-processing? To what extent does the administrative body need support regarding the permission and monitoring process?
- → Is there an effective, comprehensive quality control system in place for waste sourcing, routine deliveries, AFR product shipments, and the co-processing site's end product (clinker, cement)? Does systematic monitoring, in combination with periodic third party audits by independent institutions, ensure that the operations are in compliance with permits and other internal or external requirements?
- → Is the cement plant able to comply with the need for monitoring? Are the required equipment and trained personnel available?
- → Are independent testing laboratories (national or regional service companies) available and experienced in monitoring and controlling the quality of AFR and emissions?
- → Does the cement plant interested in processing AFR fulfill national environmental standards in using traditional fuel and raw materials?
- → Are adequate transport, storage, and handling of the waste material assured? Are there cooperation agreements between the waste-producing industries and the cement plants that allow for optimal delivery and use of the waste material? Are the pre-treatment operators and haulage companies authorized and reliable?
- → Do adequate emergency response plans exist?
- → Are occupational health and safety standards assured? Are management and staff in cement industry and haulage companies sufficiently trained in handling hazardous materials?

5.3.3 Implementation of capacity development

Capacity development is the process of strengthening the abilities of individuals, organizations, companies, and societies to make effective and efficient use of resources. In the context of these Guidelines, capacity development comprises first of all the transfer of knowledge, experience, skills and values. It includes the improvement of management systems and the extension of networking. Change management and mediation in conflicting situations are essential parts of institutional development.

When national and local decision makers decide to integrate co-processing into waste management systems, the legal and institutional framework must be adapted, and those involved from both government and business need profound knowledge of the implications of the decision. A comprehensive capacity-building strategy should be designed and agreed on with the relevant stakeholders. Training could be done through or in cooperation with bilateral and multilateral organizations (i.e. the national focal points of international conventions like Basel or Stockholm). An additional partner for training could be the cement associations and specialized research institutes and universities. → ***Annex 4*** provides sources for contacts and information.

The objectives of the capacity-building strategy could include information on legal, technical, social, environmental and financial aspects of waste management in general and co-processing in particular. The following chapter gives an overview of the different areas where capacity development and training might be required. Since conditions vary from country to country, an individual and carefully designed capacity-building strategy, including a comprehensive training concept, must be agreed on. The permitting and supervising authorities must concentrate on their coordinating and enforcement functions. Therefore the authorities do not need to provide all relevant knowledge and experience but can rely on external expertise. However, the officers directly responsible for the permitting, control and enforcement procedures should have a profound understanding of co-processing. Training might be required regarding:

- → formulation of waste management policies
- → formulation and interpretation of waste statistics
- → authorization and controlling of co-processing
- → assessment of new materials for co-processing and waste source qualification
- → monitoring of operation and transportation (methodologies of emission analysis and evaluation of analytical data)
- → management of occupational health and safety of the workers within the cement plant and during transportation
- → enforcement of the national regulations and permissions
- → systematic communication with stakeholders and the public.

Cement industry staff from various departments (production, quality, AFR, legal, OH&S etc.) may need training in:

- → control of wastes and AFR
- → operation of facilities for pre-processing and co-processing according to internal regulations
- → occupational health and safety
- → communications
- → internal monitoring of environmental (emission) aspects
- → auditing techniques and audit protocols
- → periodic re-certification for employees and subcontractors.

Reliable and well-trained external auditors, service company personnel, and experts from the public and private sector working in the field of waste management are needed to make co-processing work. To ensure quality and to simplify the work of administrative bodies, the certification of recycling and haulage companies, of laboratories for internal and external controlling, as well as of individual experts, is most important.

Waste producers and pre-treatment and haulage companies will be involved in pre-organization and pretreatment before delivery to the cement plant. Efficiency requires the optimization of material flow, waste separation, preparations for safe handling of the materials already at the source, and adequate installations for transportation and storage. Management and staff should be trained accordingly.

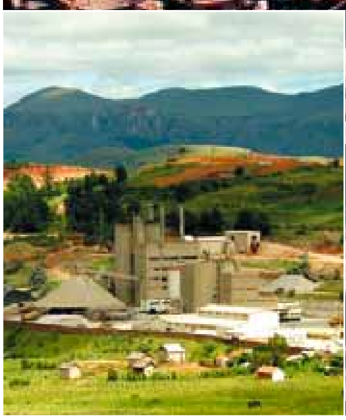
5.3.4 Implementation of the Guidelines

These Guidelines recommend environmental and social standards as well as technical and legal requirements. They shall not be regarded as binding law (see "imporant notice" on page B). Their application enhances broad acceptance of co-processing waste material in cement plants. For the implementation of the proposed ambitious but realistic principles a stepwise approach is required depending on the framework conditions in the different countries.

We have to understand that the level of economical development, environmental consciousness, political priorities, good governance or cultural habits influence the dynamics and timeframe of the modernization of waste management in a country. The implementation of co-processing must be seen as a part of this change process and will progress differently from country to country.

The Guidelines should be implemented on the basis of a spirit of cooperation between the public and private sector. As this will not happen from one day to another, a gradual phasing-in is needed, which is fixed on the given political, social and legal circumstances and based on achievable and realistic milestones.

The driving force for the introduction of co-processing in accordance with these Guidelines can be a national cement association, an individual cement company or the public sector. Whoever promotes this activity should do it in a transparent manner and within a defined and binding time horizon.



6.0 Requirements for co-processing in Cement Kilns

6.1 Legal Aspects

6.1.1 Principles

Principle 1	**An appropriate legislative and regulatory framework shall be set up:** → Co-processing shall be integrated into the overall legislation concerning environmental protection and waste management before it can be accepted as a viable waste management alternative. → Legally-binding regulations and standards are necessary to guarantee legal security and to assure a high level of environmental protection. → Law enforcement is the key to successful AFR implementation and marketing.
Principle 2	**Baselines for traditional fuels and raw materials shall be defined:** → Control and monitor inputs, outputs, and emissions during the operation of the cement plant with virgin fuel and primary raw materials. → Evaluate the given environmental situation prior to starting waste co-processing. → Use this baseline data to define potential impacts of AFR on the environment based on standardized Environmental Impact Assessments (EIA).
Principle 3	**All relevant authorities should be involved during the permitting process:** → Build credibility with open, consistent, and continuous communications with the authorities. → Consider and strive to apply Best Available Technology (BAT). → The cement plant operator shall provide necessary information to enable authorities to evaluate the option of co-processing. → Install community advisory panels early, including the authorities, to facilitate the exchange of information, opinion and know-how.

6.1.2 The legal framework

National laws should define the basic principles under which co-processing takes place. They should then define the concrete requirements and standards for co-processing. Without legally binding rules, the authorities will not be able to control compliance or to enforce environmental protection.

The regulatory framework should reflect the real capacities of environmental authorities. Complex standards are difficult for regulators to handle, particularly in developing countries. Clearly defined criteria that are easy to evaluate and to apply are more appropriate.To integrate co-processing into the national waste policies and laws, the regulatory bodies, the cement industry and other stakeholders should provide a country and sector specific input for the national institutions formulating laws and regulations.

If no specific legislative framework covers co-processing, the cement company interested in the use of AFR should prepare all the necessary documentation before starting any waste co-processing or pre-processing activities, and apply for a permit under the general environmental law in force, in close cooperation with the authorities, basing the application on existing good practices. International and regional experiences and information exchange about best practices should be considered.

6.1.3 The institutional framework

Experience from countries that allow co-processing of waste clearly shows that it is best if the permitting process, supervision and controlling functions are all concentrated in one single administrative body.

Poor enforcement often stems from a lack of awareness or of resources in terms of control and monitoring. Thus capacity building for the regulatory and administrative bodies may be needed *[→ see **chapter 5.3**]* to ensure the environmentally sound treatment of all the waste generated and efficient co-processing.

The civil servants responsible for permitting, control and supervision should have an adequate technical background and legal knowledge. However, the authorities do not need to provide all relevant knowledge and experience, but can make use of external expertise. A basic requirement for the process is the availability of qualified, reliable companies and experts.

6.1.4 Emission control and selection of waste: Enforceable standards are needed

The regulatory framework must provide rules that are easy to enforce. National emissions standards must be applied by the concerned authorities and implemented by permits in each case. Within the given standards, the technical specifications for co-processing and the waste to be used may vary from country to country or even from one cement plant to another.

Special attention must be given to reliable emissions control and monitoring, as this is one of the most sensitive areas of the co-processing activity. In many countries, industrial emissions standards already exist but do not cover emissions from cement factories using AFR. → ***chapter 6.2.2*** provides a detailed overview of environmental impacts and emission control.

Derived from the EU waste catalogue, a list of wastes suitable for co-processing has been prepared *[→ see **Annex 5**]*. This list indicates that co-processing is applicable for a wide range of waste and not limited to a certain type of waste. However, the decision on what type of waste can be finally used in a certain plant cannot be answered uniformly; it must be based on the clinker production process, the raw material and fuel compositions, the feeding points, the gas-cleaning process, the current existing local regulations, if any, and the given waste management problems *[→ see also **chapter 6.3.2**]*. The "Accept-Refuse Chart" in → ***Annex 6*** could be used by plant operators to help them in considering which type of waste is suitable for co-processing. As a basic rule, wastes accepted as AFR must give an added-value for the cement kiln:

→ calorific value from the organic part
→ material value from the mineral part.

In some cases kilns can be used for the safe disposal of special wastes such as obsolete pesticides, PCBs, or outdated pharmaceutical products. However, for this type of treatment, regulatory authorities and cement plant operators must come to individual agreements and standards on a case-by-case basis. Such disposal activity should be done as a joint effort between the public and the private sector.

As documented in → ***Annexes 2 and 5***, a wide range of waste materials may be used as AFR. The most common ones are mixed dirty paper, cartons, plastics, textiles, packaging material, tires, wood, and sorted wastes from households, commerce, or production and service industries. There are liquid waste products such as used oil, solvents or coal slurries as end-of-line products from the transport sector or derivates from industrial activities. Some waste materials can be delivered as single batches directly to the cement plant while others must be pre-processed to meet the required conditions. In some cases (e.g. municipal garbage, hospital waste), co-processing can only be applied after pre-processing phases such as segregation, sorting, making inert, neutralization, or thermal treatment. Regular quality control of the collected and delivered waste will help to ensure a smooth use of the AFR in the kiln.

The quality of what goes in determines the quality of what comes out. Therefore attention must be paid to the selection of raw materials and fuels, whether they come from primary or secondary sources. All natural resources used in cement production (raw material and fuels) contain pollutants such as heavy metals; so a pre-AFR baseline emissions study is recommended. Data from this study helps operators to understand the pollution content of traditional inputs and to demonstrate later whether the use of AFR offers environmental improvements.

Process requirements, product quality targets, and emissions regulations all have a bearing on the choice of the chemical and physical parameters of the potential waste material considered for use. In selecting and using AFR, the aims are

- → to fulfill any legal requirements about pollution, health, safety, and technical standards
- → to assure that the waste used as AFR undergoes its most favorable treatment compared to possible other technologies
- → to exclude damaging effects to the product or the production process
- → to minimize the net financial and economic costs of waste management.

In many countries regulators have produced lists of maximum pollutant values allowed for selected waste to be transferred into AFR and for the pre-processed AFR itself. → ***Annex 7*** gives an overview of such values from different countries. No agreed threshold limit values exist, as different criteria are applied, depending on the local situation. Such criteria include:

- → national environmental policies
- → significance of the impact of the cement industry in the context of regional industrial development
- → efforts to harmonize supra regional environmental laws and standards
- → pollutants in traditional raw materials
- → treatment alternatives for the available waste
- → fixed minimum calorific value
- → toxicity level of pollutants in waste
- → requirements for cement quality.

In all countries where co-processing will be used, such lists should be prepared and regularly reviewed by national or local authorities in cooperation with the cement associations. The aim is to define standard values appropriate for the local circumstances and requirements (on a country-wide basis or on a plant-by-plant approach). This sensitive task should be given special attention during any capacity development activity.

Permits for co-processing should define the waste that is licensed for co-processing. EU Directive 2000/76/EC[9], for example, provides explicitly in Art. 4, paragraph 4 that „the permit granted by the competent authority for an incineration or co-incineration plant shall ... list explicitly the categories of waste which may be treated." Kiln operators should respect these provisions.

The main objective of the permission and controlling process is to assure that only suitable wastes will be used and the AFR operations run properly. Regulators and kiln operators should be able to track the progress of the waste through the waste treatment path, either directly from a waste generator or through collecting/pre-treatment companies. The quality of the material designated for co-processing is crucial. Quality data and emissions monitoring data form the basis for scientific discussions with external stakeholders. They are also helpful tools for reducing local concern and the notion that cement plants are misused as trash bins for uncontrolled disposal of wastes.

To avoid an overload of case-by-case decisions, permitting should be done for types of wastes; though there are exceptions to this *[→ see **Table 4** next page].*

Co-processing should only be applied if not just one but all tangible pre-conditions and requirements of environmental, health and safety, socio-economic and operational criteria are fulfilled. As a consequence, not all waste materials are suitable for co-processing. → ***Table 4** on the next page* gives an overview for the justification of waste not being recommended for co-processing in cement plants. Further explanations on the exclusion criteria are given in → ***Annex 8.***

9 The EC directive can be found under: http://europa.eu.int/comm/environment/wasteinc/newdir/2000-76_en.pdf

6.0 Requirements for co-processing in Cement Kilns

	Enrichment of pollutants in the clinker	Emission values	OH&S	Potential for recycling	Landfilling as better option	Negative impact on kiln operation
Electronic waste	X	X		X		
Entire Batteries	X	X		X		X
Infectious & biol. active medical waste			X			
Mineral acids and corrosives		X	X			X
Explosives	X		X			X
Asbestos			X		X	
Radioactive waste	X		X			
Unsorted municipal waste	X	X		X		X

Table 4: List of waste material not suited for co-processing and the main reasons for the exclusion from co-processing

Cement plant operators must know the quantity and characteristics of the available wastes before applying for a permit for co-processing. However, an open communication channel and regular consultations between the public and the private sector will help to reduce possible friction and misunderstandings and to develop a permit process most suitable for all involved.

6.1.5 Permitting process for co-processing

Generic permits for heterogeneous waste groups should not be issued because it is hard to track these wastes from the generator to the kiln. And it is difficult to assess their environmental impact. It is important to know the origin of each type of waste and its composition in order to ensure safe co-processing. Agreements must be signed with the collectors or haulage companies in order to ensure these requirements.

Generic permits shall only be issued for homogeneous waste including waste coming from pre-processing facilities, for example:

→ solid substitute fuels (impregnated sawdust, refuse derived fuels, fluff)
→ liquid substitute fuels

and for waste types with a defined characteristic and a successful long-term application in cement plants (e.g. tires).

Pre-processing facilities accept different waste materials suitable for co-processing that due to their physical states cannot always be fed directly to the plant. It is therefore necessary to prepare from these wastes a single waste stream in the form of a liquid or solid substitute fuel that complies with the administrative and technical specifications of the cement plants. In this case the traceability is ensured.

Cement plant operators who co-process wastes have the main responsibility for the whole procedure, including permitting and quality assurance. Their applications must include detailed descriptions of all relevant processes within the plant, comprehensive data about all materials designated for co-processing and a detailed self-monitoring plan. These documents give the authorities an overview of the quality of the waste and the expected emissions. The authorities should not accept incomplete application documents.

Operators should apply for a permit only after considering the following elements:

→ the cement process (raw material, fossil fuels, type of kiln etc.)
→ the characteristics of the waste market
→ nearby waste markets, for possible trans-boundary shipments.

A well-documented permitting process should provide detailed information on the plant specifications *[→ see the attached permit procedure as model case in **Annex 9**]* and give information on:

→ raw materials, fuels, co-processed wastes and fuels, handling and preparation
→ expected volumes per waste stream
→ feeding point into the process for each waste stream
→ chemical/physical criteria of each waste stream
→ main items of equipment including plant capacity and operating conditions (i.e. temperature and pressure), where relevant to pollution potential
→ pollutant abatement equipment: scrubbers, filters, absorbers, precipitators, etc
→ release points
→ intermediary products, waste handling, conditioning, and storage
→ inspection plan for incoming waste and pre-processed AFR
→ sources of water and treatment used for process cooling water, effluent water etc, where relevant to pollution potential or release
→ description of the emission situation: technology for preventing pollution, contents and quantities of emissions
→ description of secondary fuels, generation, processing, using installation, supply and quality assurance system
→ investigation of the future harmful effects of pollutants in the plant's sphere of influence (sphere of influence is an assessment area within a radius of 50 times the stack height)
  – chemical/ physical reactions of emitted substances
  – potential dangers, toxicological and environmental relevance
  – loads and protection factors in the plant's sphere of influence
  – emission load of relevant components
  – pathways, periods of time, and circumferences of effects that require protection
  – suitable measures for avoiding pollutants' environmental effects
  – the emission values ascertained in the assessment areas are compared with various references, limiting values, and guide numbers for the background; pollutants to be considered in relation to the production of cement are dust, NO_X, SO_2, VOC, heavy metals, and PCDDs/PCDFs
→ maintenance of industrial and occupational health and safety standards
→ description of methods of informing the public.

When the application is completed (an example for an application form is attached as → ***Annex 10***), the authorities should be asked for review and instruction. However, continuous communications with the authorities can avoid delays in the permit process

*[→ for a flow chart of the permit process, see **Annex 11**]*

The roles and responsibility of the cement company making the application include:

→ making first contact with the competent authority and statutory consulting authority
→ preparing application forms, application for modifications in fuels and raw materials with major changes in the process
→ organizing discussions about the procedure and public participation
→ a written identification, description, and assessment of the effects of the planned activity.

The roles and responsibilities of the permit issuing authority are:

→ considering the application and all the forms
→ involving other authorities in the consultation process (health, transportation, economy)
→ public participation: public information, public inspection of an application, public hearing
→ environmental assessment
→ risk assessment evaluation with interdisciplinary teams
→ final decision on approval by the competent authority (with additional stipulations i.e. imposition, condition, time limitation, reservation as to revocation).

*[→ see **Case Study 4**: Aspects on permitting - The example of North Rhine Westfalia, Germany]*

6.1.6 Baseline testing - trial burn testing

Kiln emissions (with the exception of NO_x and some heavy metals) are produced by volatile components in the raw materials that volatilize during preheating of these materials (i.e. in the cyclone preheater of a precalciner kiln). Volatile components are hardly ever homogeneously distributed in a deposit (quarry) and thus their amounts fluctuate over days and years depending on the part of the quarry being exploited. Dynamic processes of formation and reduction during internal circulation, as well as the kiln operation modes, also affect emissions.

An emission change forecast based on expert know-how and, if required, expulsion testing and chemical analyses would provide good information. However, many authorities and external stakeholders prefer emissions measurements.

In case a trial burn testing is required, the following simple rules and regulations should be applied for the testing procedures:

→ the baseline test takes place over four to six days without the AFR in question, during which:
  – dust, SO_2, NO_x, and VOC are measured continuously
  – HCl, NH_3, benzene, PCDDs/PCDFs and heavy metals are measured

→ The trial burn test is identical to the baseline test but includes the AFR.

For the co-processing of highly hazardous wastes (such as pesticides and PCB-related wastes), a trial burn should be performed to demonstrate 99,9999% destruction and removal efficiency (DRE) and destruction efficiency (DE). A detailed description of test burns for performance verification can be found in → ***Annex 12.***

6.2 Environmental Aspects of Cement Production and AFR pre-processing

6.2.1 Principles

Principle 4	**Rules must be observed:** → The use of AFR does not have a negative impact on the emissions from a cement kiln stack, if the following rules are observed: – all alternative fuels must be fed directly into the high-temperature zones of a kiln system (i.e. via main burner, mid kiln, transition chamber, secondary (riser duct) firing, precalciner firing) – the same is true for alternative raw materials with elevated amounts of volatile matter (or ganics, sulfur) – the concentration of pollutants in alternative materials for which the cement process has insufficient retention capability (like Hg) shall be limited → Cement production lines shall be equipped with a system capable of feeding operation filter dust directly to the cement mills.
Principle 5	**Emission monitoring is obligatory:** → Emissions must be monitored in order to demonstrate: – compliance with the national regulations and agreements – compliance with corporate rules – the reliability of the initial quality control of the process input materials.
Principle 6	**Pre-processing of waste is required for certain waste streams:** → For optimum operation, kilns require very uniform raw material and fuel flows in terms of quality and quantity. This can only be achieved for certain types of waste by pre-processing the waste.
Principle 7	**Environmental impact assessments (EIA) confirm compliance with environmental standards:** → Risk assessments are an efficient way to identify weaknesses in the system. → Material flux and energy flow analyses help to optimize the use of resources.

6.2.2 Significant emissions

Each country must define its pollutant parameters and threshold values for industrial emissions taking into consideration the overall economic and industrial development. In Europe, for example, such emissions are defined by the European Waste Incineration Directive (2000/76/EC) and the European Polluting Emissions Register (EPER, 96/61/EC, → *see* ***Annex 13***). The latter covers 50 pollutants and gives reporting threshold values for releases to air and water (kg/year). In Europe no cement kiln emissions to soil and water reach EPER threshold values. The US has a similar register.

Cement plants. Air emissions and kiln air emissions considered to be of importance by the European Waste Incineration Directive as well as by EPER include:

→ Dust[10], SO_2, NO_x (sum of NO and NO_2), CO, VOC

→ HCl, HF, NH_3, PCDDs/PCDFs, benzene

→ Hg, Tl, Cd and other heavy metals.

Emissions monitoring and reporting should include the components outlined in → ***Table 5*** *on page 28.* These requirements for air emissions monitoring at cement plants are ambitious but recommended as standards for air emissions regulations.

10 Total clean gas dust, after de-dusting equipment. In the case of kiln main stacks, more than 95% of the clean gas dust has PM10 quality, i.e. is particulate matter (PM) smaller than 10 microns.

6.0 Requirements for co-processing in Cement Kilns

Calculation and reporting on greenhouse gases (CO_2 emissions) is done according to the Cement CO_2 Protocol of the WBCSD[11].

Due to the volatile nature of mercury, special attention should be given to the mercury content of the material used for clinker production (conventional or alternative raw materials and fuel) and to operational procedures.

Component	Monitoring Frequency
Dust, SO_2, NO_X, CO, VOC	Continuously
HCl, NH_3, Benzene, Hg, heavy metals Dioxins, Furans (PCDDs/PCDFs)	At least once a year

Table 5: Frequency of emission monitoring for significant components

MERCURY

Mercury (Hg) is bio-accumulative, a health hazard, and is highly toxic to humans in all its chemical forms. It is a comparatively rare element, with an average concentration in the earth's crust of only 0.00005%. It is found both naturally and as an introduced contaminant in the environment. Because of its volatile nature and its presence in fossil fuels being used in many industrial processes, mercury is released into the atmosphere from a wide variety of anthropogenic emission sources.

It is also found in nearly all cement raw materials and mineral coals. The mercury can enter the cement process via raw materials and fossil fuels in different quantities. An additional source of mercury in the kiln can be the co-processing of mercury-containing waste, e.g. pesticides, sludge, etc. Due to its physical nature, mercury is not captured in the clinker matrix. It forms gaseous compounds that are not retained in the rotary kiln and preheater area. Instead, gaseous compounds condense on the raw material particles in the raw mill and dust collector area during compound (mill on) operation. Thus mercury accumulates in the external material cycle during compound operation and escapes into the environment during direct (mill down) operation phases. Mercury emissions can be minimized by implementing an external bypass, feeding direct operation filter dust to the cement mills. To reduce mercury emissions, it may also become necessary to limit the mercury input into the kiln system via the feed materials (conventional and alternative raw materials and fuel).

The EU Waste Incineration Directive 2000/76/EC as well the USA MACT rule for the incineration of hazardous wastes limit mercury emissions to 0.05 mg/Nm^3, a threshold limit value that should be respected by all cement plant operators. Cement kilns have no problem complying with this limit under regular conditions. This is also true if alternative fuels are used to replace fossil ones. Responsible use of AFR includes testing of incoming critical materials for their Hg contents and refraining from using them if Hg content is high. Eco-balances carried out in Germany for comparing ecological differences between co-processing and other forms of waste treatment revealed that only mercury has to be seen as a "risky" element for co-processing.

AFR pre-processing plants.

In the guidance document to the EPER, the following potential air emissions are mentioned for waste management activities:
CH_4, CO, CO_2, NH_3, NO_X, SO_X, As, Cd, Cr, Cu, Hg, Ni, Pb, Zn, HCB, PCDDs/PCDFs, TCM, TCE, PAH, HCl, HF, VOC and dust.

It is unlikely that normal emissions to air, soil, and water from AFR pre-processing plants would reach EPER threshold limit values for any of the pollutants. Nevertheless, emission monitoring and reporting must be performed according to locally applicable regulations.

11 Report on CO2 Accounting and Reporting Standard for the Cement Industry. http://www.wbcsd.org/web/publications/cement-tf1.pdf

6.2.3 Generation of emissions and reduction techniques

Cement plants.

Air emissions: Reasons for air emissions from cement production, emission ranges, and appropriate reduction techniques can be found in → ***Annex 14.*** Since there is no significant change in emissions with state-of-the-art co-processing, the Annex also applies for co-processing.

Water and soil: Cement plants, as a rule, do not emit industrially polluted water. They do produce domestic waste water from various plant sections. These effluents are discharged to the plant's or to public wastewater treatment facilities. Impacts on soil can originate from fugitive dust emissions and are normally limited to the plant (and quarry) area. The growth of vegetation may be impaired by dust deposits.

Noise: It is usually generated by fans and compressors, speed reducers, ball mills, planetary coolers and traffic. Countermeasures are routine and include noise barriers, noise damping and housing, or, ideally, placing cement plants far from human settlements. Health and safety of employees and residents usually require a mix of all these abatement measures.

AFR pre-processing plants

Air emissions: Emissions to air from an AFR pre-processing plant will depend on the types of wastes treated and the processes used. Emissions of dust and VOC should be expected, and proper abatement techniques should be in place. Common reduction techniques for VOC include a nitrogen trap, biological treatment, activated carbon and thermal treatment. Dust is usually reduced by bag filters.

Water and soil: Releases to water and soil from an AFR pre-processing plant will depend on the types of wastes treated and the processes used. Proper abatement techniques should be in place. According to the degree and nature of the pollution agents and to the output (surface water, on-site water treatment, collective industrial, or urban station), different reduction techniques for water may be used alone or combined:

- → settling, hydrocarbons/oils/sludge separators
- → activated carbon (should be sufficient for water with low contamination levels)
- → physical-chemical treatment
- → biological treatment
- → thermal treatment (for highly polluted water).

The by-products of such efforts (used activated carbon, sludge, hydrocarbons, oils etc.) can be reintroduced into the cement production process for recovery/elimination or directed to external treatments plants.

Odor and noise: AFR processing can be a significant source of odor, but effects will depend on the types of wastes treated and the processes used. Proper abatement techniques should be in place. Common reduction techniques for odor include nitrogen trap, biological treatment, activated carbon, and thermal treatment. Countermeasures for noise are routine and are covered above.

6.2.4 Monitoring and reporting of emissions

Cement plants

Air emissions: The following parameters should be measured in all plants (see EC-Directive 2000-76-EC; the threshold limit values for these parameters are given in → see **Annex 15**):

→ **continuously: dust, SO_2, NO_X, and VOC**
→ **at least once a year: HCl, NH_3, Benzene, PCDDs/PCDFs, Hg, and other heavy metals.**

Reliable on-line monitors should be used for continuous measurements. For the once-a-year measurements, companies must select national or international service companies. All emission data must, for sake of worldwide comparability (benchmarking), be converted to and given in the same units as daily averages (mg of .../Nm^3, dry gas at 10% O_2 content).

During the once-a-year measurements, the service companies must measure dust, SO_2, NO_X, and VOC and compare results to the respective averages of the continuous measurements in the same time period. In case of significant deviations, continuous and discontinuous measurements must be checked for accuracy. For continuous measurements, standardized reporting includes:

→ yearly average of the daily averages
→ number of daily averages exceeding a limit value
→ standard deviation of the daily averages.

Standardized reporting for periodic measurements includes the arithmetical mean value of all (if more than one) measurements within one year.

Soil and water: Cement plants do not produce cement-specific waste water, but do produce domestic sewage water that is normally piped to a plant-owned or public sewage facility. Standard procedures are used to monitor effluent water quality and to adjust the cleaning process.

Dust: If volatile matter such as metal and organics gets into the system then it may become part of the dust from main stacks. In cases of electrostatic precipitator shutdowns, this material can be emitted and affect soils near the stacks. In a state-of-the-art cement plant, part of the direct operation filter dust is separated and fed to the cement mill, thus keeping such pollutants from building up in the dust circuit, being emitted, and polluting the soil.

Odor and noise: No monitoring methods for these issues specific to cement production are known. Monitoring odor and noise follows routine practices. Whereas noise measurements are sometimes done in and around a cement plant, odor measurements are cumbersome, complex, unreliable, and comparatively costly. No case is known of an odor measurement in or around a cement plant.

*[→ see **Case Study 5**: Emissions monitoring and reporting (EMR) - The experiences from Holcim]*

AFR pre-processing plants

Air emissions: AFR pre-processing plants should be inspected and emission samples taken by an independent testing laboratory at least once a year. The coverage of the inspection and emission testing shall be written in the permit/license condition of the treatment facility. The testing company must comply with the requirements of local regulations, both with regards to competence and reporting.

Soil and water: Cleaning and process water may be a significant source of pollution to water. Discharge limit values for pollutants should be an integral part of the permit, and compliance must be monitored and reported. With the exception of accidents, emissions to soil and groundwater are not expected. However, an independent baseline investigation of the pollution level of groundwater and soil should be performed prior to construction or start up of waste treatment in case of future allegations and liabilities.

Odor and noise: Due to the relatively low noise level expected, no specific monitoring is usually requested. However, measures can be taken for the health and safety of workers and for environmental impact evaluation, notably when new equipment is commissioned.

Odor measurements can be complex and unreliable. However, an independent baseline investigation of the odor and noise levels should be performed prior to construction or start up of waste treatment in case of future complaints from neighbors and future allegations and liabilities.

*[→ see **Case Study 6**: Pre-processing of waste material – The example of Ecoltec, Mexico]*

6.2.5 Environmental impact of pollutants in products

Some heavy metals (e.g. Hg, Tl, Cd, Sb, As, Pb, Cr) are called pollutants because if taken up by living organisms in excessive quantities, they can affect health. The same applies to organic pollutants (e.g. PCDDs/PCDFs). As heavy metals are present in all feed materials (conventional and AFR), some will be found in the final cement product.

The heavy metal content of clinker made without AFR varies significantly depending on the geographical and/or geological location of the raw materials. Lengthy investigations have shown that the effect of AFR on the heavy metals content of clinker is marginal on a statistical basis. The one exception is that the bulk use of tires will raise zinc levels.

Organic pollutants in the materials fed to the high temperature zone of the kiln system are completely destroyed, and the inorganic ashes are incorporated into the end product.

Mortar and concrete act as a "multi barrier" system against the release of metals due to the:

→ incorporation of metals in the crystal structure of clinker
→ incorporation of metals in the hydration product in cement
→ formation of insoluble minerals
→ encapsulation of metals in the dense structure of concrete.

6.2.6 Leaching of incorporated pollutants from concrete

Assessments of the environmental quality of cement and concrete are typically based on the leaching characteristics of heavy metals to water and soil. Various exposure scenarios must be considered:

→ exposure of concrete structures in direct contact with groundwater ("primary" applications)
→ exposure of mortar or concrete to drinking water in distribution (concrete pipes) or storage systems (concrete tanks); (these are „service life" applications)
→ reuse of demolished and recycled concrete debris in new aggregates, road constructions, dam fillings etc. ("secondary" or „recycling" applications)
→ dumping of demolished concrete debris in landfills ("end-of-life" applications).

The leaching of trace elements from concrete within the environmentally relevant pH values (7 to 11) is a diffusion-controlled (i.e. extremely slow) process. But all metals do not share the same principal leaching characteristics.

The main results of the many leaching studies done to asses the environmental impacts of heavy metals embedded in concrete are as follows:

→ the leached amounts of all trace elements from monolithic concrete (service life and recycling) are below or close the detection limits of the most sensitive analytical methods
→ no significant differences in leaching behavior of trace elements have been observed between different types of cements produced with or without alternative fuels and raw materials
→ the leaching behavior of concrete made with different cement types is similar
→ however, leached concentrations of some elements such as chromium, aluminum and barium may, under certain test conditions, come close to limits given in drinking water standards; hexavalent chromium in cement is water-soluble and may be leached from concrete at a level higher than other metals; so chromium inputs to cement and concrete should be as limited as possible
→ laboratory tests and field studies have demonstrated that applicable limit values (e.g. groundwater or drinking water specifications) are not exceeded as long as the concrete structure remains intact (e.g. in primary or „service life" applications)

- → certain metals such as arsenic, chromium, vanadium, antimony, or molybdenum (so-called „oxyanions“) may have a more mobile leaching behavior, especially when the mortar or concrete structure is destroyed through crushing or other size-reduction processes (e.g. in recycling stages such as use as aggregates in road foundations, or in end-of-life scenarios such as landfilling)
- → as there are no simple and consistent relations between the leached amounts of trace elements and their total concentrations in concrete or in cement, the trace element content of cements cannot be used as environmental criteria.

In cases where the concentration of heavy metals exceeds the normal range found in cements made without AFR, leaching tests should be conducted.

For different, real-life concrete and mortar exposure scenarios, different leaching tests and assessment procedures must be applied. Existing standardized test procedures have been developed mainly for waste regulations and drinking water standards. There remains a need for harmonized and standardized compliance test procedures based on the exposure scenarios as outlined above.

6.2.7 Special comments regarding Dioxins and Furans

The Stockholm Convention on Persistent Organic Pollutants (POPs) lists cement kilns burning hazardous waste as a potential source of PCDDs/PCDFs emissions. Though there are exceptions, PCDDs/PCDFs emissions from cement kilns are normally less than 0.1 ng I-TEQ/Nm^3 and seem to be independent of using AFR or not. The Stockholm Convention also regulates HCB and PCBs and is requesting more data from the industry.

WBCSD has done a comprehensive study of POPs and co-processing (summary of the report: *→ see **Annex 16***). The study found that:

- → cement kilns, with a few exceptions, do not emit PCDDs/PCDFs in any significant amounts
- → if PCDDs/PCDFs emissions are produced, they are usually reaction products from organic compounds in the raw materials, volatilized from the raw meal and acting as precursor materials in the new-formation of PCDDs/PCDFs in cooler parts of the process
- → long wet and long dry process kiln technology is somewhat more susceptible to PCDDs/PCDFs emissions than modern cyclone preheater/precalciner technology
- → PCDDs/PCDFs emissions seem to be independent of the use of alternative fuels if the general principles of good process control are observed.

*[→ see **Case Study 7:** Test burns with PCDDs/PCDFs Monitoring - The Philippine Examples]*

DIOXINS AND FURANS

Any chlorine introduced to the kiln system in the presence of organic material may cause the formation of polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in combustion and wet-chemical processes. PCDDs and PCDFs can form after the preheater in the air pollution control device if chlorine, hydrocarbon precursors from the raw materials and time are available in sufficient quantities. The formation of dioxins and furans is known to occur by de novo synthesis within the temperature window between 250-450^{o}C. Thus it is important that the exit gas are cooled rapidly through this range. Due to the long residence time in the kiln and the high temperatures, emissions of PCDDs and PCDFs are generally low during steady kiln conditions. In Europe cement production is rarely a significant source of PCDDs/PCDFs emissions The reported data indicate that kilns can comply with an emission concentration of 0.1 ng TEQ/Nm^3, which is the limit value in the European legislation for hazardous waste incineration plants (Council Directive 94/67/EC). German measurements at 16 cement clinker kilns (suspension preheater kilns and Lepol kilns) indicate that the average concentration amounts to about 0.02 ng TE/m^3.

Source: Integrated Pollution Prevention and Control (IPPC): Reference Document on the Best Available Technology in Cement and Lime Manufacturing Industries, 12/2001

6.2.8 Management of kiln and bypass dust

In cases of excessive intake of chlorines with feed materials, cement kilns develop operational problems due to sticking of the processed materials. Such problems are solved by extracting part of the kiln gases at the point of highest chlorine concentration. Upon air quenching, the chlorines condense on dust particles and can then be removed from the system by means of de-dusting devices. The resulting intermediate or by-product is called bypass dust (BpD).

In some cases, particularly in the US, the market requires low-alkali cements. Alkali volatilization is enhanced by chlorine addition. Both are then removed with a bypass-system generating BpD.

If alkali removal is done in long wet or long dry kilns then a different type of dust, called cement kiln dust (CKD, moderate enrichment levels) is produced.

Both BpD and CKD can be minimized and can be added to cements (if local standards allow) but cannot in some cases be completely re-used. Thus landfilling might be needed.

- → If landfilling cannot be avoided, it must be done according to the rules of controlled landfilling
- → BpD and CKD must be compacted to prevent wind erosion, and the exposed face must be minimized
- → Effluents must be collected and treated before release.

6.3 Operational Issues

6.3.1 Principles

Principle 8	**The sourcing of waste and AFR is essential:** → Traceability of waste helps to avoid undesired emissions, to minimize operational risks and to ensure final product quality. → Traceability shall be ensured at the pre- or co-processing facility from reception up to final treatment. → Business agreements with regular customers (waste producers, waste handling companies) shall include quality and delivery criteria to allow for a uniform waste stream. → Waste categories unsuitable for co-processing should be refused. → All candidate (new) wastes will be subject to a detailed source qualification test procedure prior to acceptance.
Principle 9	**Materials transport, handling, and storage must be monitored:** → General Guidelines for waste and AFR transportation must comply with regulatory requirements. → Instructions and adequate equipment for transport, handling, and storage of solid and liquid wastes and AFR are provided and maintained regularly. → Conveying, dosing, and feeding systems are designed to minimize fugitive dust emissions, to prevent spills, and to avoid toxic or harmful vapors. → Adequate spill response and emergency plans must be developed, implemented, and communicated to plant employees *(→ see also **6.4.3**)*.
Principle 10	**Operational aspects must be considered:** → AFR will be fed to the kiln system only at appropriate introduction points determined by the characteristics of the AFR. → The technical conditions of the plant that influence emissions, product quality, and capacity will be carefully controlled and monitored. → For start-up, shut-down, or upset conditions of the kiln, the strategy dealing with the AFR feed has to be documented and must be accessible to operators.
Principle 11	**Quality control system is a must:** → Documented control plans for wastes and AFR must be developed and implemented at each pre-processing or co-processing site. → Procedures, adequate equipment, and trained personnel for the control of wastes and AFR must be provided. → Appropriate protocols in case of non-compliance with given specifications must be implemented and communicated to operators.
Principle 12	**Monitoring and auditing allow transparent tracing:** → Monitoring and auditing protocols for waste and AFR management in pre- and co-processing installations are developed and implemented. → Instructions and adequate training of company staff in performing internal audits are provided.

6.3.2 Waste and AFR sourcing

The potential use of a waste as AFR at a pre- or co-processing site requires a careful selection process to make sure that the material meets given external and internal specifications and other requirements.

Prior to acceptance of a waste, the waste will be subject to a detailed qualification process consisting of the following steps:

- identification of the generator of the candidate waste
- evaluation of existing information, such as
  - business activity or process type of waste generation
  - intermediate disposal, storage, or treatment of the waste
  - physical and chemical characteristics of the waste;
  - health and safety data and hazards classification (Materials Safety Data Sheets etc.)
  - existing stock volumes and expected monthly delivery rates
  - transport conditions (waste codes, transport codes, packaging, transport mode, legal requirements)
- full-scale testing of a representative waste sample including at least all chemical and physical characteristics listed in the operational permit and in the plant specifications
- comparison against given specifications
- creation of a "master data file" of the candidate waste *[→ see **Annex 17** as example]*
- in case of acceptance of candidate waste: contract and arrangement for waste deliveries.

Wastes listed under → ***chapter 6.1.4*** and wastes with insufficient, doubtful, or unreliable information will not be accepted.

6.3.3 Materials transport, handling and storage

Transport, storage, and handling of waste materials – especially those with hazardous characteristics – are frequently subject to detailed legal requirements and/or other regulations. These local, national, and international (e.g. Basel Convention) requirements or regulations must be observed. The following good management practices and commitments shall be adopted.

Guidelines for transportation. Only authorized transporters will be selected to deliver waste and AFR to the pre- and co-processing site. Owners and/or operators of transport equipment shall

- provide evidence of proper maintenance of their equipment
- employ only trained operators
- comply with all relevant regulations and legal requirements in accordance with the nature of the materials delivered
- strictly observe procedures and protocols of the manufacturing site when on plant property.

The pre- or co-processing site will inform transport owners and operators about applicable requirements and procedures inside the property. The pre- or co-processing site shall request the waste suppliers to provide evidence about appropriate training of operators.

Guidelines for internal transport, handling and storage. Internal transport, storage, and handling of wastes and AFR shall be done in a manner to prevent the possibility of spills and groundwater/soil contamination, to minimize the risk of fire or explosion, to control fugitive dust from dry materials, and to contain volatile components, odors and noise.

The pre-processing and co-processing site shall:

- develop and specify procedures and instructions for unloading, handling and storage of solid and liquid fuels and raw materials
- provide sufficient and adequate storage capacity and handling installations
- implement and communicate detailed spill response and emergency response plans
- implement adequate fugitive dust controls during plant transport, unloading, conveying, and reclaiming from storage sites
- control wind erosion and water run-off from stockpiles
- apply fire and explosion safe design for all installations in accordance with the nature of the materials
- provide adequate installations and equipment for suppression or containment of volatile gaseous components
- ensure adequate protective equipment and training available for workers on-site.

6.3.4 Operational aspects

Safe and responsible use of AFR requires careful selection of the feed points in the kiln system as well as comprehensive operational control according to the specific characteristics and volumes of the AFR.

Guidelines for feed point selection

Adequate feed points will be selected according to the physical, chemical, and (if relevant) toxicological characteristics of the AFR used [→ see **Figure 6**].

Alternative fuels are always fed into the high-temperature combustion zones of the kiln system. The physical and chemical natures of the fuel determine the exact feed point, i.e. either the main burner, the precalciner burner, the secondary firing at the preheater, or the mid-kiln (for long dry and wet kilns). Alternative fuels containing stable toxic components should be fed to the main burner to ensure complete combustion due to the high temperature and the long retention time.

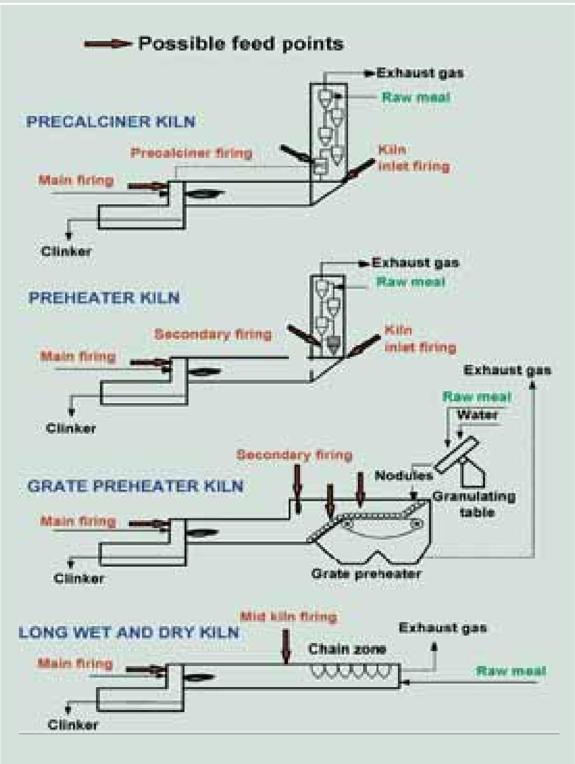


Figure 6: Possible feed points for AFR

Feeding of alternative raw materials containing volatile (organic and inorganic) components to the kiln via the normal raw meal supply is forbidden unless it has been demonstrated by controlled test runs in the kiln or by adequate laboratory tests that undesired stack emissions can be avoided.

Guidelines for kiln operation control

The application of AFR should not negatively affect smooth and continuous kiln operation, the product quality, or the site's environmental performance. Therefore, a constant quality and feed rate of the AFR must be assured.

The impact of AFR on the total input of circulating volatile elements such as chlorine, sulfur, or alkalis is assessed very carefully prior to acceptance, as they may cause operational troubles in a kiln. Specific acceptance criteria for these components are set individually by the site based on the process type and on the specific kiln conditions.

The general principles of good operational control of the kiln system using conventional fuels and raw materials are applied. In particular, all relevant process parameters are measured, recorded, and evaluated continuously. Kiln operators are trained accordingly, with special focus on requirements related to the use of AFR - including OH&S and environmental emission aspects.

For start-up, shut-down, or upset conditions of the kiln, written work instructions describing the strategy to disconnect or reduce the AFR feed should be available and known to the kiln operators.

The mineral content of AFR may change the characteristics of the clinker. The raw mix composition must be adjusted accordingly to stick to the given chemical set points. Input limits for chlorine, sulfur, and alkalis must be defined, and operational set points must be strictly observed. Bypass installations to increase AFR use shall only be considered if appropriate solutions for the management of the bypass dust generated have been identified. Uncontrolled landfilling of bypass dust is not acceptable.

Use of AFR is based on state-of-the-art technology for conventional fuels and raw materials. Essential technical developments and improvements will be evaluated and adapted if needed.

6.3.5 Quality control system

Each site, pre-processing or co-processing, must establish a comprehensive quality control system for waste source qualification, routine deliveries, AFR product shipments, and the co-processing site for its end product (clinker, cement).

Guidelines for control plans

The model control scheme *[→ see **Annex 18**]* illustrates the control of wastes and AFR. The control plan must be developed in cooperation with the commercial department responsible for waste sourcing, and with the waste pre-processor and/or cement plant management.

Delivery controls in routine operations must be carried out for each individual shipment. Delivery control has an administrative part (document control, waste/AFR certificate identification, transport certificate control etc.) and an analytical part (sampling, tests/analysis, comparison against specifications).

The detailed control plan depends on the origin and nature of the waste or AFR and contains specifications on identification codes, responsibilities, sampling location and frequency, type of analytical tests, test frequency, and permit requirements.

In pre-processing plants, each batch of treated AFR has to be controlled prior to dispatch to the cement plant or prior to transfer to the feed tanks or silos. Test samples and test results must be stored or filed for a defined period of time. Comparison tests must be carried out periodically in order to verify and improve the analytical performance of the control laboratory.

*[→ see **Case Study 8**: AFR Quality control laboratory - The example of Resotec in Brasil]*

Guidelines for procedures, equipment and training

Documented work instructions (standard operating procedures) for sampling, analytical tests, sample storage, laboratory equipment management (calibration, maintenance etc.), administrative procedures and validation of results must be available and communicated to the service personnel.

Adequate laboratory design, infrastructure, and sampling and test equipment must be provided and maintained to enable all required tests corresponding to the waste/AFR types and the control plan.

Service personnel must be adequately trained according to the specific needs and to the nature of the wastes or AFR. Documented training plans and training records are to be developed and kept for reference. The training includes OH&S and environmental aspects.

Guidelines for non-compliance cases

Written protocols and instructions must be available detailing measures in case of non-compliance with given specifications or regulations. Suppliers of the waste or AFR must be informed about non-compliance deliveries.

If explanations given by the supplier are not satisfactory, the shipment must be rejected, and the authorities must be notified (if this is required in the permit).

Test results must be evaluated for each supplier on a statistical basis in order to assess the performance and reliability of the waste/AFR supplier, and in order to periodically review the contract.

Guidelines for end-product control

Final products such as clinker or cement are subject to regular control procedures required by the usual quality specifications as laid down in applicable national or international quality standards.

6.3.6 Monitoring and auditing

Systematic monitoring of a site's performance in combination with periodic auditing shall ensure that the site's operations are always in compliance with all operating permits and other internal or external requirements.

Guidelines for monitoring and auditing

The company shall conduct systematic and periodic audits to ensure compliance with its waste operating permit, with regulatory requirements, and with internal standards and Guidelines as stated in → ***Operational Principles 8-12.*** The company shall train selected personnel from various departments (production, quality, AFR, legal, OH&S etc.) in auditing techniques and audit protocols.

Internal audits are carried out at least once per year. These audits may be carried out in combination with the audits as required by the ISO 9001/14001 management systems. Written work instructions and audit protocols (including checklists) must be developed and provided by the company.

Audit reports with main conclusions and recommendations are submitted to senior management for review. Senior management must take actions in order to ensure that root causes for non-compliance are evaluated and non-compliance cases are eliminated. Additional third party audits (by independent institutions) should be carried out periodically to verify or complete the audit findings of the company's internal audit team.

6.4 Occupational Health and Safety (OH&S)

6.4.1 Principles

Principle 13	**Site suitability avoids risks:** → Proper location (environmental, proximity to populations of concern, impact of logistics/ transport); good infrastructure (technical solutions for vapors, odors, dust, infiltration into ground or surface waters, fire protection etc.) and properly trained management and employees with regard to the handling and processing of AFR can all minimize risks.
Principle 14	**Safety and security:** → Each site must have a unit for safety and security. → A risk manager is responsible for the arrangement and performance of the unit.
Principle 15	**Documentation and information is a must:** → Documentation and information are the basis for openness and transparency about health and safety measures. → Information must be available for employees and authorities before starting any co-processing activity.
Principle 16	**Training should be provided at all levels:** → Management should be trained before starting with co-processing at a new facility or site. Field visits at already existing facilities are strongly recommended. → Hazardous operations training for new workers and sub-contractors should be completed before starting with co-processing. Periodic re-certification should be done for employees and sub-contractors. Include induction training for all visitors and third parties. → Understanding risks and how to mitigate them are key to training. → Training and information of authorities is the basis for building credibility.
Principle 17	**Emergency and spill response plans:** → Good, regular emergency and spill response planning and emergency response simulations, including the neighboring industries and the authorities, contribute to the safe use of AFR.

6.4.2 The cornerstones of an occupational health & safety (OH&S) system.

OH & S is of primary importance in co-processing. OH&S is based on thorough information, efficient risk assessment, and complete implementation of all preventive measures. A technical measure is always preferred over a personal preventive measure. Information about decisions on OH & S must be available to employees and other concerned stakeholders. The risk and crisis management are the main pillars of OH & S. This goes along with risk assessment, design safety and quality management system.

Risk assessment/risk management: There is no such thing as zero risk, but risks can be properly managed. Risk assessment is the examination of the probability and magnitude/impact of an event that could occur. Risk assessments must be performed by commercial staff, waste transporters/handlers, the pre-processing facilities, the cement plant and engineers involved in the design and selection of AFR handling and storage equipment. Risk assessment must be carried out during:

→ initial facility design or modification
→ process modification
→ determination of criteria for acceptance – banned materials due to OH & S or process reasons
→ determination of what constitutes hazardous work activities and where work permits will be required
→ development of a site-specific industrial hygiene program, ensuring no adverse impacts to workers or those exposed to AFR
→ determination of when and where personal protective equipment will be necessary as determined by personal exposure measurements, environmental concentrations, and mandated occupational exposure limits (OELs)
→ development of an emergency response plan for the pre-processing or co-processing facilities (the site management must ensure that adequate emergency procedures are in place and communicated to employees, authorities, and neighboring industries)
→ review of critical equipment and safety equipment (development of a preventive checks system).

Figure 7: Integration of risk and crisis management in a quality management system.

Data obtained from risk assessments can be used by the pre-processing or co-processing facility to prioritize which items must be immediately addressed or put into the subsequent years' budgetary process. Communications of identified risks and mitigation means are required for all stakeholders, including authorities.

Design safety: Design safety is one of the easiest, yet often most overlooked, aspects of ensuring OH&S. Risk assessments are part of the process for design safety:

- → the site with all buildings must fulfill legal compliances (correspond with the regulations of authorities)
- → suitability of the site; chose the least vulnerable location based upon possible scenarios using available information on predicted waste types, usage, volumes, rates and proximity to populations of concern; aspects of site security must be considered
- → layout of the site should be scaled and designed for the anticipated activity to be carried out, including enough space for installation of increased production capacity and storage
- → well-maintained equipment for processing and handling of alternative fuels and raw materials must be used when possible to decrease the danger to personal safety or property
- → storage areas for alternative fuels and secondary raw materials should be designed to avoid or minimize health and safety risk to employees and surrounding communities
- → engineering designs must comply with international Guidelines or codes and legal requirements (Seveso II, ATEX, RMP, NFPC, VDI etc.).

Hazardous operations (exceeding design operational limits) or design consequence analysis (for example: if water lines to fire protection systems have no pressure, what is your default or backup solution?) can help in the determination of safety measures such as layers of protection (blast doors, reinforced walls, parallel water lines etc) for critical processes or equipment.

Management systems: Having an OH&S management system is essential during the operational phase of sites handling, processing, or using AFR. The basis of the management system is to:

- → strive for continual improvement in OH&S performance (i.e.18001, CEFIC, Responsible Care etc.)
- → audit system and review (plan, do, check, act); management review, internal audits, external audits (such as OSHA VPP Five Star), systems for OH&S
- → have in place documentation (i.e. data sheets or similar documents, hazardous work permits, training records, equipment inspection and maintenance records, operational permits, audit results, environmental and medical monitoring results, and industrial hygiene results) and task descriptions linked to necessary OH&S considerations including personal protective equipment etc.
- → create mandatory hazard communication: how to indicate existing or potential hazards, i.e. personal protective equipment (PPE) mapping or zones
- → create stakeholder communications, i.e. employees, sub-contractors, community, NGOs, authorities and other concerned parties
- → train in OH&S: job or task specific including OH&S considerations (including inspection and testing of all safety equipment regularly) for all workers who might be exposed to AFR
- → introduction of an OH&S officer post.

6.4.3 Organization for safety and security

General requirements: some general requirements must be followed so that an organization for safety and security is functional and has enough weight in the management board:

- → The organization for safety and security is located directly under the management board
- → A risk manager, nominated by the board, leads this organization; the risk manager should be a member of management
- → The different safety and security departments are headed by safety or security officers; the tasks of the safety officer must not be a full time job, and the work load depends on the plant size; it is common that a safety officer has additional OH&S tasks in the site.

Emergency intervention group: Having an emergency intervention group is essential to take first measures against an emergency impact:

- → each site must organize an emergency intervention group, equipped and instructed (fire brigade, organization against oil and chemical impacts)
- → the quantity, the tasks and the equipment depends on the size of the site, the risks on the area of the site and the distance to the next public intervention originations (police, fire brigade, chemical intervention group, medical corps).

These units must be trained regularly, including by means of live exercises and drills, also involving if possible the response units of the public sector organizations mentioned above (police etc.). This is also true for spill response teams (see below).

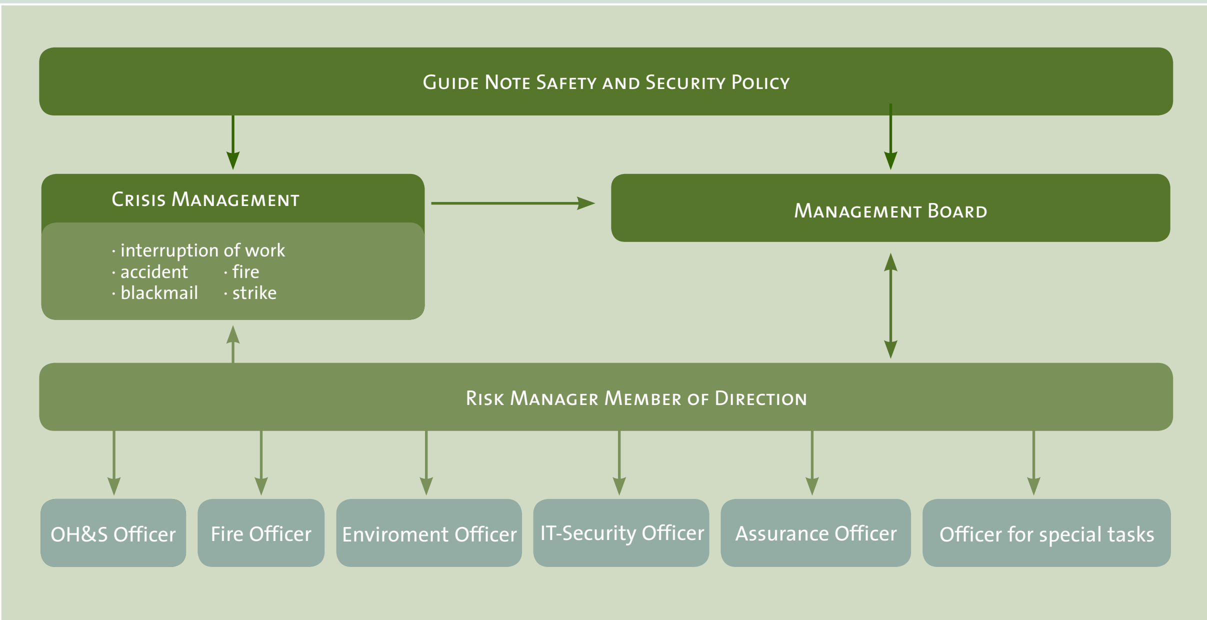


Figure 8: Example of an organizational safety and security set-up

6.4.4 Spill response plan

Each site shall develop, implement and communicate a detailed spill response plan to ensure effective and rapid containment and clean-up in the event of a spill. The spill response plan shall:

- → review and describe areas of potential spills
- → include written work instructions and procedures to be used in the event of a spill
- → assign responsibilities to plant operators and provide them with appropriate training
- → provide training and protective equipment for all plant employees (including sub-contractors) in spill prevention, spill detection, and immediate spill response procedures
- → define clean-up procedures and provide necessary resources in accordance with the characteristics of the materials
- → describe reporting and communication requirements and measures.

6.4.5 Emergency response plans

The site management must ensure that adequate emergency response procedures are in place and communicated to all plant employees, responsible authorities and other relevant stakeholders, such as communities. Emergency response plans mean contingency planning, i.e. what can be done by site staff and sub-contractors, when to alert neighboring industries for help, when to alert community emergency response, etc. Everyone working on or visiting the site must understand the site layout, potential hazards and emergency response plans.

6.5 Communication and Social Responsibility

6.5.1 Principles and requirements

Principle 18	**Openness and transparency:** → Provide all necessary information to allow stakeholders to understand the purpose of co-processing, the context, the function of parties involved and decision-making procedures. → Open discussions about good and bad experiences / practices are part of transparency.
Principle 19	**Credibility and consistency:** → Build credibility by being open, honest and consistent. Rhetoric must be matched with demonstrated facts and good performance. Gaps between what you say and what you currently do must be avoided.
Principle 20	**Cultivating a spirit of open dialogue, based on mutual respect and trust:** → Communication also means seeking feedback and dialogue with stakeholders and integrating external views. Participants in stakeholder engagement activities must be able to express their views without fear of restriction or discipline.
Principle 21	**Cultural sensitivity:** → Take into account the different cultural environments in which we operate. Be target-oriented and truthful.
Principle 22	**Continuity:** → Start early; and once you start, never stop.

6.5.2 The importance of communication

Communication and stakeholder engagement are success factors in the co-processing of waste in cement production. Some stakeholders are pleased by the "win-win" possibilities of using waste and by-products as fuels in cement kilns, while others are concerned about potential health or environmental impacts from the handling and incineration of alternative fuels. The cement industry can be a valuable and respected partner for communities in infrastructure improvements, emergency cases or social developments. This opportunity and these advantages must be communicated in an open and unselfish manner.

Guidelines, policies and regulations address these concerns on an operational and scientific level, but communication plays a crucial role in public perception.

*[→ see **Case Study 9**: Erika waste recovery – The example of Holcim support for oil tanker spill clean-up, France]*

6.5.3 A systemic approach to communications

Communication must be done in a systemic way. This means that a process must be initiated and all the relevant stakeholders and their needs and interests be taken into account to create a shared vision.

To be effective, communication should be planned as early as possible. The standard communications cycle consists of:

a. assessment of the situation
b. definition of the communication objectives
c. assignment of roles and responsibilities
d. identification of stakeholders and their communication needs
e. development of topics and messages
f. implementation of tools and activities
g. evaluation of the communication activities and review of the communication cycle.

The following explanations provide guidance on how to plan and conduct your communications activities.

Situation analysis: The identification of perceptions, expectations and needs provides the basis for all communications activities. Surveys, interviews and analysis of media coverage are the instruments to be used to identify strengths, weaknesses, opportunities and threats. The assessment may also provide information on any concerns of stakeholders. A situation analysis also helps to assess the needs of the community where a cement plant operates and to identify potential projects in the community. → ***Annex 19*** provides a step-by-step approach to carrying out a situation analysis.

Communication objectives: They need to be adapted to the local and/or national circumstances. Examples include:

Plant level

- → ensure support of your employees
- → earn the trust of neighbors and relevant stakeholders such as local NGOs and local authorities, and obtain or maintain the „license to operate".

National level

- → promote understanding of co-processing in the ce ment industry and raise awareness of its benefits
- → raise awareness of the importance of disposing of hazardous wastes in a controlled, environmentally sound manner
- → draw policy-makers' attention to the subject of hazardous waste management
- → support the development and enforcement of an appropriate regulatory framework
- → promote acceptance and support for internationally endorsed Guidelines for the co-processing of waste in the cement industry.

Roles and responsibilities: It is important to clearly assign roles and responsibilities for communications. For example, it must be clear who will be responsible for the coordination of communications, media relations, relations with authorities and crisis management.

Levels	Key stakeholders	Engagement activities
Local	Employees, community, authorities, local NGOs	Communication and community advisory panels
National	National governments, NGOs, customers	Communication, lobbying, stakeholder dialogues, memberships[12] and partnerships
Regional	EU, regional offices of international organizations	Advocacy activities
International	International government organizations (UN bodies), international NGOs, WBCSD	Communication, stakeholder dialogues, memberships and corporate partnerships

Table 6: Stakeholder classification according to different levels

Stakeholders and their communication needs: Stakeholders are people, groups, or institutions that are affected, might be affected, or might feel affected by the co-processing of waste or related activities. They have an interest in the company and its performance and can influence its activities. Stakeholders to be considered include employees, communities around cement operations and waste pre-processing facilities, authorities at different levels, NGOs, customers, suppliers, businesses and business associations, and journalists.

The communications needs of the different stakeholders vary from one group to the other. The situation analysis helps to identify these needs and the appropriate opinion leaders (people, groups, or organizations, depending on the cultural context).

Topics and messages: Topics and key messages can be extracted from these Guidelines. They must be developed for internal and external stakeholders. They should be adapted to specific needs based on the information gathered in the previous steps. Developing fact sheets on key issues and assembling a list of anticipated or frequently asked questions (FAQ) provides a basis for communications with all types of stakeholders.

Engaging with stakeholders helps to prioritize issues, reduce conflicts, and to forge alliances and shared principles. Joint ownership of difficult decisions can be another important result of stakeholder engagement activities. In return, companies must be willing to provide time and resources and commit to increased transparency.

An early start with general sustainable development messages will give you a solid foundation on which to develop specific communications activities and help create a trouble-free introduction of co-processing.

Tools: As stakeholder involvement is fundamental to maintaining a license to operate, tools for interactively engaging with stakeholders to manage and integrate their expectations are of particular importance.

12 For example, membership in an industry association or environmental organization

Communications and engagement tools should be chosen by anticipating how the targeted stakeholders can be reached most effectively.

Evaluation: Periodic evaluation of communications and stakeholder engagement activities provides information on their effectiveness. The evaluation can be conducted by media coverage, feedback from the community advisory panels or surveys. Based on the results of the evaluation, topics, messages, and tools are adapted to changing circumstances or to improve the effectiveness of communication.

Concluding remarks: The above Guidelines provide a basic framework for communications activities. For specific topics such as media relations, stakeholder relations, or crisis communications, each organization needs to implement appropriate procedures and trainings adapted to existing organizational structures and available resources. If necessary, seek support and advice from specialized agencies or partner organizations.

*[→ see **Case Study 10**: Community Advisory Panel: The example of Energis in Albox, Andalusia]*

	Information sharing	Participation/consultation and coordination	Collaboration and partnerships
Internal	→ Newsletter (print, e-mail) → Bulletin board → Intranet → Internal briefing documents → Standard presentations → FAQ fact sheets → Websites → Case studies	→ Meetings → Conference calls → Workshops → Training	
External	→ Internet → Reports, various types of publications, brochures → Advertising and sponsoring → Press information (media release, press conference) → Fact sheets → Standard presentations → FAQs → Case studies	→ Meetings → Conferences → Stakeholder dialogues → Events (open days, site visits) → Focus groups: research tool of small group discussions, generally on specific topic/ project → Community advisory panels - a key for the co-processing of waste: regular ongoing meetings with cross-section of stakeholder interests on diverse topics/ issues → Community involvement: Addressing real needs and contributing to the development of host communities. Being a good neighbor entails working with stakeholders to help improve their quality of life.	→ Partnership projects: pooling resources (e.g. business, community, NGOs, government) to achieve a common social or environmental goal.

Table 7: Categorization and overview of communication and stakeholder engagement tools





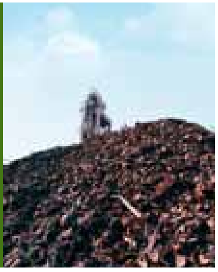

Index of Case Studies

Holcim

gtz

Case Study

Co-processing Waste Materials in Cement Production





Selection of Adequate Feed Points

The Example of Lägerdorf, Holcim Germany

Background

In the 1980's and early 1990's co-processing of waste in cement plants was not common in Germany. As one of the first plants, Holcim Germany's Lägerdorf plant started with waste oil and selected industrial waste such as diatomaceous earth and paper sludges. In 2004, the plant was co-processing a total volume of 118,000 t of alternative fuels, and 228,000 t of alternative raw materials.

Process

The Lägerdorf plant was originally equipped with two grate preheater ("Lepol") kilns. As from 1995, kiln No.11 was put into operation. This is an SP kiln with precalciner and flash dryer for the raw material that is prepared in a wet process. This kiln was especially designed for the use of AFR. A large variety of AFR with completely different material characteristics requires different feed points to be selected in the kiln system (see figure below). In Lägerdorf, examples for all types of feed points can be found.

Feed Point Selection

Sludges from the treatment of drinking water are even less polluted than the virgin raw material. Hence they can be fed without further testing, together with the natural raw materials. Fly ash from coal-fired power plants contain residues of unburned carbon and traces of mercury. In this case a compre-hensive emission assessment (including an "expulsion test" by HGRS) was carried out. It showed that feeding via the flash dryer does not cause any additional emissions, neither of organic nor of metallic origin. This was confirmed by several measurements of the stack emissions.

All other AFRs are fed directly to the "hot" part of the process where organic components would not just evaporate but be burnt completely.

Examples: Organic distillation residues from the chemical industry are considered "hazardous wastes" due to their chemical characteristics. In the calciner they are completely burned with full recovery of their considerable calorific value. Animal meal – a "high risk material" that is a perfect substitute for brown coal due to its similar calorific value and burning behavior – is also fed to the precalciner firing, the same as fuller´s earth – a soil-type residue from the food and lubrication oil industry.

The treatment of salt slags – a residue from the aluminum smelting process – provides a fine grained aluminum oxide very similar to natural clay. It is fed into the calciner as an alternative raw material where its ammonia content even contributes to the reduction of NO_x from the main flame.

Other alternative fuels such as waste oil, solvents or "fluff" – the combustible fraction of sorted municipal waste – are fed directly to the main burner of the kiln system.

Slurry storage tanks

Storage and dosing of waste

Good Practice

Prior to co-processing AFR, all candidate wastes are subject to a sophisticated preassessment procedure, consisting of:

- a pre-screening step to check compliance with internal and external requirements
- a process check to ensure compatibility with the cement kiln operations
- a plant trial with a limited quantity of waste.

All necessary measures must be taken to protect health and safety of workers and nearby residents.

Further Development

Recently the series of alternative fuels and raw materials was extended by fluffy foil and paper from municipal and commercial waste, and by shredded roof felt.

Occasionally services are rendered at the request of authorities, for example the co-processing of animal meal, or rotten or contaminated feed stuff. The incineration of confiscated cigarettes, drugs, counterfeit money or even outdated banknotes has been requested in the past. These projects are typically not attractive in most cases due to the very demanding control measures, and were finally accomplished by commercial waste incinerators available in the region.

Lessons Learnt

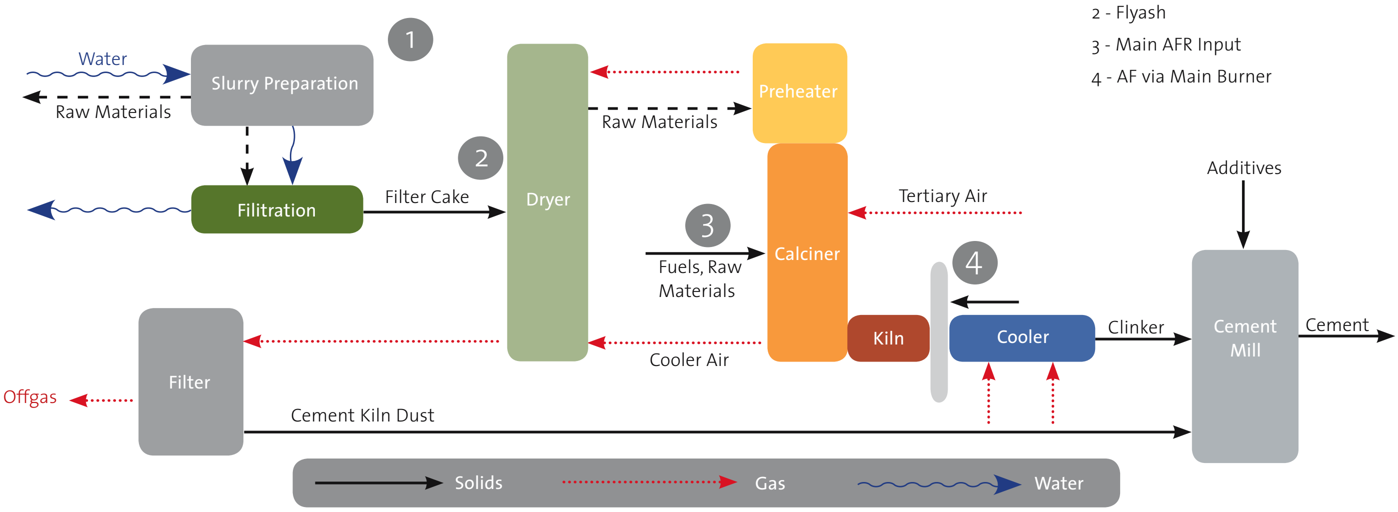
An early decision to build up a pre-processing platform would have been acceptable from today's point of view. As the situation was less favorable for such a decision then, the intensive cooperation with an external platform was the best compromise and is still well maintained. However, waste streams and waste handling can be controlled more easily and more efficiently in a wholly owned pre-processing plant.

References

www.coprocem.com
www. holcim.com/de

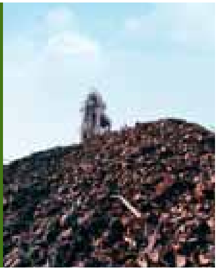
AFR Feeding Points

1 - Sludges from water processing
2 - Flyash
3 - Main AFR Input
4 - AF via Main Burner



Integrated Waste Management Concept

The Example from Cartago, Costa Rica



Background

In Costa Rica the industry is responsible for its own waste management and the common waste disposal method is landfilling. The given infrastructure is suitable for the disposal of municipal waste but not designed for hazardous wastes. Industrial waste is collected from private companies and co-disposed at landfill sites designed for municipal waste. At present the only possible way to dispose of hazardous waste in an environmental sound manner would be the export to an industrialized country for final treatment.

Process

To improve the waste management system in the district of Cartago, an integrated waste management concept has been elaborated with a clear distribution of responsibilities between the public (responsible for municipal waste) and the private sector (in charge of industrial waste). For both waste streams, programs for waste reduction (cleaner production), recycling and sound disposal have been initiated. In this context co-processing has been selected as a recovery and treatment technology first of all for industrial waste but was also considered as a solution for those leftovers from municipal waste which can't be recycled anymore or are unsuitable for the disposal at a sanitary landfill.

In 2004 Holcim Costa Rica S.A. put a new state-of-the-art cement kiln into operation with auxiliary monitoring and filtering equipment. The facility fulfils the requirements for co-processing waste material. The permit issued by the concerned authority allows for co-processing of four types of waste:

- → Used solvents (halogen free)
- → waste oil
- → waste tires and rubber scrap
- → plastics (except PVC).

Those waste materials are either obtained directly from the waste producing industry or from the public sector. Some waste categories, like used tires or pesticide containers, are collected through environmental and health programs. Such actions have been initiated by voluntary groups in cooperation with the public sector as randomly disposed waste tires provide an ideal breeding area for dengue transmitting mosquitoes. The illegal and unsound disposal of used pesticide containers causes harmful environmental impacts.

Legal Framework

Before 2004 co-processing of waste material in cement kilns was not regulated by national legislation. Holcim Costa Rica S.A. proved with test burns the ability of an environmentally sound handling and disposal of waste material in the new cement kiln. In a joint effort between the cement manufacturers and the Ministry of Health, a regulation was implemented that permits the co-processing of the above mentioned waste materials.

Future co-processing potential: PBCs from transformers

Collected waste tires

Good Practice

Co-processing at Holcim Costa Rica SA involves high-quality work throughout the supply chain. Controlling and monitoring mechanisms minimize the risk for the emission of toxic substances from the waste treatment activity. Wherever possible, waste products are obtained directly from the generating industry in order to assure a good traceability of waste. The offered services by Holcim are regulated by individual contracts, depending on the waste material and the required transportation. The waste oil is collected from the garages by some major lubricant manufacturers within their sales activities, and then delivered to Holcim.

Further Development

The existing national regulation restricts the use The existing national regulation restricts the use of the cement kiln to the co-processing of waste material with a significant calorific value only. But there is an urgent need to implement also solutions for the treatment of other hazardous wastes, including obsolete pesticides.

GTZ and Holcim Costa Rica S.A., in cooperation with other stakeholders from the public and private sector started to contribute in a joint effort to the elaboration of a new waste law that would introduce mechanisms to minimize the waste streams, and to optimize the re-use of waste material before final disposal is applied. In the new legislation co-processing will be considered as a technical option for the recovery of material and energy.

Other joint activities launched are the classification and quantification of wastes which are generated country wide and to estimate the future potential for co-processing. In order to respond to the new situation Holcim Costa Rica S.A applied for an increase in the number of types of waste to be permitted for co- processing.

Lessons Learnt.

Co-processing was seen as waste incineration with In the past, co-processing was seen as waste incineration with harmful impacts on health and the environment.

With the communication policy of Holcim S.A. Costa Rica and activities to promote co-processing in the country (e.g. participation on the national program to combat dengue fever) co-processing is now recognized as a valuable waste treatment alternative. A close and professional cooperation between the Ministry of Health, the Ministry of Environment, the local government of Cartago allowed for the integration of co-processing into a regional waste management concept. This ensured a quick start-up of local co-processing activities and it is expected that – over the long term– co-processing will be incorporated into the national waste strategy and will be applied in many more regions of the country.

References

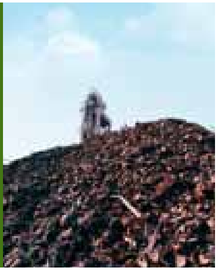
www.coprocem.com

Holcim gtz

Case Study
Co-processing Waste Materials in Cement Production

Pre-processing of Waste Material

The Example of Energis, Holcim Group, in Albox, Spain



Background

Energis was created in 1997 as a subsidiary of Holcim Spain. The purpose of the company is to add value to Holcim Spain's cement operations by providing waste management solutions to industry and communities through co-processing of waste in Holcim cement kilns. To directly access the waste market, Energis established the pre-treatment plant at Albox in 2003. The plant, located in southeastern Spain, transforms a wide range of solid, pasty, and liquid wastes into impregnated sawdust and liquid substitution fuels.

Process

Albox has two main production lines: (1) a shredding and mixing line in which solid and pasty waste is mixed with sawdust to produce impregnated sawdust and solid substitute fuel (CSS), and (2) a liquid storage and blending line for liquid substitution fuel (CSL). The lines are designed to produce 60,000 tons of CSS and 20,000 tons of CSL per year.

In July 2005 Spain introduced a law banning organic waste in landfills. This gives Albox more opportunities to find organic waste on the market.

Waste Delivery

About 90% of Albox's waste is delivered in drums, 10% is transported in bulk by tanker or container truck, and a small amount is delivered in large bags.

- → Source materials for Solid Substitute Fuel (SSF) include contaminated earth and sand; resin; paint; distillation residues; sludges of ink, glue, varnish, and oil; mastic; filter cake; grease; soap; used catalyzers; and alumina sludge, etc.
- → Source materials for Liquid Substitute Fuel (LSF) include waste oil, polluted water, and halogenated and non-halogenated solvents, etc.

Quality Assurance

Albox accepts waste from authorized producers or collectors only. To become authorized, the waste producer must submit a sample for analysis in Albox's on-site laboratory, and permit Energis representatives to visit the producer and collect information about its manufacturing process. If the producer and the waste meet Albox's requirements, Albox issues a certificate. To prevent contamination, each delivery undergoes rigorous quality control.

Good Practice

Albox does not treat wastes such as pressed drums and metal separator residues, which are sent to a foundry for recycling. Pallets are taken back by the sawdust supplier, non-polluted scrap metal is sold to a local scrap dealer, and waste that cannot be processed – such as drums that cannot be shredded – is sent to a third party for treatment. Thanks to preliminary testing, a strong external communications policy, detailed analysis and a strict refusal policy, the percentage of refused waste is low.

Energis director of quality, Isidora Diaz (left) together with Martin Berbel Granados (right) in front of the pre-processing-plant.

Sawdust

Half of the sawdust used in CSS production must be fresh, and substitutes may be mixed with the sawdust. The main impregnation substitute material is compressed cellulose. Moisture content varies significantly among deliveries and suppliers, and greatly affects the impregnation capability of sawdust. This in turn affects the percentage of sawdust required for CSS production.

Further Development

The plant's success ensures a sustainable flow of AFR to Holcim Spain, offers an innovative and practical solution to waste producers and, above all, benefits the cement industry as a whole.

Lessons Learnt

The design of Albox is similar to an earlier plant in Belgium: Scoribel. Albox profited from the many lessons learned at Scoribel. But market conditions in Spain and Belgium differ: 90% of the waste in Belgium is transported in bulk, whereas 90% of the waste in Spain is transported in drums. Each drum must be sampled as part of the quality assurance program, and properly handled and stored, which increases operational costs.

The plant faced the problem of shredder fires caused by friction between the drums, their contents and the machinery during shredding. To reduce this risk, Albox used nitrogen during the shredding operation, which increased the overall pre-processing costs. Over the past two years, Albox has got these problems under control. It has improved its sourcing of critical spare parts, and developed a special course to teach workers how to prevent shredder fires

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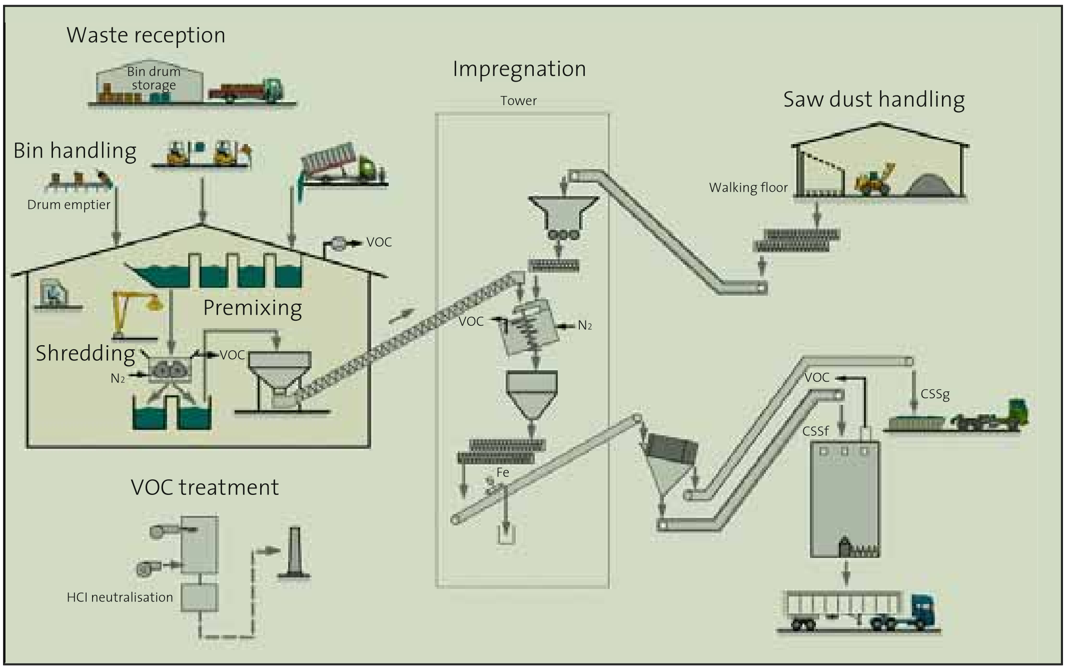
www.coprocem.com

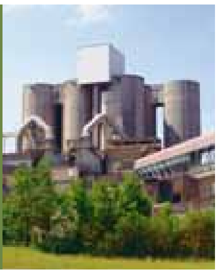


Scheme Alternative Fuel production

Case Study

Co-processing Waste Materials in Cement Production





Aspects of Permitting

The Example of North Rhine Westfalia, Germany

Background

In Germany, cement kilns are subject to authorization; their operation is governed by the requirements of the Federal Emission Control Act. This act protects against harmful effects such as air pollution and similar problems. It forms the basis of nationwide, comprehensive laws on air quality, noise abatement and plant safety. The emission limits in exhaust gas from cement plants are regulated by the Technical Instructions on Air Quality Control, and if waste fuels are used, by the Ordinance on Incineration Plants Burning Waste and Similar Substances. This ordinance is based on the EU Directive 2000/76/EC.

Permit Conditions

The key environmental issues associated with cement production in the licensing procedure are air pollution and the efficient use of energy. The application for a license must give comprehensive specifications for the operating requirements for the cement kiln to ensure safe combustion of the residues, together with a description of the necessary operational measures. The basic principle that is always applied to carcinogens as a requirement for issuing a license states that emissions are to be restricted as far as possible. In addition to maintaining low mass concentrations, it is also important to minimize the mass flows.

Application Documents

- → Topographical map
- → Constructions documents
- → Diagrammatic section of the plant, Machine site plan
- → Exposition of the plant, of the operation terms of normal working conditions
- → Description of the emission situation and prevention of pollution
- → Secondary fuels: generation, processing, quality assurance system, utilizing installation, supply
- → Air pollution emission prognosis (NO_X, SO_2, Dioxins/ Furans (PCDD/F), dust, heavy metals),
- → health and safety standards
- → energy saving measures
- → paper for public information.

Waste Information

A key parameter is the quality of the substituted fossil fuel. A small difference in the burden of pollutants between conventional fuel and waste fuel can arise. Co-processing might still be accepted by authorities who need to balance the advantages of minimizing environmental impacts of waste and fuel consumption against the impact of small increases in pollutants. To compare scenarios between "with and without waste fuel" it is advisable to define an average content of heavy metals in fossil fuels for benchmarking. It can be used for direct comparison of different types of waste fuel qualities or even serve as the basis for the development of a material specific standard. The standard could be defined as an average content of heavy metals and maximum

Pollutant	C
Total dust	30
HCl	10
HF	1
NO_x	500[1]/800[2]
Cd + Tl	0.05
Hg	0.05
Sb, As, Pb, Cr, Co, Cu, Mn,Ni, V	0.5
Dioxins and Furans	0.1
SO_2	50[3]
TOC	10[3]

Daily average 10% O_2, dry all values in mg/m^3 dioxins and furnans in ng/m^3
1) new plants
2) existing plants
3) exceptions may be authorized by the competent authority in cases where SO_2 and TOC do not result from the incineration of waste

Directive 2000/76/EC incineration of waste

Continous monitoring of emissions and operating conditions:
→ Total Dust
→ Hg
→ O_2 volume concentration
→ NO_X
→ TOC
→ CO
→ SO_2
→ exhaust volume (Nm^3/h)
→ exhaust gas temperature
→ material feed kiln inlet.

content in the high calorific waste fuel. The level of calorific value in waste fuel from manufacturing processes is 20 ± 2 MJ/kg, while the calorific value content for the high calorific part of municipal waste is fixed at 16 MJ/kg.

Monitoring Emissions

The use of various secondary fuels is always accompanied by extensive emissions measurements. A distinction is made between continuous and individual measurement. Another is made between first time- and repeat measurements, measurement for special reasons, calibrations and function tests. The measurement-relevant parameters to be considered in measurement planning derive from regulatory requirements, e.g. the operating permit, information from the technical supervisory body responsible for the plant and from on-site inspection.

Monitoring Combustion

- → The burning process has to be monitored continuously using modern process technology
- → constantly fixed inspections on arrival of waste materials
- → Liquid media are sampled continuously through trickle tubes for quality control
- → the main parameters of the waste materia must be put into the process control system on a continuous basis
- → regulations of primary energy have to follow in reliance on secondary fuel data
- → waste fuels may only be supplied during normal continuous operation.

Energy Aspects

The production of clinker is energy-intensive. Theoretically an average of 1.75 MJ of thermal energy is needed to burn 1kg clinker. The actual requirement for thermal energy in modern plants is approximately 2.9 to 3.2 MJ/kg (BREF 2001) depending on the process, up to 4 MJ/kg. Most installations use the dry process, which is the most economical in terms of energy consumption. In practice, fuels with an average net calorific value of at least $h_{u,m}$ 20 – 25 MJ/kg are normally used in a main firing system.

Lessons Learnt

Past experiences have shown that the cement industry can play an important part in the use of secondary fuels. Key factors include favorable conditions inside rotary tube kilns, optimized process and safety technology, improved exhaust gas cleaning systems and a comprehensive control of the input substances.

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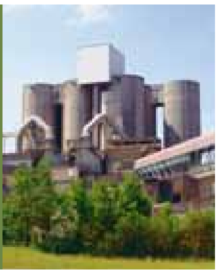
www.coprocem.com
www.bezreg-muenster.nrw.de

Stack with monitoring platform

Components (mg/m^3)	Emissions (daily average values)	Emission limits in permits in Germany (daily average values)
Dust	1-15	14-20
HCl	0,3-5	10
HF	0,1-2,0	1
SO_2	100-400	350
NO_x	300-500 (600)	500
Hg	0,005-0,03	0,03-0,05
Cd + Tl,	< 0,001	0,05
Sb, As, Pb, Cr, Co, Cu, Mn,Ni, V	< 0,002	0,05
PCDD+PCDF (TE) [ng/m^3]	0,001 - 0,01	0,05-0,1

Case Study

Co-processing Waste Materials in Cement Production



Emissions Monitoring and Reporting (EMR)

The Experiences at Holcim

Background

The Holcim company is one of the leading producers of cement worldwide. Cement production requires considerable amounts of fossil energy to fire the kilns.

According to its environmental policy, Holcim strives to conserve non-renewable resources such as raw materials and fossil fuels.

Relative to cement production, this means use of waste-derived raw materials and fuels. Holcim has started this approach in the early 1980s and today has the highest alternative fuel rate of all cement producers. It has acquired leading edge know-how in alternative fuels preparation (pre-processing) and co-processing.

In many industrialized countries alternative fuel schemes (including other industries besides cement) contribute importantly to resource conservation. They also contribute considerably to national waste management schemes. Since the cement industry is one of the early industries developing in a national economy, it can thus play an important role in the development of up-to-date national waste management schemes.

Unfortunately, many stake-holders still perceive waste management and cement production as a combination of two evils, combining perceptions of first generation garbage incinerators with the dusty cement plants of the past.

This perception is no longer valid today. Waste incinerators are built as waste-to-energy plants and include sophisticated exhaust gas cleaning equipment. Cement plants are built as modern cyclone preheater/precalciner plants with efficient dust suppression features and exhaust gas and air de-dusting equipment. Also, and in contrast to most other industries, cement plant main stack emissions (with the exception of NO_2) are not from the fuels, but from thermally volatilizable components of the raw materials, expelled (roasted off) during the heating process of these materials.

Emissions from modern cement plants are largely produced by thermally volatilizable components in raw materials. With regard to combustion gases from main and precalciner firing, the process-inherent cyclone-type raw meal preheater as well as the raw mill system act as alkaline dry scrubbers. Therefore, cement kiln emissions do not change in the function of the fuel mix, even if it includes waste-derived materials and, of course, if some expertise is used.

To prove this and to demonstrate the stable quality of cement kiln exhaust gases, but also to know the emissions from its plants, Holcim decided to develop and to implement the Holcim EMR program from 2004 in all its cement plants.

A measuring team working on a main stack in South Africa

Holcim's EMR Program

Basically it was decided that the program would include the relevant emission components defined in the EU Waste Incineration Directive (EU 76/2000/EC).

The components – dust, SO_2, NO_x, VOC, often also NH_3 and HCl, as well as O_2 and H_2O (for data evaluation purposes) – are measured continuously with most up-to-date equipment from three selected main suppliers.

Continuous emission monitoring equipment in place

The components NH_3, HCl, benzene, PCDD/ DF and 12 heavy metals are measured at least once a year by acknowledged (whenever possible) measuring institutes (test houses).

The quality of the continuous measurements is assured by the cooperation of the Holcim companies with the main equipment suppliers in the sectors of maintenance and personnel training.

Holcim's central technical services support the program by constantly updated documentation (EMR manual and 13 Guidelines) as well as by ongoing consultancy for the Group plants.

Once a year the respective spot data and yearly averages from the continuous measurements are reported to corporate level in a standardized way by means of the Plant Environmental Profile (PEP) questionnaire.

Best practice/lessons learned

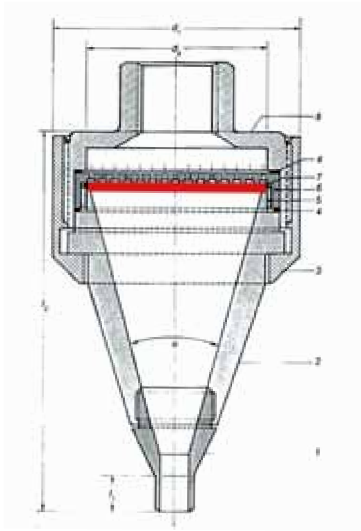
The continuous emission monitoring (CEM) equipment has reached a high technical level of accuracy and reliability. In order to achieve this standard, permanent availability of the equipment (exceeding 90%) must be ensured. This requires systematic maintenance work and, most importantly, the availability of appropriate fuels, spare parts and trained personnel both at the supplier and the cement plant end.

With regard to the once a year measurements, the recommendation has been to select a performance test house and then to stick to it, profiting from the test house's progress on the learning curve for even more reliable data.

Further development

At the end of 2005, 90% of the Holcim stacks earmarked for EMR, had been equipped with respective equipment and 90% also supplied, in most cases, complete and reasonable, data from spot measurements.

New production lines will incorporate the entire EMR infrastructure including e.g. a well designed measuring platform on the main stack from the very beginning. Newly acquired plants are given three to four years to live up to Holcim's EMR program.



Measuring head with plane filter for low dust emission rates

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gtz

Case Study

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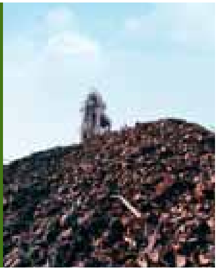


Pre-processing of Waste Material

The Example of Ecoltec, Mexico

Background

Wastes come in different forms and qualities. The transformation of waste into Alternative Fuels and Raw materials (AFR) must meet certain requirements. Some types of waste cannot be used directly as AFR. A single waste stream, in the form of a liquid or solid substitute fuel, therefore needs to be created. This step produces an AFR that complies with the technical specifications of cement production, and which guarantees that environmental standards are met.

Process

Ecoltec has facilities that process all types of waste. Agreements with the customers regulate the packaging and the collection/delivery conditions of waste materials. Transport is done in tanks or barrels or as bulk material by an external company.

Liquid waste (e.g. waste oil, solvents, etc.) is mixed and stored in tanks before being fed into the cement kiln. Solid waste (e.g. plastic packaging, chipped tires, waste textiles etc.) and sludgy waste (e.g. paint residues, distillation sludges, oil sludge, etc.) are mixed with clean sawdust and then shredded. During the sieving process, the fine, solid mix is separated fromthe coarse mix and then forwarded via conveyer belt to the storage building. The AFR is now ready to be transported by truck to the cement plant.

Quality Control

Quality control is an essential part of pre-processing activities. First, clinker production requires that the used AFR fulfils certain requirements concerning calorific value, ph-value, humidity, chlorine and sulfur content. Second, accumulation of pollutants in the cement and excessive air emissions must be avoided. Quality control takes place in the internal laboratory, where test samples of incoming waste and of AFR are held ready to be fed into the cement kiln. The test samples and records of the results of the analysis are stored for security and reference purposes. The results are are reported to the authorities on a regular basis.

Good Practice

The pre-processing activities are organized by Holcim Apasco's pre-processing subsidiary, Ecoltec. It offers complete waste disposal solutions to customers, independent of whether the waste is suitable for co-processing or not. Waste not suitable for co-processing is forwarded to companies with adequate treatment facilities. For the transport of certain wastes, plastic or steel barrels are used. The plastic barrels are shredded and used as AFR. The steel barrels are forwarded for recycling once waste is removed. The barrels are squeezed flat with a special machine before recycling.

Impregnated sawdust

Further Development

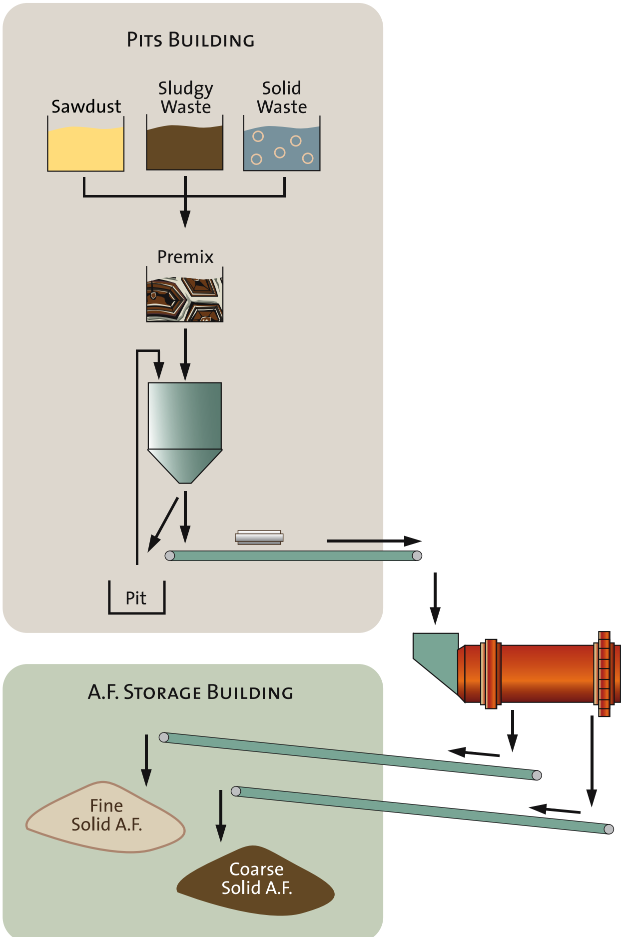
The mixing process of sludgy waste with solid waste is done in an open building. The Volatile Organic Compound (VOC) emissions from the sludge must be drawn away to protect occupational health. A monitoring program assesses environmental impacts so managers can decide if further measures are required.

VOC emissions are involved in the formation of summer smog. Common reduction techniques are nitrogen traps, biological treatment.

Lessons Learnt

The many different types of customers and the analysis of their different wastes require attention. Problems encountered in the transformation process from waste to AFR and in the clinker production due to unexpected pollutants in the waste, can be avoided by a frequent analysis of waste samples and securing the traceability of the waste from the customer to the cement kiln.

The installation and running of pre-processing facilities requires development of strong relations with local communities. Their worries and fears about the negative effects of waste treatment needed to be overcome. So Ecoltec planned a series of open days for the public that included a plant tour. Beside the general rules for pre-processing, special regulations are required for certain wastes such as persistent organic pollutants. Although not critical from a technical point of view, there remain public concerns about the formation of dioxins and furans during the combustion of POPs.



Scheme Alternative Fuel production

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www.coprocem.com

Holcim gtz

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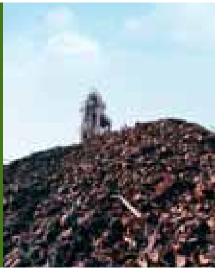



Test Burns with PCDDs/PCD Monitoring

The Philippines Examples

Background

Co-processing in the cement industry is an alternative form of waste disposal. Especially high calorific waste can be disposed of as alternative fuels in the cement kilns to replace fossil fuels. In all incineration processes, special attention must be paid to the formation of polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) as unintentional byproducts of chlorine and hydrocarbon precursors from the raw materials.

The formation of dioxins and furans is known to occur by "de novo synthesis" during cooling within the temperature range from 450 to 200°C. This can happen during the co-processing of halogenated waste in a kiln. In order to establish a better understanding of the destruction process in a kiln, a trail burn was proposed to measure the unintentional by products. The test trial was carried out in the Bulacan cement plant of the Union Cement Corporation in the Philippines in November 2004.

The Conditions

The test was done for two reasons:

- → to demonstrate that co-processing is a pragmatic and environmentally sound way to treat waste
- → to use a batch of 1,200 tons of imported pet food, with a calorific value of 4,600 MJ and chlorine content of 1.28 %. chloride. The pet food was contaminated with mould toxins.

In comparison, the chloride content of coal used in the Bulacan plant is only in the range of zero to 0.08%. The greater amount of chlorine in the pet food in the cement process increases the probability of the formation of PCDDs/PCDFs. The trial burn in the Bulacan Cement Plant complied with the Clean Air Act of the Philippines.

The Bulacan cement plant is equipped with a semi-automatic facility for co-processing solid, liquid, and sludge wastes as alternative fuels. The units consist of a big feeding hopper and a conveyer, which carries the solid waste directly to the riser duct below the inline calciner (ILC). From there the waste materials are introduced into the kiln on the secondary side.

The Test Trial

All criteria for the test trial for measuring PCDDs/PCDFs emissions in the stack gas has been worked out and defined in a test protocol. According to this protocol, the test trial must be in compliance with international regulations and procedures, like the "US-EPA Codes of the Federal Regulations (CFR) 40" and the "EU Directive 2000/76 EC on the incineration of waste". The trial included three test runs with the following parameters:

- → A blanc test run (without pet food), second test run with a feeding rate of 1.75 tons pet food/hour and a third test run with a feeding rate of 3.5 tons pet food/hour

Stack with the monitoring platform and the adjustment of the probe into the kiln

- → The cement kiln did run in the "Compound mode (the normal working conditions)"
- → The sampling time of the stack gas took 6-8 hours per run. The stack gas sampling started only after all process parameters of the cement kiln were stable
- → All standard operating and emission parameters were monitored continuously
- → The trail burn and the testing were carried out on three following days.

For the performance of the stack gas sampling and analysis to get reliable results the following qualified test methods of the U.S. Environmental Protection Agency US-EAP Methods 1, 2, 3A, 4, 5, and 23 as well as the European Standard EN 1948-2 were used. The stack gas was collected with a special probe on the stack sampling platform of the cement kiln. The PCDDs/PCDFs were collected in a combined condenser with a XAD-2 resin absorbent trap. In a specialized laboratory in Australia the PCDDs/PCDFs were analyzed by using a high resolution gas chromatography/mass spectrometer in accordance with US-EPA Method 1613A.

The test results of the stack samples of this trial were all below 0.1 ng TEQ/Sm^3, which is the limit value in the European legislation for hazardous waste incineration plants (Council Directive 2000/76/ EC). The results reveal clearly that the co-processing of the pet food has no effect on the emissions.

Lessons Learnt

Before the start of the co-processing, it is important to study the chemical structure and the decomposition process of the waste under the conditions of cement kilns.

Depending on the outcome of the evaluation, a trail should be carried out to evaluate the emissions in the stack gas of the cement plant as well as to calculate the risks for the environment.

Co-processing is playing a more and more a significant role in waste management in developing countries. Test trails are an important tool to get information about the expected emissions and the behavior of the waste during the destruction process.

Good practice

The decision to start co-processing waste and to carry out a test depends on the chemical composition as well as the quantity of the waste. The relevant national agency should be involved in the planning process in a very early stage. Cement plants should execute co-processing and test trails only if they are able to abide by the national emission standards.

The semi-automatic co-processing facility for solid waste

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www.coprocem.com | www.gtz.de/chs

Holcim gtz

Case Study
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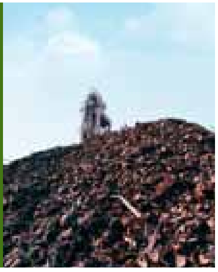

AFR Quality Control Laboratory

The Example of Resotec, Brazil

Background

Resotec, a division of Holcim (Brasil) S/A, operates two waste pre-processing facilities close to its Pedro Leopoldo and Cantagalo cement plants. Each facility has an installed capacity of about 120,000 tons per year.

In order to qualify candidate waste streams for both pre-processing and co-processing in the cement kilns, Resotec has established detailed quality control plans at each plant. The control plans are based on protocols that include administrative procedures, sampling strategies, and analytical test programs for wastes shipped to the facilities and finally for processed waste streams to be fed to the cement kilns. Specialized AFR laboratories are an essential part of Resotec's waste management strategy.

Process

At Pedro Leopoldo, a large variety of wastes is co-processed in the kilns, including waste oils, solvents, industrial sludges, and impregnated solids (plastics, textiles etc.).

Pedro Leopoldo runs a modern AFR laboratory at its pre-processing site with five trained chemists and laboratory assistants. Between 200 and 300 analyses are carried out every month on average. The major tasks of the laboratory include:

- Physical and chemical characterization of incoming wastes and outgoing AFR
- Control of legal aspects and internal technical specifications (i.e. comparison against permit-specifications and internal requirements)
- Environmental monitoring and analysis of waste water, soil or stack emission
- Environmental control (i.e. heavy metals analyses) of products of the cement plant (clinker, cement, filter dust).

The laboratory equipment comprises a comprehensive set of state-of-the-art analytical instruments such as ICP spectrometer (for heavy metals analyses), gas chromatograph (for organics, PCBs), calorimeter (calorific value), sulfur and chlorine analyzers, flash point meter, viscosimeter and others. The total of about USD 500,000 was invested in this analytical equipment.

Zero Head Space Extractor for the Determination of Volatile Components

Service Brochure of Resotec AFR Laboratory Components

Good Practice

All laboratory assistants receive training in complying with the facility's stringent requirements with regard to analytical performance and health and safety in the workplace.

The pre-processing facility including the AFR laboratory has obtained certification against the international standards ISO 9001 (quality management) and ISO 14001 (environmental management). In the framework of these certifications the laboratory has developed a series of standard operating procedures for all tests applied.

The AFR laboratory participates in various national and international interlaboratory proficiency tests in order to verify and improve its analytical capabilities and in order to increase the confidence of their clients.

Further Development

The AFR laboratory has started to offer its services to third parties on the market. The revenues from these external services have reduced the operating costs of the laboratory significantly.

Lessons Learnt

The chemical and physical characterization of highly variable waste streams is an extremely demanding task both with regard to professional skills of laboratory personnel and to selection of analytical equipment and infrastructure.

Standardized test procedures have to be adapted frequently to the specific characteristics of a waste stream. Obtaining representative samples of wastes delivered in different types of packaging, e.g. drums, or out of a load of very heterogeneous materials, requires a sophisticated sampling strategy. A brochure has been published by Resotec describing the services and capabilities of their AFR laboratories.

Unidade Pedro Leopoldo

ICP Spectrometer for the Determination of Heavy Metals

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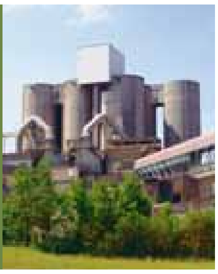
www.coprocem.com
www.resotec.com.br

Holcim gtz

Case Study

Co-processing Waste Materials in Cement Production



Erika Waste Recovery

The Example of Holcim Support for Oil Tanker Spill Clean-up, France

Background

Environmental disaster struck in December 1999 when the oil tanker Erika was wrecked off the coast of France, spilling thousands of tons of oil that washed ashore on the fragile beaches of Brittany.

Clean-up was hampered by rough weather, and 19,000 tons of oil produced over 300,000 tons of waste. The responsible tanker operator wanted to find a way to recycle the waste as a material or energy source.

Process

Holcim France Benelux was engaged to help dispose of some of the recovered waste by co-processing the sludge as alternative fuels and raw materials (AFR) in our cement kilns. But before the contract was awarded, a rigorous review was conducted and our technology carefully examined in action.

The BEMTI (Boues d'Epuration Mixtes Traitées Industriellement) process set up at the Holcim Obourg plant in 1998 is unique in the cement sector and is used for the recovery of chiefly mineral residues.

Trials were also carried out at the Rochefort cement plant, where a pyrolysis kiln is used for preprocessing, before the recovery of mineral waste containing organic components (hydrocarbons).

Once the trials were successfully completed, the first waste shipment arrived at Obourg in January 2003. In all, more than 20,000 tons of pretreated sludge (limed and pressed) were fed into the kiln lines of Holcim France-Benelux.

Good Practice

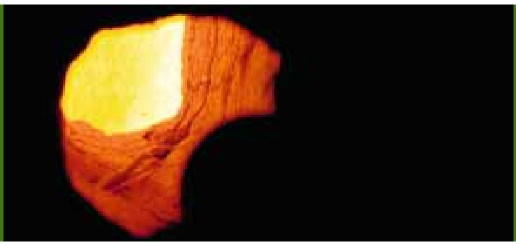
The expertise that Holcim's AFR team had acquired over more than 15 years in the field was key to winning the contract.

The dedication and hard work of Holcim specialists was more than matched by the Group's technology. Holcim has an established program of sharing knowledge and multiplying good practices across its global operations.

Further Development

It is clear that our AFR solutions enable the Group to respond to growing demands from industry and local authorities for waste treatment across an ever-widening range of applications.

Respect for the environmental and a commitment to sustainable development underpin Holcim know-how, while the Group's AFR policy provides strong and responsible principles to guide behavior.



Feeding the sludge into the kilns.

Lessons Learnt

Demonstrating the Group's ability to contribute to difficult waste recovery solutions builds Holcim's own experience and expertise while growing our reputation as a responsible service provider.

Now that Holcim has gained this know-how, demonstrating it so convincingly in this example, the Group is in an excellent position to offer this solution for similar environmental disasters if and when they arise.

More than 20,000 tons of pretreated sludge (limed and pressed) were fed into the kiln lines of Holcim France-Benelux.

19,000 tons of spilled oil produced more than 300,000 tons of waste.

References

www.coprocem.com
www.holcim.com/sustainable

Holcim gtz

Case Study

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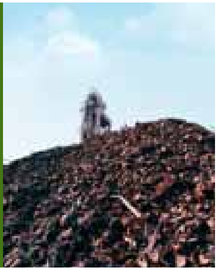


Community Advisory Panels

The Example of Energis in Albox, Spain

Background

In 2003, Holcim Spain opened the waste pre-treatment platform of its AFR subsidiary Energis in Albox, Andalusia.

Running a new industrial activity in town, local management recognized the value of stakeholder engagement and dialogue with the community, decided to establish a community advisory panel (CAP) from the beginning.

Holcim actively encourages all operational sites to engage with stakeholders and has developed Guideline recommendations and a process model to assist local management in their engagement activities.

Process

The objective of the CAP is to inform and involve all relevant stakeholders regarding plant operations, through active and direct dialogue. Stakeholders invited to join the group included the mayor of Albox, other local authorities, representatives of environmental and community groups, and Energis management.

The CAP sees its role as being an active company-community mediator. This extends to the development of an external coordination plan in the event of an accident, where CAP members have defined roles and follow public alert protocols.

Activities

Management saw the need to open the plant's doors to the community, giving it an opportunity to see and hear first-hand about plant operations. On November 4, 2005, more than 100 guests toured the facilities. Of particular interest were areas of the plant where waste is collected and classified as well as the company laboratories where waste samples are analyzed prior to their acceptance.

Stakeholder Voices

As a representative of the center for environmental studies for the Almanzora River and a member of the NGO "Ecologistas en Accion", Martin Berbel Granados has also taken the role of secretary for the CAP in Albox.

"The Albox CAP is an important tool for 'greening' the town through educational projects," he said. "To ensure transparency, we will develop Guidelines for its operation, a website disclosing its activities, and will invite a health expert to join."

Good Practice

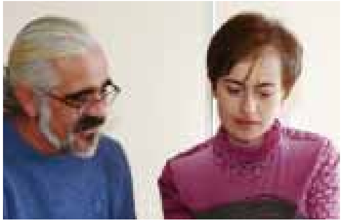
Holcim has an established program of sharing knowledge and multiplying good practices across its global operations. Experiences with AFR stakeholder engagement in other locations have informed the Albox CAP's priorities of safety and environmental performance.

Further Development

Following more than a year of operations, an assessment was undertaken seeking the input of both plant employees and panel members. Results of the review indicated that the CAP's role was well perceived.

Yet there was potential for improvement, notably to differentiate the plant from its immediate neighbor, a landfill, as well as to communicate more about CAP activities and the value they have brought to the community.

There was also a request to focus corporate social responsibility activities on educational priorities, including environmental, waste and recycling issues.



Energis director of quality, Isidora Diaz (right), meets the CAP secretary Martin Berbel Granados (left). Granados believes the CAP is an important tool for 'greening' the town.

Lessons Learnt

Of highest priority to the community was assurance about plant safety as well as the AFR process itself. During 2004-2005, three accident simulations were undertaken, involving plant employees and local emergency services.

As a result, recommendations to improve the plant's emergency response were made, thus alleviating community concerns.

In a spirit of transparency, the CAP has promoted public access to all company documents relevant to safety and environment. These are available from the Town Hall and include impact assessments, emissions data, safety reports and hazardous waste declarations.

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www.holcim.com/sustainable

Index of Annexes

Annex 1: Bibliography, Literature and Internet Links

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Annex 1: Bibliography, Literature and Internet Links

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Japan Cement Association, 2005
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http://www.swissi.ch

Annex 2: Waste used for AFR in Europe and Japan

Table 2.1: Utilization of alternative Fuels in the European Cement Industry (2002)

Alternative fuels	Quantity in kT/y	Energy in TJ	Substitution rate
Animal meal & bone meal & animal fat	760	15'000	2.0%
Tires	500	13'200	1.8%
Other hazardous	360	6'500	0.9%
Plastic	210	5'000	0.7%
Paper/ cardboards/ wood/ PAS	180	2'800	0.4%
Impregnated sawdust	165	1'900	0.3%
Coal slurries/ distillation residues	110	1'650	0.2%
Sludge (paper fiber, sewage)	100	970	0.1%
Fine/ anodes/ chemical cokes	90	1'600	0.2%
RDF	40	530	0.1%
Shale/ oil shale	15	130	<0.1%
Packaging waste	12	260	<0.1%
Agricultural & organic wastes	10	170	<0.1%
Other non hazardous	730	14'100	1.9%
Subtotal solid fuels (75%)	3'282	63'810	8.5%
Waste oil and oiled water	380	13'500	1.8%
Solvents and others	260	3'900	0.5%
Other hazardous liquid fuels	170	4'300	0.6%
Subtotal liquid fuels (25%)	810	21'700	2.9%
Total	**4'092**	**85'510**	**11.4%**

Annex 2: Waste used for AFR in Europe and Japan

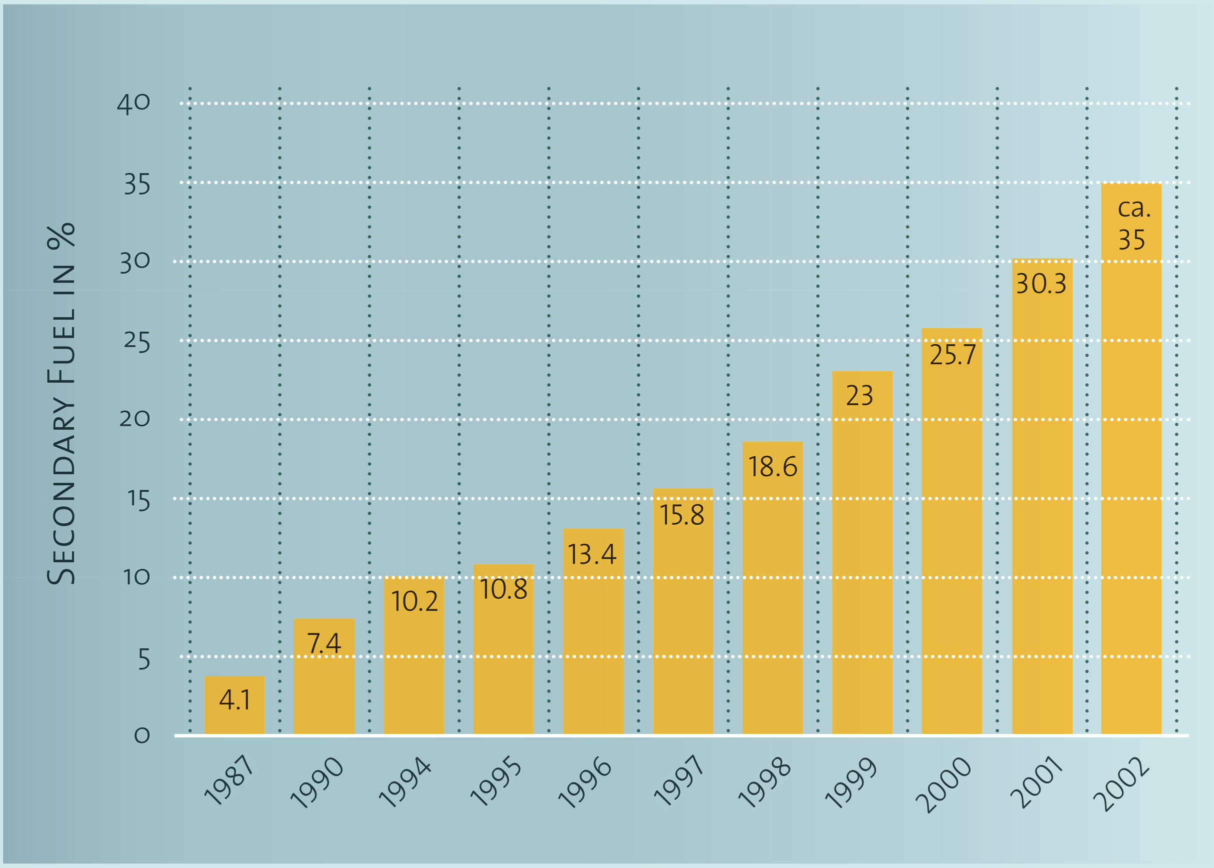
Table 2.2: Utilization of alternative raw material in the European cement industry (2002)

Alternative raw materials		Quantity in kT/y	Substitution rate
Silicon (Si)	Foundry sand	131	2.2%
	Sand	93	1.6%
Calcium (Ca)	Ca-sources	396	6.7%
	Waste limestone	438	7.4%
Iron (Fe)	Fe-containing material	699	11.8%
	Blastfurnace & converter slag	215	3.6%
	Pyrite ash	438	7.4%
Aluminum (Al)	Al-containing materials	150	2.5%
	Industrial sludge	137	2.3%
Si – Al - Ca	Other Si-Al-Ca containing material	247	4.2%
	Fly ash	1140	19.3%
	Others	1823	30.8%
	Total	**5907**	

Table 2.3: Utilization of alternative fuels in the Japanese cement industry (2001)

Type of waste	Use at cement plant	Weight ('000 ton)
Blast Furnace	Raw Material, Mixing Material	11,915
Coal Ash	Raw Material, Mixing Material	5,822
By-product Gypsum	Raw Material(Additive)	2,568
Low Quality Coal from Mine	Raw Material, Fuel	574
Non-iron Slag	Raw Material	1,236
Revolving Furnace Slag	Raw Material	935
Sludge etc.	Raw Material, Fuel	2,235
Soot & Dust	Raw Material, Fuel	943
Molding Sand	Raw Material	492
Used Tires	Fuel	284
Waste Oils	Fuel	353
Spent Activated Clay	Fuel	82
Waste Plastics	Fuel	171
Others	Raw Material, Fuel	450
Total		**28,061**

Annex 3: Development of the Utilization of alternative Fuels in the German Cement Industry



Source: VDZ, 2003

Annex 4: Sources for Contacts and Information

Organizations offering assistance and contacts for capacity building
in the field of co-processing and environmental monitoring

Name	Address	Contact person	Field of competence
CEMBUREAU	Rue d'Arlon 55 1040 Brussels Belgium-1040 Phone: +32-(0) 2 234 10 11 technical@cembureau.be		All about cement production
FHNW	University for Applied Sciences Northwestern Switzerland Institute for Ecopreneurship St. Jakobs-Strasse 84 4132 Muttenz, Switzerland Phone: +41-(0) 61 467 45 68 dieter.mutz@coprcem.com	Dr. Dieter Mutz	Training & Capacity building
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (GTZ) Convention Project Chemical Safety PO Box 5180 65726 Eschborn, Germany www.gtz.de/chs	Wolfgang Schimpf	Chemical substances
RP-NRW	Bezirksregierung Münster Domplatz 1-3 48128 Münster, Germany Phone: + 49-(0) 251 411 1550 richard.bolwerk@bezreg-muen-ster.nrw.de	Richard Bolwerk (Dipl. Ing)	Environment. AFR, Legal Aspects
SINTEF	P.O Box 124 Bindern, NO-0314 Oslo, Norway +47-(0) 22 06 73 00 khk@sintef.no	Research Director Kåre Helge Karstensen	Co-Processing of Hazardous Wastes, Obsolete pesticides and POPs Environment
UBA	Umweltbundesamt Postfach 33 00 22 14191 Berlin, Germany Phone: +49-(0) 8903 3075 silke.karcher@uba.de	Dr. Silke Karcher Dr. Bernicke Steffi Richter	Mineral industry Cement industry POP

Name	Address	Contact person	Field of competence
VDZ	Verein Deutscher Zementwerke e.V. Forschungsinstitut der Zementindustrie Tannenstr. 2 40476 Düsseldorf, Germany Phone: +49-(0) 211 45 78 1 info@vdz-online.de		All about cement production
WBCSD	World Business Council for Sustainable Development 4, chemin de Conches 1231 Conches-Geneva Switzerland Phone: +41-(0) 22 8 39 31 00 info@wbcsd.org		Sustainable Development, Networking

Annex 5: List of Waste Material suited for co-processing[13]

A. Industrial Wastes

1. 0 Organic Chemical Wastes | 1.1 Mineral oils, synthetic oils and fats

05 01 00	**oil sludges and solid wastes**
05 01 01	sludges from on-site effluent treatment
05 01 03	tank bottom sludges
12 01 00	**wastes from shaping (including forging, welding, pressing, drawing, turning, cutting and filing)**
12 01 06	waste machining oils containing halogens (not emulsioned)
12 01 07	waste machining oils free of halogens (not emulsioned)
12 01 08	waste machining emulsions containing halogens
12 01 09	waste machining emulsions free of halogens
12 01 10	synthetic machining oils
13 01 00	**waste hydraulic oils and brake fluids**
13 01 01	hydraulic oils, containing PCBs or PCTs
13 01 02	other chlorinated hydraulic oils (not emulsions)
13 01 03	non-chlorinated hydraulic oils (not emulsions)
13 01 04	chlorinated emulsions
13 01 05	non-chlorinated emulsions
13 01 06	hydraulic oils containing only mineral oil
13 01 07	other hydraulic oils
13 02 00	**waste engine, gear and lubricating oils**
13 02 01	chlorinated engine, gear and lubricating oils
13 02 02	non-chlorinated engine, gear and lubricating oils
13 02 03	other engine, gear and lubricating oils
13 03 00	**waste insulating and heat transmission oils and other liquids**
13 03 01	insulating or heat transmission oils and other liquids containing PCBs (chlorinated waste and PCB are subject to legal limitations, maximum concentration in input and maximum T/year allowed)
13 03 02	other chlorinated insulating and heat transmission oils and other liquids
13 03 03	non-chlorinated insulating and heat transmission oils and other liquids
13 03 04	synthetic insulating and heat transmission oils and other liquids
13 03 05	mineral insulating and heat transmission oils and other liquids
13 04 00	**bilge oils**
13 04 01	bilge oils from inland navigation
13 04 02	bilge oils from jetty sewers
13 04 03	bilge oils from other navigation

13 This list is derived from the European Waste Catalogue but is not an exclusive and compulsory document. It gives a general overview of possible wastes to be used as AFR in cement kilns.

13 05 00	**oil/water separator contents**
13 05 02	oil/water separator sludges
13 05 03	interceptor sludges
13 05 04	desalter sludges or emulsions
13 05 05	other emulsions
13 06 00	**oil waste not otherwise specified**
13 06 01	oil waste not otherwise specified

1. 0 Organic Chemical Wastes | 1.2. Petrochemical wastes

05 01 00	**oil sludges and solid wastes**
05 01 01	sludges from on-site effluent treatment
05 01 02	desalter sludges
05 01 03	tank bottom sludges
05 01 04	acid alkyl sludges
05 01 05	oil spills
05 01 06	sludges from plant, equipment and maintenance operations
05 01 99	wastes not otherwise specified
05 05 00	**oil desulphurisation waste**
05 05 01	waste containing sulphur
05 06 00	**waste from the pyrolytic treatment of coal**
05 06 01	acid tars
05 06 03	other tars
05 06 04	waste from cooling columns

1. 0 Organic Chemical Wastes | 1.3 Solvents, paints, varnishes, glues (adhesive, sealants), organic rubbers

07 03 00	**waste for the MFSU of organic dyes and pigments (excluding 06 11 00)**
07 03 01	aqueous washing liquids and mother liquors
07 03 02	sludges from on-site effluent treatment
07 03 03	organic halogenated solvents, washing liquids and mother liquors
07 03 04	other organic solvents, washing liquids and mother liquors
07 03 07	halogenated still bottoms and reaction residues
07 03 09	halogenated filter cakes, spent absorbents
08 01 00	**wastes from the MFSU of paint and varnish**
08 01 01	waste paints and varnish containing halogenated solvents
08 01 02	waste paints and varnish free of halogenated solvents
08 01 03	waste from water-based paints and varnishes

Annex 5: List of Waste Material suited for co-processing

08 01 06	**sludges from paint and varnish removal containing halogenated solvents**
08 01 07	sludges from paint and varnish removal free of halogenated solvents
08 01 08	aqueous sludges containing paint or varnish
08 01 09	wastes from paint or varnish (except 08 01 05 and 08 01 06)
08 01 99	wastes not otherwise specified
08 03 00	**wastes from the MFSU of printing inks**
08 03 01	waste ink containing halogenated solvents
08 03 02	waste ink free of halogenated solvents
08 04 00	**wastes from the MFSU of adhesives and sealants (including waterproofing products)**
08 04 01	waste adhesive and sealants containing halogenated solvents
08 04 02	waste adhesive and sealants free of halogenated solvents
08 04 03	waste from water-based adhesive and sealants
08 04 05	adhesive and sealants sludges containing halogenated solvents
08 04 06	adhesive and sealants sludges free of halogenated solvents
08 04 07	aqueous sludges containing adhesive and sealants
08 04 08	aqueous liquid waste containing adhesive and sealants
14 05 00	**wastes from solvent and coolant recovery (still bottoms)**
14 05 01	chlorofluorocarbons
14 05 02	other halogenated solvents and solvent mixes
14 05 03	other solvents and solvent mixes
14 05 04	sludges containing halogenated solvents
14 05 05	sludges containing other solvents

1. 0 Organic Chemical Wastes | 1.4 Wastes from synthetic materials and rubbers

07 02 00	**waste for the MFSU of plastics, synthetic rubber and man-made fibres**
07 02 01	aqueous washing liquids and mother liquors
07 02 02	sludges from on-site effluent treatment
07 02 03	organic halogenated solvents, washing liquids and mother liquors
07 02 04	other organic solvents, washing liquids and mother liquors
07 02 07	halogenated still bottoms and reaction residues
07 02 08	other still bottoms and reaction residues

2. 0 Other Chemical Wastes

03 02 00	**wood preservation waste**
03 02 01	non-halogenated organic wood preservatives
03 02 02	organochlorinated wood preservatives
03 03 00	**wastes from pulp, paper and cardboard production and processing**
03 03 05	de-inking sludges from paper recycling
03 03 06	fiber and paper sludge
04 01 00	**wastes from the leather industry**
04 01 03	degreasing wastes containing solvents without a liquor phase
04 02 00	**wastes from textile industry**
04 02 11	halogenated waste from dressing and finishing
04 02 13	dye stuffs and pigments
07 01 00	**waste from the manufacture, formulation, supply and use (MFSU) of basic organic chemicals**
07 01 01	aqueous washing liquids and mother liquors
07 01 02	sludges from on-site effluent treatment
07 01 03	organic halogenated solvents, washing liquids and mother liquors
07 01 04	other organic solvents, washing liquids and mother liquors
07 01 07	halogenated still bottoms and reaction residues
07 01 08	other still bottoms and reaction residues
07 04 00	**waste for the MFSU of organic pesticides**
07 04 01	aqueous washing liquids and mother liquors
07 04 02	sludges from on-site effluent treatment
07 04 03	organic halogenated solvents, washing liquids and mother liquors
07 04 04	other organic solvents, washing liquids and mother liquors
07 04 07	halogenated still bottoms and reaction residues
07 04 08	other still bottoms and reaction residues
07 05 00	**waste for the MFSU of pharmaceuticals**
07 05 01	aqueous washing liquids and mother liquors
07 05 02	sludges from on-site effluent treatment
07 05 03	organic halogenated solvents, washing liquids and mother liquors
07 05 04	other organic solvents, washing liquids and mother liquors
07 05 07	halogenated still bottoms and reaction residues
07 05 08	other still bottoms and reaction residues

Annex 5: List of Waste Material suited for co-processing

07 06 00	**waste for the MFSU of fats, grease, soaps, detergents, disinfectants and cosmetics**
07 06 01	aqueous washing liquids and mother liquors
07 06 02	sludges from on-site effluent treatment
07 06 03	organic halogenated solvents, washing liquids and mother liquors
07 06 04	other organic solvents, washing liquids and mother liquors
07 06 07	halogenated still bottoms and reaction residues
07 06 08	other still bottoms and reaction residues
07 07 00	**waste for the MFSU of fine chemical products not otherwise specified**
07 07 01	aqueous washing liquids and mother liquors
07 07 02	sludges from on-site effluent treatment
07 07 03	organic halogenated solvents, washing liquids and mother liquors
07 07 04	other organic solvents, washing liquids and mother liquors
07 07 07	halogenated still bottoms and reaction residues
07 07 08	other still bottoms and reaction residues
08 03 00	**wastes from the MFSU of printing inks**
08 03 03	waste from water-based inks
08 03 05	ink sludges containing halogenated solvents
08 03 06	ink sludges free of halogenated solvents
08 03 07	aqueous sludges containing ink
08 03 08	aqueous liquid waste containing ink
08 03 99	wastes not otherwise specified
09 01 00	**wastes from the photographic industries**
09 01 01	water based developer and activator solutions
09 01 02	water based offset plate developer solutions
09 01 03	solvent based developer solutions
09 01 04	fixer solution
09 01 05	bleach solutions and bleach fixer solutions
10 03 00	**wastes from aluminum thermal metallurgy**
10 03 01	tars and other carbon-containing wastes from anode manufacture
14 01 00	**waste from metal degreasing and machinery maintenance**
14 01 01	chlorofluorocarbons
14 01 02	other halogenated solvents and solvent mixes
14 01 03	other solvents and solvent mixes
14 01 04	aqueous solvent mixes containing halogens
14 01 05	aqueous solvent mixes free of halogens
14 01 06	sludges and solid wastes containing halogenated solvents
14 01 07	sludges and solid wastes free of halogenated solvents

14 02 00	**wastes from textile cleaning and degreasing of natural products**
14 02 01	halogenated solvents and solvent mixes
14 02 02	solvent mixes or organic liquids free of halogenated solvents
14 02 03	sludges and solid wastes containing halogenated solvents
14 02 04	sludges and solid wastes containing other solvents
14 03 00	**wastes from the electronic industry**
14 03 01	chlorofluorocarbons
14 03 02	other halogenated solvents and solvent mixes
14 03 03	other solvents and solvent mixes
14 03 04	sludges and solid wastes containing halogenated solvents
14 03 05	sludges and solid wastes containing other solvents
14 04 00	**wastes from coolants, foam/aerosols propellants**
14 04 01	chlorofluorocarbons
14 04 02	other halogenated solvents and solvent mixes
14 04 03	other solvents and solvent mixes
14 04 04	sludges and solid wastes containing halogenated solvents
14 04 05	sludges and solid wastes containing other solvents
16 03 00	**off-specification batches**
16 03 02	organic off-specification batches
16 05 00	**chemicals and gases in containers**
16 05 03	other wastes containing organic chemicals, e.g. lab chemicals not otherwise specified
17 03 00	**asphalt, tar and tarred products**
17 03 03	tar and tar products
18 02 00	**waste from research, diagnosis, prevention of diseases involving animals**
18 02 04	discarded chemicals

Annex 5: List of Waste Material suited for co-processing

B. Wastes of Animal and Vegetal Origin

(except municipal, textile, agricultural and hospital wastes)

1.0 Fats and oils from animal and vegetal origin

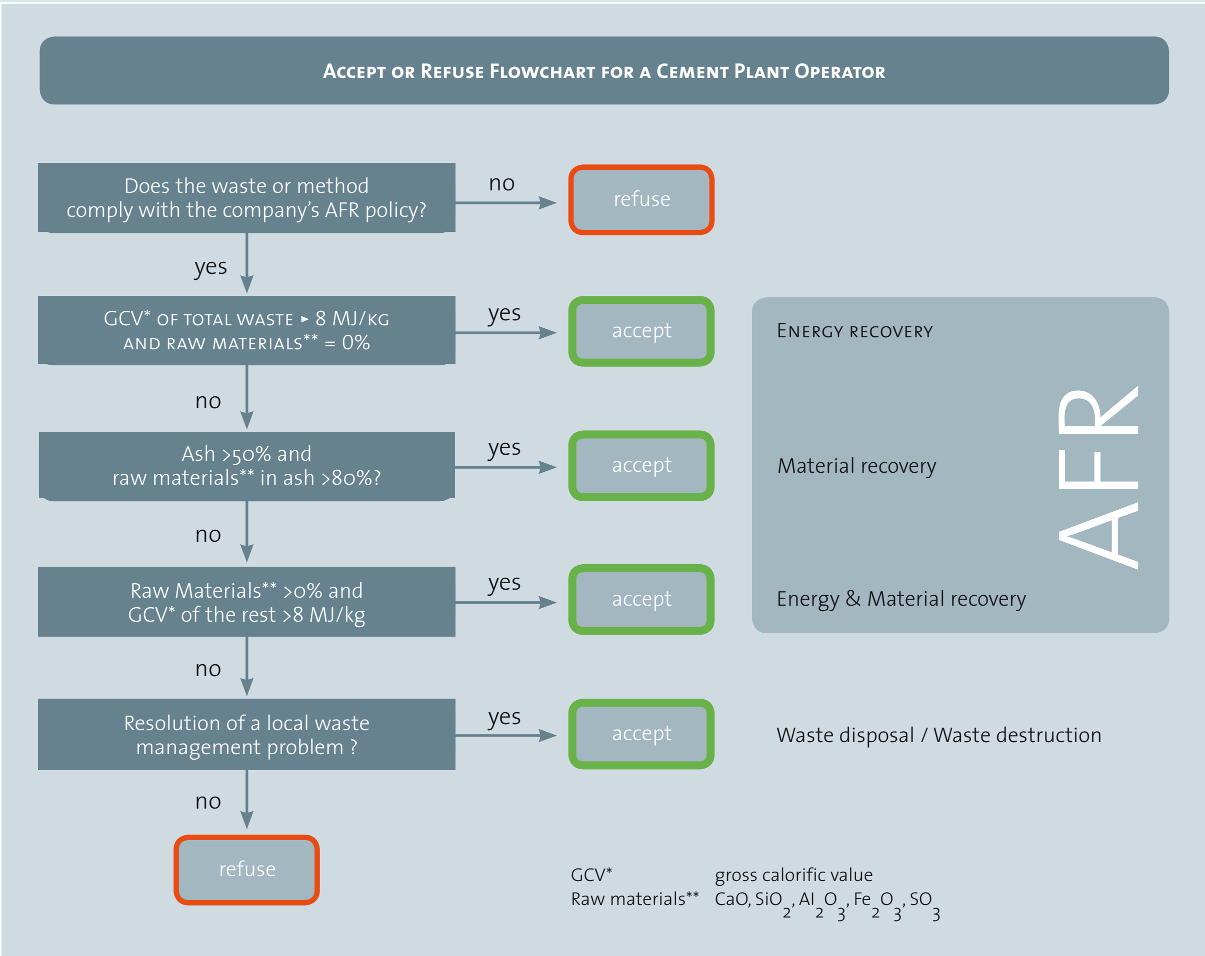
02 01 00	**primary production waste**
02 01 01	sludges from washing and cleaning
02 01 06	animal feces, urine and manure (including spoiled straw), effluent, collected separately and treated off-site
02 02 00	**wastes from the preparation and processing of meat, fish and other foods of animal origin**
02 02 01	sludges from washing and cleaning
02 02 03	materials unsuitable for consumption or processing
02 02 04	sludges from on-site effluent treatment
02 03 00	**wastes from fruit, vegetables, cereals, edible oils, cocoa, coffee and tobacco preparation, processing; conserve production; tobacco processing**
02 03 01	sludges from washing, cleaning, peeling, centrifuging and separation
02 03 02	wastes from preserving agents
02 03 03	wastes from solvent extraction
02 03 04	materials unsuitable for consumption or processing
02 03 05	sludges from on-site effluent treatment
02 04 00	**wastes from sugar processing**
02 04 03	sludges from on-site effluent treatment
02 05 00	**wastes from dairy products industry**
02 05 01	materials unsuitable for consumption or processing
02 05 02	sludges from on-site effluent treatment
02 06 00	**wastes from backing and confectionery industry**
02 06 02	wastes from preserving agents
02 06 03	sludges from on-site effluent treatment
02 07 00	**wastes from the production of alcoholic and non-alcoholic beverages (excluding coffee, tea and cocoa)**
02 07 01	wastes from washing, cleaning and mechanical reduction of the raw material
02 07 02	wastes from spirits distillation
02 07 03	wastes from chemical treatment
02 07 04	materials unsuitable for consumption or processing
02 07 05	sludges from on-site effluent treatment

C. Other Wastes

1.0 Disposed, sorted and/or stocked wastes from a waste treatment facility

05 08 00	**waste from oil regeneration**
05 08 02	acid tars
05 08 03	other tars
05 08 04	aqueous liquid waste from oil regeneration
14 05 00	**wastes from solvent and coolant recovery (still bottoms)**
14 05 01	chlorofluorocarbons
14 05 02	other halogenated solvents and solvent mixtures
14 05 03	other solvents and solvent mixtures
14 05 04	sludge containing halogenated solvents
14 05 05	sludge containing other solvents
16 07 00	**waste from transport and storage tank cleaning (except 05 00 00 & 12 00 00)**
16 07 01	wastes from marine transport tank cleaning, containing chemicals
16 07 02	wastes from marine transport tank cleaning, containing oil
16 07 02	wastes from marine transport tank cleaning, containing oil
16 07 03	wastes from railway and road transport tank cleaning, containing oil
16 07 04	wastes from railway and road transport tank cleaning, containing chemicals
16 07 05	wastes from storage tank cleaning, containing chemicals
16 07 06	wastes from storage tank cleaning, containing oil
	Wastes from drums and tanks treatment facility, contaminated by one or more constituent enumerated in Annex II of Directive 91/689/CEE
19 01 00	**wastes from incineration or pyrolysis of municipal and similar commercial, industrial and instit. waste**
19 01 08	pyrolysis wastes
19 06 00	**wastes from anaerobic treatment of wastes**
19 06 01	anaerobic treatment sludges of municipal and similar wastes
19 06 02	anaerobic treatment sludges of animal and vegetable wastes
19 07 00	**landfill leachate**
19 07 01	landfill leachate
19 08 00	**wastes from waste water treatment plants not otherwise specified**
19 08 03	grease and oil mixture from oil/waste water separation
20 01 00	**separately collected fractions**
20 01 09	oil and fat
20 01 12	paint, inks, adhesive and resins
20 01 13	solvents
20 01 16	detergents
20 01 18	medicines
20 01 19	pesticides
20 03 00	**other municipal waste**
20 03 04	septic tank sludge

Annex 6: Example of an Accept-Refuse Chart



Annex 7: Limit Values for Waste and AFR

Table 7.1: Limit Values in different Permits and Regulations in Austria, Switzerland and Germany for used Wastes for co-processing

	Austria[1]			Switzerland[2]		Germany[3]	
	In general combustible wastes[4]	Plastic, paper, textile waste, wood, etc. high calorific fraction from common waste	Solvents, spent oil, waste lacquers	In general combustible wastes[5]	Other wastes for disposal	Plastic, paper, textile waste, wood, etc. high calorific fraction from common waste[6]	Solvents, spent oil
	Maximum values [mg/kg]						
As	15	15	20	15		13	15
Sb	5	20 (200)[7]	100	5	800[4]	120	20
Be	5			5		2	2
Pb	200	500	800	200	500	400	150
Cd	2	27	20	2	5	9	4
Cr	100	300	300	100	500	250	50
Cu	100	500	500	100	600	700	180
Co	20	100	25	20	60	12	25
Ni	100	200		100	80	160	30
Hg	0,5	2	2	0,5	5[8]	1,2	1
Tl	3	10	5	3		2	2
V	100			100		25	10
Zn	400			400			
Sn	10	70	100	10		70	30
Cl (total)	1%	2%				1,5%	
PCBs	50		100				

1 voluntary self-commitment of the cement industry with authorities and concerned ministry
2 BUWAL, Co-processing Guidelines from Switzerland
3 voluntary self-commitment from the waste industry and regulations from the Government North Rhine Westfalia (NRW) Germany
4 net calorific value 25 MJ/kg
5 net calorific value average value 18 MJ/kg
6 PET
7 PET, Polyester
8 special case, flue gas cleaning for Hg

Annex 7: Limit Values for Waste and AFR

Table 7.2: Examples of limit Values for alternative Fuels for different Countries / Regions based on individual Permits

Parameter	Unit	Spain[14]	Belgium[1]	France[1]
Calorific values	MJ/kg	-	-	-
halogens (exp.as Cl)	%	2	2	2
Cl	%	-	-	-
F		0.20%	-	-
S	%	3%	3%	3%
Ba	mg/kg	-	-	-
Ag	mg/kg	-	-	-
Hg	mg/kg	10	5	10
Cd	mg/kg	100	70	-
Tl	mg/kg	100	30	-
Sum Hg + Cd + Tl	mg/kg	100	-	100
Sb	mg/kg	-	200	-
Sum Sb+ As+Co+ Ni+ Pb+ Sn+ V+ Cr	mg/kg	0.50%	2500	2500
As	mg/kg	-	200	-
Co	mg/kg	-	200	-
Ni	mg/kg	-	1000	-
Cu	mg/kg	-	1000	-
Cr	mg/kg	-	1000	-
V	mg/kg	-	1000	-
Pb	mg/kg	-	1000	-
Sn	mg/kg	-	-	-
Mn	mg/kg	-	2000	-
Be	mg/kg	-	50	-
Se	mg/kg	-	50	-
Te	mg/kg	-	50	-
Zn	mg/kg	-	5000	-
PCBs	mg/kg	30	30	25
PCDDs/PCDFs	mg/kg	-	-	-
Br+I	mg/kg	-	2000	-
Cyanide	mg/kg	-	100	-

1 voluntary self-commitment of the cement industry with authorities and concerned ministry
2 BUWAL, Co-processing Guidelines from Switzerland
3 voluntary self-commitment from the waste industry and regulations from the Government North Rhine Westfalia (NRW) Germany
4 net calorific value 25 MJ/kg
5 net calorific value average value 18 MJ/kg
6 PET
7 PET, Polyester
8 special case, flue gas cleaning for Hg
14 Limit values set by authorities for individual permits for cement plants in Spain, Belgium and France

Table 7.3: Examples of limit Values for Waste to be used as alternative Raw Materials in different Countries / Regions

Parameter	Unit	Spain[15]	Belgium[1]	France[1]	Switzerland[16]
TOC	mg/kg	2%	5000	5000	-
Total halogens (expr.as Cl)	%	0,.25	0.5	0.5	-
F	%	0,1	-	-	-
S	%	3	1	1	-
Hg	mg/kg	10	-	-	0.5
Cd	mg/kg	100	-	-	0.8
Tl	mg/kg	100	-	-	1
Sum Hg + Cd + Tl	mg/kg	100	-	-	-
Sb	mg/kg	-	-	-	1
Sum Sb+As+ Co+Ni+ Pb+ Sn+V+ Cr	mg/kg	0.50%	-	-	-
As	mg/kg	-	-	-	20
Co	mg/kg	-	-	-	30
Ni	mg/kg	-	-	-	100
Cu	mg/kg	-	-	-	100
Cr	mg/kg	-	-	-	100
V	mg/kg	-	-	-	200
Pb	mg/kg	-	-	-	50
Sn	mg/kg	-	-	-	50
Mn	mg/kg	-	-	-	-
Be	mg/kg	-	-	-	3
Se	mg/kg	-	-	-	1
Te	mg/kg	-	-	-	-
Zn	mg/kg	-	-	-	400
PCBs	mg/kg	30	-	-	1
pH	mg/kg	-	-	-	-
Br+I	mg/kg	-	-	-	-
Cyanide	mg/kg	-	-	-	-

15 Limit values set by authorities for individual permits for specific cement plants in Spain, Belgium and France
16 Limit values for alternative raw materials, BUWAL 1998. Guidelines Disposal of Wastes in Cement plants, table 1

Annex 8: Justification for the Exclusion of certain Waste Material from co-processing

1. Electronic waste

E-waste is composed of computer and accessories, entertainment electronics, communication electronics, toys but also white goods such as kitchen devices or medical apparatus. A recent study[17] of the Swiss environment agency BAFU reveals that average electronic scrap consists of 45% of metals in terms of weight, with the highest portion on heavy metals and rare metals. With 23%, plastic ranges second in the composition, and compounds of picture tubes are at 20%.

The average composition shows that electronic scrap contains on one hand substances harmful to health and the environment such as Cl, Br, P, Cd, Ni, Hg, PCB and brominated flame retardants in high concentration, often higher then threshold limit values as fixed in the permits.

On the other hand, the scrap contains so much scarce precious metals that all efforts have to be undertaken to recycle it. Co-processing of the plastic parts of the electronic waste would be an interesting option but requires disassembling and segregation first.

2. Entire Batteries

Batteries can be classified as automotive batteries, industrial batteries and portable (consumer) batteries. Automotive batteries are mainly lead-acid batteries; industrial batteries comprise both lead-acid batteries and nickel-cadmium batteries. The portable battery consists of general purpose batteries (mainly zinc carbon and alkaline manganese batteries), button cells (mainly mercury, zinc air, silver oxide, manganese oxide and lithium batteries) and rechargeable batteries (mainly nickel-cadmium, nickel-metal hydride, lithium ion and sealed lead-acid batteries). Most of these substances are harmful to health and the environment. Co-processing of batteries would lead to an undesirable concentration of pollutants in the cement and the air emissions. Also, some battery contents, such as mercury, nickel or cadmium, exceed any limit value for AFR. In addition, commercially viable battery recycling plants have been successfully introduced..

3. Infectious and biologically active medical wastes

Infectious, biologically active hospital wastes are generated in the human medical, in veterinary care and in the research. Examples are used blood transfusion bags, blood contaminated bandages, dialyse filters, injection needles, and also parts of the body and organs. Biologically active hospital wastes include pharmaceuticals. The disposal requires special hygienic and work safety requirements on handling, packaging and transportation.

The conditions in the cement kiln would be appropriate to treat infectious and biologically active hospital wastes, but would require special precautions on occupational health and safety in the supply chain of this type of waste. As the required OH&S conditions can't be fully assured, co-processing is presently not recommended. However, the problem of inadequate handling of medical waste has persisted for years, especially in developing countries. Although it is well known that segregating waste at the source is the most important step in managing medical waste, this principle is not yet sufficiently applied. Even less attention is given to the ultimate safe storage and final treatment (sterilization or microwave) of infectious waste.

Small medical waste incinerators have been promoted and introduced in the past in many countries as a decentralized solution. However, experiences gained show that this technology is in many cases not appropriate due to the absence of qualified personnel and the high costs associated with building, operating, maintaining and monitoring such facilities. As a consequence, the release of unwanted emissions (such as PCDDs and PCDFs, hydrochloric acid or heavy metals) in relatively high concentration must be considered.

As the problem persists and might become even more severe with a wider spread of infectious diseases (such as AIDS, SARS, Bird flu, Ebola etc.) co-processing might become part of the solution for final treatment, but only if defined pre-conditions in hospitals and health care centers have been introduced. Future coop

17 Schriftenreihe Umwelt Nr. 374, BUWAL, 2004

eration and research between international organizations such as the WHO and the cement industry could result in joint activities, such as the definition of standardized handling procedures.

4. Mineral acids and corrosives

Mineral acids are derived from inorganic minerals. Examples are hydrochloric acid, nitric acid, phosphoric acid and sulphuric acid (e.g. automotive batteries). The inorganic minerals such as S and Cl that are the main component of the acid have a negative impact on the clinker process and product quality and may lead to unwanted waste gas emissions. Acid may corrode and damage the production facilities.

Beside mineral acids, substances that can cause severe damage by chemical reaction to living tissue, or freight, or the means of transport are prohibited, as are all corrosive substances. Well known examples are aluminium chloride; caustic soda; corrosive cleaning fluid; corrosive rust remover/preventative; corrosive paint remover. These types of materials should be excluded from co-processing due to the upstream collection, transport risks and handling hazards.

5. Explosives

Explosives are any chemical compound, mixture or device capable of producing an explosive-pyrotechnic effect, with substantial instantaneous release of heat and gas. Examples are nitro-glycerine, fireworks, blasting caps, fuses, flares, ammunition, etc. Reasons to exclude them from co-processing are occupational safety due to the risk of uncontrolled explosions during preprocessing activities such transportation, handling, shredding etc. Explosive reactions in the cement kiln would have and negative impact on process stability.

6. Asbestos

Asbestos is a name given to a group of minerals that occur naturally as masses of long silky fibers. Asbestos is known for its unique properties of being resistant to abrasion, inert to acid and alkaline solutions, and stable at high temperatures. Because of these attributes, asbestos was widely used in construction and industry. Asbestos fibers are woven together or incorporated within other materials to create many products.

Airborne asbestos fibres are small, odourless and tasteless. They range in size from 0.1 to 10 microns in length (a human hair is about 50 microns in diameter). Because asbestos fibres are small and light, they can be suspended in the air for long periods. People whose work brings them into contact with asbestos may inhale fibers. Once inhaled, the small, inert asbestos fibers can easily penetrate the body's defenses. They are deposited and retained in the airways and tissues of the lungs and can cause cancer. Due to this negative health impacts, the use of asbestos has been forbidden for around 25 years. (Source: Utah Department of Environmental Quality)

Asbestos-containing materials can be classified into one of three types: sprayed or trowelled-on material (e.g. ceilings or walls), thermal system insulation (e.g. plaster cement wrap around boilers, on water and steam pipe elbows, tees, fittings, and pipe runs), or miscellaneous materials (e.g. floor tile, sheet rock, ceiling tiles, automotive friction products). Millions of tons of asbestos products will be transferred into waste material in the future, especially in developing countries and not all countries have national regulation on the handling and final disposal of this significant waste stream.

Asbestos-containing products could be treated in specially equipped rotary kilns at a temperature > 800°C for a certain time. The asbestos minerals would be transformed into other minerals like olivine or forsterite. Therefore co-processing could be, from a technical point of view, an option for treatment of asbestos waste. However, sanitary landfilling must be regarded as the most appropproriate way of final disposal as the material can be disposed undisturbed and does not provoke the release of unwanted fibers into the air. Once safely dumped, the asbestos waste does not have further negative environmental impacts. As the availability and new installation of sanitary landfill become more and more a problem, requests for co-processing asbestos might arise in the future. However before cancelling asbestos from the banned list, detailed investigations are required in particular on occupational health and safety in the whole supply chain. Further, asbestos-specific regulations have to be introduced and enforced by the national authorities.

Annex 8: Justification for the Exclusion of certain Waste Material from co-processing

7. Radioactive waste

Radioactive waste is normally excluded from "classical" waste management, and therefore specific regulations have to be applied according to international agreements. This means that radioactive waste can't be treated under the regulations of municipal and household waste and special permissions for its treatment are required. The procedure is normally stipulated in national nuclear laws. Cement plants are not suited to handle radioactive waste.

However, there is a borderline case for those wastes that have a low dose of radioactivity (e.g. waste from research, cleaning devices or in medical entities). Following the recommendations from the International Atomic Energy Agency and other organizations, many countries define waste as low radioactive if the radiation of this material to humans does not exceed 10 μSv per year. For this case a restricted or even an unrestricted clearance for handling this waste within an integrated waste management scheme could be given. At the international level, there is still a big discrepancy on procedures for clearance, and no uniform levels are given. As it is very difficult for most companies and/or authorities to provide the evidence that the threshold limit valid of 10 μSv could be assured at any time, it is recommended not to use any kind of radioactive waste for co-processing.

8. Unsorted municipal waste

Municipal waste is a heterogeneous material and consists in developing countries mainly of native organic (e.g. kitchen refuse), inert (e.g. sand) and post-consumer (e.g. packing material) fraction. Valuable recycling goods such as cardboard, plastic, glass or metal are often sorted out by the informal (waste pickers) or formal (cooperatives) sector.

Despite recrent efforts by local authorities in keeping their cities cleaner, the problems persist with the final disposal of the waste if no sanitary landfill sites can be made available due to protests by citizens or the high costs of the transport to a suitable site. In order to escape from this bottleneck, local and national decision makers opt for co-processing of the collected mixed waste material and to shift the responsibility of final treatment to the cement industry.

However, from an ecological, technical and financial point of view, the co-processing of unsorted municipal waste is not recommended. Mixed municipal waste must be sorted in order to obtain defined waste streams from a known quality. For selected materials, co-processing should be regarded as an integrated part of municipal solid waste management (→ *see* ***chapter 5.2.2***).

Annex 9: Permit Model

Permit / Model

Sender: Licensing authority

Addressee: Company

I.
By these presents, pursuant to articles ....Act....... you shall be granted the permit to build and operate a plant for the production of cement with Co-processing Waste fuel with an output of ....t/d cement in............(place) ....(street, correct address)

II.
Plant Components
→ rotary kiln with fuel gas channels, stack
→ raw material storage
→ fuel storage (primary fuel, secondary fuel)
→ crushers, mills, coolers
→ conveying facilities
→ electrostatic filter
→ waste processing, supply station
→ .....

III.
Application Documents
1. Topographical map
2. Constructions documents:
   _ key plan
   _ drawings
   _ building specification
3. Diagrammatic section of the plant
4. Machine site plan
5. Description of the plant and operation of the plant, the terms of normal working conditions
6. Description of the emission situation
   _ the technology for prevention the pollution
   _ contents of quantities of emissions
7. Description of secondary fuels: generation, processing, utilizing installation, supply, quality assurance system.
8. Environmental assessments
   _ Air pollution emission prognosis (e.g. dust, NO_X, SO_2, heavy metals, PCDDs/PCDFs)
   _ Noise emission prognosis
   _ Odor emissions
9. Maintenance of industrial and occupational health and safety standards
10. Description of energy saving techniques and/or measures
11. Description for public information

Annex 9: Permit Model

IV.
Plant Data
Output: ....t/d cement
Primary Fuel : coal dust, heating oil,
Secondary fuel: solid fuels, liquid fuels, ...

V.
Collateral Regulations
1.0 Air pollution control

1.1 All waste gases must be collected and must be discharged in a controlled manner via stack.

1.2 Emission measurements must satisfy the following requirements. They must be representative and comparable with one another permit uniform evaluation permit monitoring and verification of compliance with emission limit by state –of-the art measurement practice

1.3 According to the EU directive 2000/76/EG, the emission in the exhaust air of waste gas purification plants shall not exceed the following mass concentrations, always referred to standardized conditions (273 K; 1013 hPa) after deduction moisture. Reference oxygen content 10%

Pollutant (daily average value in mg/m^3)	Total emission limit*
Particulate emissions (Total dust)	30
HCL	10
HF	1
NO_X	500 - 800
SO_2	50** – (350)
TOC	10**
Dust constituents and filter-slipping metals, metalloid and compounds there of:	
Cd + Tl	0,05
Hg	0,05
Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V	0,5
PCDDs and PCDFs	0,1 ng I-TE/m^3

* Emission limits are fixed on the basis "EU directive 2000/76/EG" but local authorities may establish special limits in case by case
** Exemption my be authorized by competent authority in cases where TOC and SO_2 do not result from the incineration waste

1.4 Monitoring of emissions:

→ Substances contained in dust, HCL, PCDDs/PCDFs
For the monitoring of emissions, single measuring are to be conducted. The emission limit values are being observed if single measuring results exceed the fixed emission limit value. Measurements have to be repeated at least every year an be performed independent experts.

→ Dust, NO_X SO_2
In order to monitor emissions, continuously measuring devices with automatic evaluation are to be installed. The result of the continuous measuring must be recorded. The measuring instruments have to be tested with regard to their functioning once a year by independent experts

→ CO (limit value can set by competent authority)

1.5 Qualified laboratories
To ensure a uniform measurement practice, representative measurement results and comparable quality procedures, qualified laboratories are to be commissioned with sampling and analysis activities and calibration procedures. The location and configuration of the sampling point is to be coordinated with the competent authorities (and the commissioned laboratory, where applicable)

2.0 Waste fuel control
2.1 Monitoring of Quality assurance for co-processing waste fuels
→ point of generation (producer):
  – listing the waste according to type
  – contractual agreement over permissible quality and composition of the waste
  – documentation of quantities disposed of
→ processing installation (incoming):
  – routine sampling and analysis*, retention samples
  – documentation of the quantities received and processed
  – routine sampling and analysis by independent expert
→ processing installation (outgoing):
  – routine sampling and analysis*, retention samples
  – documentation of the outgoing quantities
→ utilizing installation (cement kiln, incoming):
  – routine sampling and analysis*, retention samples
  – documentation of the incoming quantities
→ **parameters investigated:*
  – calorific value, moisture chlorine, sulfur, ash and ash components
  – heavy metals (Cd, Tl, Hg, Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V)
  – PCBs, PAH, etc.
  – maximum value, median value of the level of pollutants in the waste mix

2.2 Pollutant limits in waste fuels for co-processing [18]

	median value (ppm)	maximum value (ppm)
Cadmium		
Thallium		
Mercury		
Antimony		
Arsenic		
Cobalt		
Nickel		
Selenium		
Tellurium		
Lead		
Chromium		
Copper		
Vanadium		
Manganese		
Tin		
Beryllium		
Chlorine		
PAH		
Sulfur		
PCBs		

2.3 Waste fuel catalogue for co-processing in cement kiln

Waste key / group	description of the co-processing fuel

3.0 Monitoring safe Combustion

- → The burning process has to be monitored continuously using modern process control technology,
- → The main parameters for analysis of the waste materials (calorific value, chemical composition, etc.) must be put into the process control system on a continuous basis,
- → Regulations of primary energy have to follow in reliance on secondary fuel data,
- → Waste fuels may only be supplied during normal continuous operation within the rated output range.

[18] Must be defined from the local authorities

3.1 Safety regulations

For supervising the parameters listed below, they should be linked to one another by a computer-controlled logic system e.g.:

- → Gas temperature less than 900°C at kiln inlet
- → Temperature of material at kiln outlet less than 1250°C
- → CO- level above a value to be established by trial (Vol.%)
- → Inadmissible control deviations in the set point/actual value comparison for the primary and secondary fuel feed
- → Raw meal feed of less than 75% of the max. possible quantity
- → Negative pressure before the exhaust gas fan below the value required at rated output
- → Permissible O_2 level lower than inspection measurements require
- → Permissible NO_x level above 500 mg/m^3
- → Failure of burner
- → Dust level above permissible limit

(This should ensure rapid detection of any disruption to normal operation and use appropriate response system to prevent uncontrolled combustion of residues)

VI.
Noise

In so far as noise must be taken into consideration, the noise emission limit values shall be determined in dependence of existing, surrounding development.

VII.
Sewage Water (if applicable)

VIII.
Reasons

(Reasons for a permission for co-processing waste

- → environmental assessment,
- → air pollution control,
- → waste management, waste hierarchy,
- → public involved

Annex 10: Application Form

Address (authority)

1.0 Informations to the applicant

Name / company: ....

City / post code: .... District: ....

Phone No.: ....

Queries by: ....

Department / person responsible/ phone No.: ....

2.0 General information of plant

2.1 Location of plant

location of industry / area / municipal / town / street / street number:

2.2 Type of plant

marking of plant / scope of plant / capacity / output:

2.3 Is submitted

- ☐ The permission for building and operating ....
- ☐ The permission for modification operating ....

2.4 Application with the following technical documentations (e.g.)

- ☐ Topographical map
- ☐ Construction documents
- ☐ Description of the plant and operation of the plant
- ☐ Diagrammatic section of the plant (flow chart)
- ☐ Machine site plan
- ☐ Description of the emission situation
- ☐ Environmental assessments
- ☐ Application forms
- ☐ Description for public information
- ☐ Other technical documentations
- ☐ Index

City, Date (signature of applicant)

3.0 Technical specifications for the main parts of the plant					
Technical entity No:					
3.1 Inputs: Raw materials and suplies					
Number in comply with flow chart	Description of the material	Quantity of the material [kg/h]	Composit		
			Component	Proportion [%]	
				Min.	Max.
3.2 Outputs : Products, waste-products, waste-water					
Number in comply with flow chart	Description of the material	Quantity of the material [kg/h]	Composit		
			Component	Proportion [%]	
				Min.	Max.

Annex 10: Application Form

4.0 Purification of waste gas

Combined with point source No.: : ....

Typ of cleaning system: ....

Flue gas stream .... m^3/h..................................... °C ....m^3/h*)

Efficiency of the Purification of waste gas in basic disign			
purification materials	Conzentration mg/m^3 *) before - Cleaning - after		Collection efficiency %

*) standard conditions

5.0 Operating proceduere and und Emissions

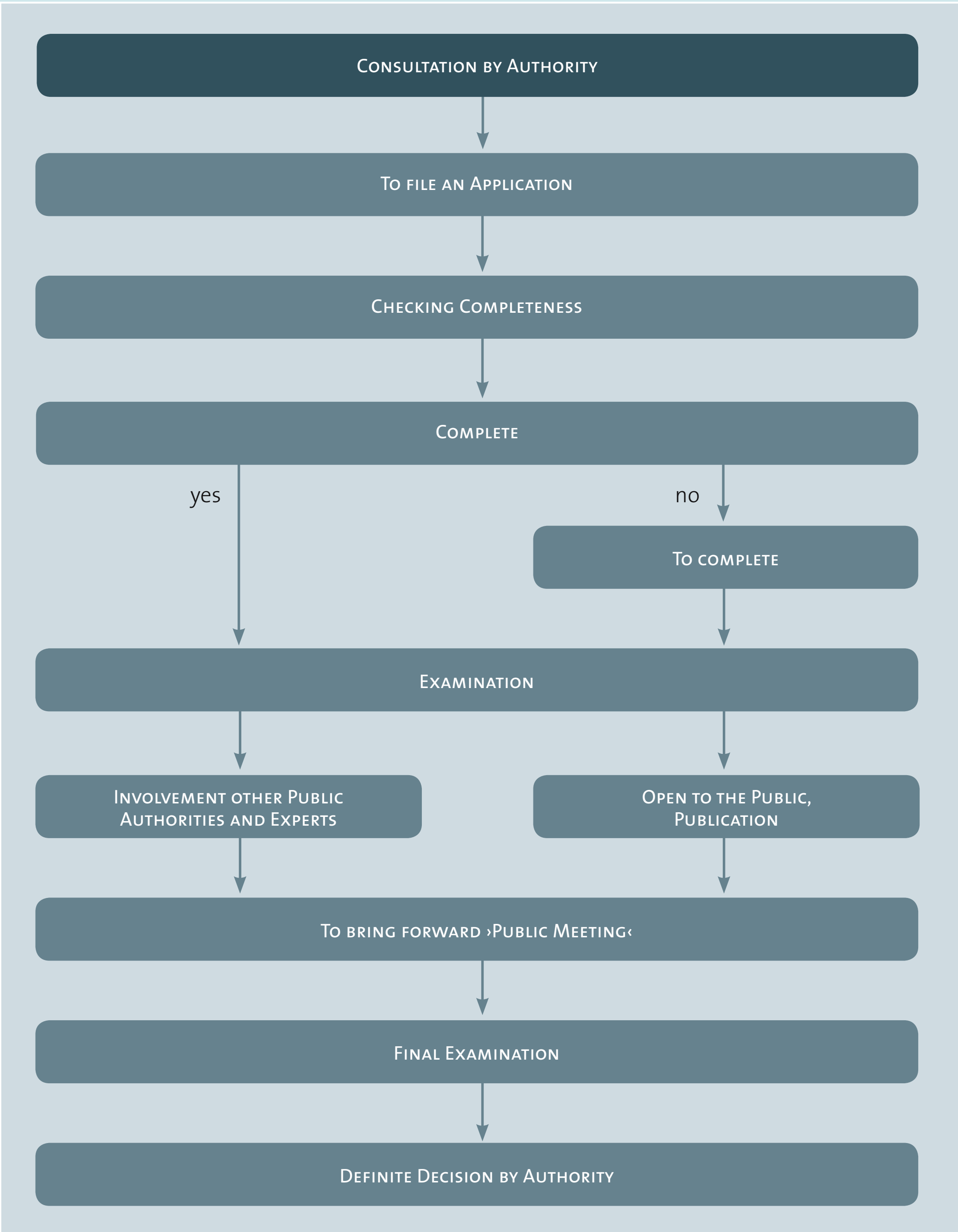
Technical entity No.: ....Name of the Technical entity : ....

In the follow shedule to descibe: all operating procederes with emissions:

Operation state ** inter-ferences, operation states with emissions	Frequency and duration for the emission process	Date, time, weekday month	Rice number according to flow chart	Waste gas		Emission substance (seperated in specific components)						Perform-ance of measure-ments
				Flow m^3/h*)	Tempe-rature°C	Name	Physical condition	Concentration mg/m^3 *)		Mass-flow **) kg/h		
								Min. value	Max. value	Min. value	Max. value	

* standard conditions
** (e.g. working conditions, non-steady working conditions)

Annex 11: Permitting Process



Annex 12: Information on Test Burns

Test Burns for Performance Verification

Test burns are required in some regulations and conventions for the verification of the destruction and removal efficiency (DRE) or the destruction efficiency (DE) of certain principal organic hazardous compounds (POHC) in a cement kiln. 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. 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 non-hazardous AFR are not a regulatory requirement but are sometimes done to evaluate the behavior of the process and the influence on main gaseous emissions and the cement clinker quality when feeding AFR 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. However, test burns with hazardous compounds require professional supervision and independent verification.

Cement kilns co-processing hazardous wastes in the EU are not required to carry out a test burn but must comply with emission limit values for dusts, HCl, HF, NO_x, SO_2, 12 heavy metals, total organic carbon (TOC) and dioxins and furans (PCDDs/PCDFs). The emission limit values for PCDDs/PCDFs are slightly more stringent in the EU regulation than in the US. In the US, cement kilns co-processing hazardous wastes must perform a test burn to demonstrate the combustion performance on selected hazardous wastes to demonstrate the DRE for POHCs in the waste stream. The test burn must fulfil three major requirements regarding combustion performance, whereas the DRE is the most important: POHCs must be destroyed and/or removed to an efficiency of 99.99% or better; POPs wastes must achieve a DRE of 99.9999%. The remaining two requirements deal with emissions of particulates and gaseous hydrogen chloride. A destruction and removal efficiency of 100% will not be possible to establish due to limitations in the analytical instruments. The Stockholm and the Basel Conventions require a DE test for kilns aiming to treat POPs or POPs waste.

Taking into consideration the inherent features of a cement kiln – the high temperatures, long residence times, excess oxygen etc. – a test burn seems to be redundant. However, a test burn is actually the only way to prove the destruction performance of a kiln and its ability to destroy hazardous wastes in an irreversible and sound way. However, the design and the conditions of the test are crucial. Earlier data that indicated cement kiln DRE results below 99.99% are either from outdated sources or improperly designed tests, or both.

In the early years of development of this technology and the sampling and analytical techniques to evaluate its environmental performance, there were several instances where POHCs were selected that did not meet the necessary criterias. For example, a major problem with many early tests was that the POHCs selected for DRE evaluation were organic species that are typically found at trace levels in the stack emissions from cement kilns that burn only fossil fuel. While these products of incomplete combustion (PICs) were emitted at very low levels, they nonetheless greatly interfered with the measurement of POHC destruction, i.e. DRE could not be properly measured if POHCs used in testing were chemically the same or closely related to the type of PICs routinely emitted from raw materials. In some instances, operational factors during the testing or sampling and analytical techniques contributed to low DRE results.

The US test burn permitting process, originally designed to determine how effectively an incinerator is able to operate under specifiable ”worst cases”, is however regarded as unnecessarily complex and costly, and has discouraged cement plant owners from adopting the test burn concept. An alternative approach will in most cases provide the same qualitative information: a „one-run“ test burn investigating the destruction performance when feeding a suitable hazardous waste combined with a baseline study measuring the „blank“ emissions when no hazardous waste are introduced, both tests done under normal process operating conditions. A cement plant is operated continuously, i.e. usually more than 330 days a year, and such a test scheme will together with a feasibility study and an environmental impact assessment provide sufficient information on the performance for the cement kiln in question. The following conditions should be fulfilled in the one-run test burn:

- → The destruction and removal efficiency for the 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 of 99.9999% should be achieved.
- → The cement kiln should meet an emissions limit for PCDDs/PCDFs of 0.1 ng TEQ/Nm^3 both under baseline and test burn conditions.
- → The cement kiln should comply with existing national emission limit values.

Such an approach for performance verification will, together with adequate safety arrangements, input control and operational procedures secure the same level of environmental protection as the current EU and US regulation.

Excerpts: from Kåre Helge Karstensen „Co-Processing of Organic Hazardous Wastes in Cement Kilns in Developing Countries - Proposed Requirements", article submitted for publication.

Annex 13: EPER – European Polluting Emissions Register for the Cement Industry

Activity code:	3.1/3.3/3.4/3.5 - Installations for the production of cement klinker (>500t/d), lime (>50t/d), glass (>20t/d), mineral substances (>20t/d) or ceramic products (>75t/d)
Area:	EU
Year:	2001
Pollutants:	31
Facilities:	665

Total emission values for activity grouped by pollutant:

Pollutant	To air (kg)	Direct to water (kg)	Indirect to water (kg)
Methane (CH_4)	1,151,000.00	-	-
Carbon monoxide (CO)	277,250,000.00	-	-
Carbon dioxide (CO_2)	142,011,000,000.00	-	-
Dinitrogenoxide (N_2O)	136,500.00	-	-
Ammonia (NH_3)	3,450,600.00	-	-
Non methane volatile organic compounds (NMVOC)	6,228,000.00	-	-
Nitrogen oxides (NO_x)	427,178,000.00	-	-
Sulfur oxides (SO_x)	145,486,000.00	-	-
Nitrogen, total	-	216,000.00	-
Phosphorus, total	-	5,180.00	8,640.00
Arsenic and its compounds	5,038.20	4,156.10	17.50
Cadmium and its compounds	2,829.90	242.24	-
Chromium and its compounds	11,872.00	8,091.30	-
Copper and its compounds	5,895.00	2,870.00	-
Mercury and its compounds	2,889.90	76.30	-
Nickel and its compounds	14,287.00	7,438.50	-
Lead and its compounds	44,373.00	3,700.60	219.90
Zinc and its compounds	35,190.00	8,155.00	2,358.00
Dichloromethane (DCM)	158,490.00	-	-
Dioxines and furans (PCDDs and PCDFs)	0.0322	-	-
Trichloroethylene (TRI)	3,180.00	-	-
Benzene	126,070.00	-	-
Polycyclic Aromatic Hydrocarbons (PAH)	7,970.30	-	-
Phenols	-	246.00	1,775.00
Total Organic Carbon (TOC)	-	282,000.00	358,700.00
Chlorides	-	781,000,000.00	-
Chlorine and inorganic compounds (as HCl)	1,956,000.00	-	-
Cyanides, total CN	-	204.00	-
Fluorides	-	11,750.00	-
Fluorine and inorganic compounds (as hydrogen fluoride)	1,541,883.00	-	-
PM10 (Particulate matter less than 10 µm)	19,290,000.00	-	-

Annex 14: Ranges of emissions and Reduction Techniques

Cement Plants, Generation of Air Emissions and Respective Reduction Techniques

Point Source Dust

Reasons for emissions:	The cement production process includes thermal treatment (drying, heating, calcining, clinkerization, cooling) of materials through direct contact with hot gases. It also includes pneumatic material transports and material classification/separation. At the end of these processes air/gas and pulverized materials have to be separated again. Incomplete separation gives rise to dust emissions (kiln/raw mill main stack, clinker cooler stack, cement mill stacks, material transfer point dedusting air outlets).
Ranges of emissions:	Outdated dedusting equipment may emit up to several 100 mg/Nm3. Electrostatic precipitation easily reaches < 50 mg/Nm^3. Bag filter dedusting produces values < 20 mg/Nm^3. The visibility limit for point source dust is generally assumed to be around 80 mg/Nm^3.
Reduction techniques:	Bag filters and electrostatic precipitators for all kiln types and input materials.

Fugitive Dust

Reasons for generation:	Material spills from inadequately dedusted and/or worn out material transfer points/material feeding points, material storage areas, dusty transport roads etc. with subsequent wind erosion/dispersion.
Ranges of emissions:	Hard to quantify, mainly short range in-plant impacts (coarse dust).
Reduction techniques:	Preventive and quick reactive maintenance, wetting of stockpiles, roof covering of stockpiles, vacuum cleaning systems, etc.

SO_2

Reasons for emissions:	Volatile sulfur in raw materials roasted off at material preheating. Wet kilns only: 10% to 50% of total sulfur inputs are emitted
Ranges of emissions:	Dependent on content of raw materials of volatile sulfur compounds. Mostly below 300 mg/Nm^3. Sometimes up to 3000 mg/Nm^3.
Reduction techniques:	Hydrated lime addition to kiln feed for small gaps (<700 mg/Nm^3). Wet sulfur scrubbers for large gaps.

NO_x

Reasons for emissions:	Thermal NO is produced in the main flame of all cement kilns in varying quantities dependant on sintering zone and flame temperatures. Some fuel NO_x might be added via precalciner fuels.
Ranges of emissions: (unabated)	300 to 2000 mg/Nm^3
Reduction techniques:	With limited effect: → Water cooling of main flame → Low-NO_x burner → Reducing zones (mid kiln, transition chamber, low-NO_x calciner) With good effect: → Selective non-catalytic reduction (SNCR) with → ammonia or urea injection in appropriate → temperature window. → <800 mg/Nm^3 achievable with existing SP/PC kilns. → <500 mg/Nm^3 achievable with new SP/PC kilns.

VOC

Reasons for emissions:	Volatile organics in raw materials roasted off at material preheating (idem SO_2). No products of incomplete combustion from main or precalciner firing.
Ranges of emissions:	Dependant on content of raw materials of volatile organics. Mostly below 50 mg/Nm^3. Sometimes up to 500 (+) mg/Nm^3.
Reduction techniques:	No cost effective end-of pipe techniques available to date, therefore avoid use of critical input materials or feed them together with the fuels.

HCl

Reasons for emissions:	Chlorine may be present in raw materials as well as in alternative fuels (spent solvents, plastic). If inputs exceed the (low) carrying capacity of the clinker/kiln system then emission might result.
Ranges of emissions:	SP/PC kiln systems: <10 mg/Nm^3. Wet kilns: Up to 80 mg/Nm^3
Reduction techniques:	No direct HCl abatement technique available, but sulfur wet scrubbers also reduce HCl emissions.

Annex 14: Ranges of Emissions and Reduction Techniques

NH_3

Reasons for emissions:	Some natural raw materials (particularly clays) may contain NH3 which is partially roasted-off at material preheating. Other NH_3 might be NH_3 slip (loss) from a SNCR NO_x reduction installation.
Ranges of emissions:	<1 to 15 mg/Nm^3 as a rule with exceptions up to 40 mg/Nm^3.
Reduction techniques:	Keep enrichment in outer circulation low by extracting dust from a suitable point in the process and feeding to the transition chamber.

Benzene (C_6H_6)

Reasons for emissions:	Benzene might be present in conventional and alternative raw materials and is partially roasted off at material preheating.
Ranges of emissions:	Normally 1 to 2 mg/Nm^3, up to 3 and more mg/Nm^3 in rare cases
Reduction techniques:	No reasonable abatement technique, input limitation with raw materials is the option.

Dioxins and Furans

Reasons for emissions:	Dioxins, furans or advanced precursors might be present in conventional (rarely) and alternative raw materials and are partially roasted off at material preheating. Reactive forms at chlorine (Cl_2) present in the exhaust gases might expedite PCDDs/PCDFs formation or modification.
Ranges of emissions:	From below detection limits up to around 20% of the often adopted emission limit value of 0.1 ng/Nm^3. Sometimes values up to 2 or 3 ng/Nm^3 can be found.
Reduction techniques:	Same as benzene.

Heavy Metals

Reasons for emissions:	Heavy metals are ubiquitous in all cement kiln input materials. Since clean gas dust (i.e. dust after the dedusting equipment) is an input materials fraction, it also contains heavy metals. In addition, semi-volatile and volatile heavy metals are evaporated and condense (predominantly) on the fine dust fraction.
Ranges of emissions:	Most heavy metal emissions (typically 80%) remain below the detection limits. All (with one exception) remain safely below generally adopted limit values. The one exception is mercury, which can exceed limit values in case of excessive inputs with materials. **Emission range of mercury:** from below detection limit up to < 0.05 mg/Nm^3
Reduction techniques:	Efficient dedusting equipment and limitation of mercury inputs in feed materials.

Annex 15: Total Emission limit Values for Cement Kilns co-processing Waste

Directive 2000/76/EC incineration of waste

Pollutant	C
Total dust	30
HCl	10
HF	1
NO_x	500[1]/800[2]
Cd + Tl	0.05
Hg	0.05
Sb, As, Pb, Cr, Co, Cu, Mn,Ni, V	0.5
Dioxins and Furans	0.1
SO_2	50[3]
TOC	10[3]

Daily average 10% O_2, dry all values in mg/m^3 dioxins and furnans in ng/m^3

1) new plants
2) existing plants
3) exceptions may be authorized by the competent authority in cases where SO_2 and TOC do not result from the incineration of waste

Source: Directive 2000/76/EC of the European Parliament and the Council of 4. December 2000 on the incineration of waste. Annex II: Determination of air emission limit values for the incineration of waste – Special provisions for cement kilns.

The directive can be downloaded under:
→ *http://europa.eu.int/comm/environment/wasteinc/newdir/2000-76_en.pdf*

Annex 16: Summary of the WBCSD/UNEP report on POPs

Summary of the WBCSD/UNEP report on POPs

Formation and Release of POPs in the Cement Industry / Second edition

World Business Council for Sustainable Development
Cement Sustainability Initiative

30 January 2006
Written by Kåre Helge Karstensen

SINTEF

Executive summary

The Stockholm Convention requires Parties to take measures to reduce or eliminate releases of persistent organic pollutants (POPs) from intentional production and use, from unintentional production and from stockpiles and wastes. The chemicals intentionally produced and currently assigned for elimination under the Stockholm Convention are the pesticides aldrin, chlordane, dieldrin, endrin, heptachlor, hexachlorobenzene (HCB), mirex and toxaphene, as well as the industrial chemical Polychlorinated Biphenyls (PCBs).

The Convention also seeks the continuing minimisation and, where feasible, elimination of the releases of unintentionally produced POPs such as the by-products from wet chemical and thermal processes, polychlorinated dibenzo-p-dioxins/-furans (PCDDs/PCDFs) as well as HCB and PCBs. Concepts of Best Available Technology and Best Environmental Practices to achieve such minimisation and reduction from all potential source categories will be further developed by the Conference of the Parties. Cement kilns co-processing hazardous waste are explicitly mentioned in the Stockholm Convention as an "industrial source having the potential for comparatively high formation and release of these chemicals to the environment".

The cement industry takes any potential emission of POPs seriously, both because perceptions about these emissions have an impact on the industry's reputation, and because even small quantities of dioxin-like compounds can accumulate in the biosphere, with potentially long-term consequences.

The main objective of this study was to compile data on the status of POPs emissions from cement kilns co-processing hazardous wastes, to share state of the art knowledge about PCDDs/PCDFs formation mechanisms in cement production processes and to show how it's possible to control and minimise PCDDs/PCDFs emissions from cement kilns utilising integrated process optimisation, so called primary measures. This report provides the most comprehensive data set available on POPs emission from the cement industry collected from public literature, scientific databases and individual company measurements. This report evaluates around 2200 PCDDs/PCDFs measurements, many PCB measurements and a few HCB measurements made from the 1970s until recently. The data represents emission levels from large capacity processing technologies, including wet and dry process cement kilns, performed under normal and worst case operating conditions, with and without the co-processing of a wide range of alternative fuel and raw materials and with wastes and hazardous wastes fed to the main burner, to the rotary kiln inlet and to the preheater/precalciner. Vertical shaft kilns, regarded to be an obsolete technology but still common in many countries, have not been dealt with in this report due to lack of emission data. The PCDDs/PCDFs data presented in this report shows that:

- Most cement kilns can meet an emission level of 0.1 ng TEQ/Nm^3 if primary measures are applied
- Co-processing of alternative fuels and raw materials, fed to the main burner, kiln inlet or the precalciner does not seem to influence or change the emissions of POPs

* Data from dry preheater and precalciner cement kilns in developing countries presented in this report show very low emission levels, much lower than 0.1 ng TEQ/Nm^3.

The emissions from modern dry preheater/precalciner kilns seem generally to be slightly lower than emissions from wet kilns. A common practice in many countries today is to co-process energy containing wastes and alternative raw materials in dry preheater/precalciner kilns, thereby saving fossil fuel and virgin raw materials. One example illustrates this: a UNEP project measured emissions between 0.0001-0.018 ng TEQ/m^3 from a dry preheater kiln in Thailand replacing parts of the fossil fuel with tyres and hazardous waste; the lowest concentration was found when the kiln was co-processing hazardous waste, 0.0002 ng TEQ/m^3.

Emission data from US cement kilns in the 1980s and first part of the 1990s stands in contrast with newer findings. They often indicated that cement kilns co-processing hazardous waste as a co-fuel had much higher PCDDs/PCDFs emissions than kilns co-processing non-hazardous wastes or using conventional fuel only. In recent documents however, the US EPA has explained the most probable cause for these findings, namely that cement kilns burning hazardous waste were normally tested under "worst" scenario trial burn conditions, i.e. typically high waste feeding rates and high temperatures in the air pollution control device, conditions today known to stimulate PCDDs/PCDFs formation.

Cement kilns burning non-hazardous waste or conventional fossil fuel only were however tested under normal conditions, no "worst" scenario conditions, making a comparison between hazardous waste burning and non-hazardous waste burning kilns dubious. Reducing the temperature at the inlet of the air pollution control device is one factor which has shown to limit dioxin formation and emissions at all types of cement kilns, independent of waste feeding, as lower temperatures are believed to prevent the post-combustion catalytic formation of PCDDs/PCDFs. The US EPA concluded in 1999 in the new Maximum Achievable Control Technology regulation that hazardous waste burning in cement kilns does not have an impact on PCDDs/PCDFs formation because they are formed post-combustion, i.e. in the air pollution control device.

This report also provides a large number of measurements of PCDDs/PCDFs in products and residues from the cement industry. The levels are normally low and in the same magnitude as found in foods like fish, butter and breast milk as well as soil, sediments and sewage sludge. For new cement plants and major upgrades the Best Available Technology 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 for the energy use.

Annex 16: Summary of the WBCSD/UNEP Report on POPs

The most important primary measures to achieve compliance with an emission level of 0.1 ng TEQ/Nm^3 is quick cooling of the kiln exhaust gases to lower than 200°C in long wet and long dry kilns without preheating. Modern preheater and precalciner kilns have this feature already inherent in the process design. Feeding of alternative raw materials as part of raw-material-mix should be avoided if it includes organic material and no alternative fuels should be fed during start-up and shut down.

The UNEP Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases assign emission factors to all source categories and processes that are listed in Annex C, Parts II and III of the Stockholm Convention. The emission factors for cement kilns co-processing hazardous wastes are among the lowest of all source categories.

Since PCDDs/PCDFs is the only group of POPs commonly being regulated up to now, there are fewer measurements available for HCB and PCBs. However, the more than 50 PCB measurements referred to in this report show that all values are below 0.4 µg PCB TEQ/m^3, many at a few nanogram level or below the detection limit. 10 HCB measurements show a concentration of a few nanograms per cubic meter or concentrations below the detection limit.

The whole report can be downloaded from:
→ *www.wbcsdcement.org*

Annex 17: Template for Master Data File for commonly used Waste

AFR / WASTE PROFILE

	AFR / WASTE PROFILE 1 of 4		GENERAL
Designation		Industry of origin	
Waste codification (national)		Codification according to [Company]	
Potential (and/or)	☐ AR ☐ AF		

Source				User			
waste generator	○	platform	○	plant	○	platform	○
Company				Company			
Adress				Adress			
Contact				Contact			
Phone				Phone			
Fax				Fax			
E-mail				E-mail			

AFR / Waste generating process	

Principal constituents	Chemical formula	Minimum	Average	Maximum
		%	%	%
		%	%	%
		%	%	%
		%	%	%
		%	%	%

AFR / Waste availability

from process	○	t / year		Expected duration					
storage capacity				spot	○	> 1 year	○	< 1 year	○
from stock	○	stock	t	cost / t					

AFR / Waste delivery

Timing of delivery		Transport					
Continous over the year	○	Rail	○	Drums	○	Tank truck	○
Irregular / seasonal	○	Big bag	○	IBC	○	Bulk truck	○

Macroscopic properties

solid	○	Max. particle size / mm				Dust generation	high	○ ○ ○	low
		>100	○	10 - 1	○	Foreign bodies	frequent	○ ○ ○	none
		100 - 10	○	< 1	○	Flowability	high	○ ○ ○	low
		homogeneous		○ yes	○ no	Stickiness	high	○ ○ ○	low
sludge	○	homogeneous		○ yes	○ no	Stickiness	high	○ ○ ○	low
						Foreign bodies	frequent	○ ○ ○	none
liquid	○	aqueous	○	organic	○	Viscosity	high	○ ○ ○	low
		Different phases			○	Particles	much	○ ○ ○	none
						Sedimentation	strong	○ ○ ○	weak

Other characteristics						
Color	dark	○ ○ ○	light	Odor	strong ○ ○ ○	no

Banned wastes - not allowed for AFR utilization

Anatomical hospital wastes	○ yes	○ no	Explosives	○ yes	○ no
Asbestos-containing wastes	○ yes	○ no	High-concentration cyanide wastes	○ yes	○ no
Bio-hazardous wastes	○ yes	○ no	Mineral acids	○ yes	○ no
Electronic scrap	○ yes	○ no	Radioactive wastes	○ yes	○ no

Annex 17: Template for Master Data File for commonly used Waste

	AFR / WASTE PROFILE	CHEMICAL & PHYSICAL PROPERTIES
	2 of 4	

Designation		Industry of origin	
Analytical laboratory		**Information source**	
Company		Date	
Adress		Sample information	
		one spot sample ◯	Composite sample ◯
Contact		taken by	
Phone	Fax	Comments	
Email			

Physical and chemical properties

	Min.	Average	Max.		Min.	Average	Max.
H_2O content as delivered %				Boiling point °C			
Viscosity Pa				Melting point °C			
Density kg / m³				Residue on ....mm %			
Bulk density kg / m³				Residue on ....mm %			
pH				Residue on ....mm %			
Water soluble compounds							

Organic properties

Sample preparation	air dried ◯	dried ◯	other				
	Sample Average	estimated Min.	estimated Max.		Sample Average	estimated Min.	estimated Max.
Ash content %				S %			
Volatiles content %				C %			
CV gross MJ / kg				H %			
CV net MJ / kg				PCB ppm			
Flash point °C				PCT ppm			
TOC %				Phenols ppm			

Inorganic properties

Sample preparation	air dried ◯	dried ◯	other				
Mineral components	Min.	Average	Max.		Min.	Average	Max.
Quartz %				Other			
L. o. i. %				Cd ppm			
SiO_2 %				Hg ppm			
Al_2O_3 %				Tl ppm			
Fe_2O_3 %				As ppm			
CaO %				Ni ppm			
MgO %				Co ppm			
SO_3 %				Se ppm			
K_2O %				Te ppm			
Na_2O %				Cu ppm			
TiO_2 %				Pb ppm			
Mn_2O_3 %				Sb ppm			
P_2O_5 %				Sn ppm			
F %				V ppm			
Cl %				Be ppm			
Br %				Ba ppm			
I %				Mn ppm			
CN %				Zn ppm			
NH_3 %				Cr ppm			

AFR / WASTE PROFILE

HEALTH & SAFETY

3 of 4

Designation		Industry of origin	

Material safety data sheet

available	○	not available	○	

Hazards identification

Inflammable	☐	Irritant	☐	By eye contact	☐
Corrosive	☐	Harmful	☐	By skin contact	☐
Reactive	☐	Toxic	☐	By inhalation	☐
Respirable	☐	Carcinogen	☐	By ingestion	☐

Risk of hazardous reactions

with ? \ to ?	Toxic vapour	Ignition	Explosion	Polymerisation	Solidification
High temperature	☐	☐	☐	☐	☐
High pressure	☐	☐	☐	☐	☐
Water	☐	☐	☐	☐	☐
Air	☐	☐	☐	☐	☐
Acids	☐	☐	☐	☐	☐
Bases	☐	☐	☐	☐	☐
Oxidants	☐	☐	☐	☐	☐
Reductants	☐	☐	☐	☐	☐
Other	☐	☐	☐	☐	☐
Comments					

Personal protection

Acid resistant clothes	☐	Safety helmet	☐	Safty gloves	☐
Full protection mask	☐	Safty glasses	☐	Semi-protection mask	☐

First aid

Appropriate measures	
Inappropriate measures	

Fire instruction

Appropriate measures	
Inappropriate measures	
Specific risks / instructions	

Spill instructions

Clean-up procedures	
Recovery procedures	
Disposal procedures	
Contact in urgent cases	

Transport

Hasard code		Transport code		Waste code	
Comments					

Annex 17: Template for master data file for commonly used waste

AFR / WASTE PROFILE

4 of 4

PLANT HANDLING & APPLICATION

Designation		Industry of origin	
Classification		Code	
Actual amount consumed	t / year	t / h (average)	t / h (max.)

Pretreatment

drying	☐	grinding	☐	screening	☐	shredding	☐
mixing	☐	other:					
Comments							

Storage

open storage	☐	covered storage	☐	sealed floor	☐	non-sealed floor	☐
Bunker	☐	Silo	☐	Tank	☐	Pit	☐
drums	☐	big bag	☐	IBC	☐	Moving floor cont.	☐
other:				Storage capacity:			
Comments							

Extraction from storage

Front end loader	☐	Live bottom feeder	☐	Aeration	☐	Mechanical outlet activation	☐
Crane	☐	Reclaimer	☐	other:			
Comments							

Transport from storage to process

Front end loader	☐	Crane	☐	Chain conveyor	☐	Bucket elevator	☐
Hydraulic	☐	Pump type:		Screw conveyor	☐	Belt conveyor	☐
Pneumatic	☐			other:			
Comments							

Dosing

gravimetric	☐			volumetric	☐		
Belt scale	☐	Impact flowmeter	☐	Rotary valve	☐	Belt feeder	☐
Lossweight feeder	☐	Coriolis flowmeter	☐	Positive Displacement Pump	☐	Screw feeder	☐
Rotor weigh feeder	☐	other:				other:	
Comments							

Feed to process

Raw mat. crusher	☐	Raw mill	☐	Preheater	☐	Kiln inlet	☐
Preblending bed	☐	Slurry mill	☐	Lepol grate	☐	Mid kiln	☐
Slurry basin	☐	Coal mill	☐	Calciner	☐	Next to main flame	☐
other:						Main burner	☐
Comments							

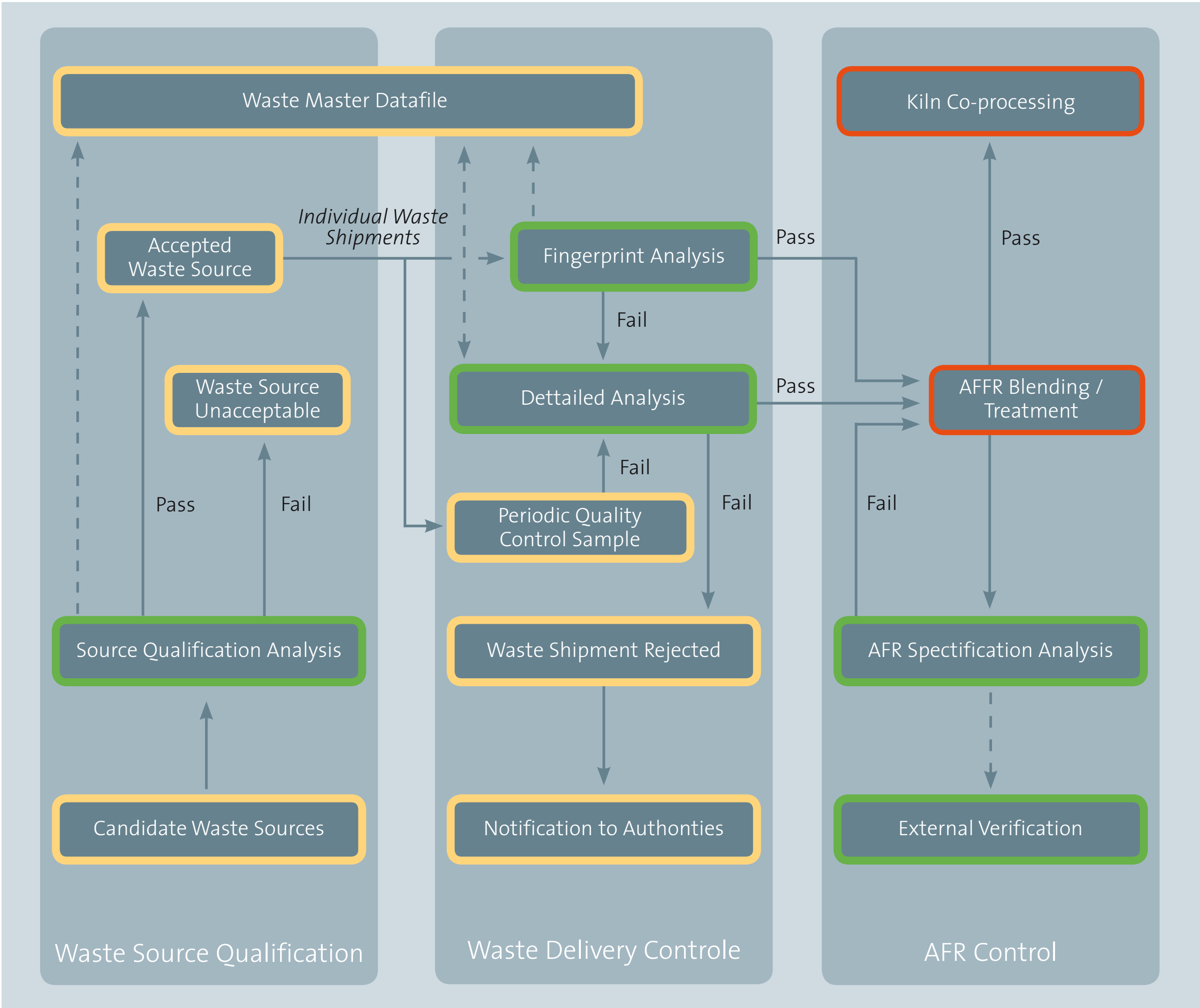
Quality control

Comments	

Limiting factors for utilisation

Market availability	☐	Handling problems	☐	Feeding capacity	☐	Cost	☐
Main oxides	☐	Chlorids	☐	Trace elements	☐	Toxicity	☐

Annex 18: AFR Quality Control Scheme



Annex 19: Situation Analysis – how to do it

The following research tools are examples of how to do a situation analysis. The best will be to choose research tools that suit both your and your stakeholders' needs.

→ **Door knocking** – probably the least formal and most effective way to engender community spirit about your company in the neighborhood.

→ **Interviews** – one-on-one interviews provide you with concentrated information about a particular topic and the opportunity to probe further on specific points as needed.

→ **Questionnaires** – these include in person, telephone or mail surveys. Random selection of respondents is key to obtaining objective survey results.

→ **Needs assessment** – conducting a needs assessment with a small ‚focus' group of stakeholders is a formal method to gain valuable information about stakeholder needs and expectations. Focus groups can either be internal or external. The following four steps are recommended in conducting a needs assessment:

→ **Media monitoring** - this technique is used to gauge the company reputation. This includes analyzing positive, negative or neutral stories in the media, number of mentions, length of stories, content and focus, etc. You can then interview selected journalists to gain more in-depth information.

Step I: Identify users and uses of the needs assessment

→ Identify the persons who will act on the assessment

→ Identify the use of the assessment e.g. provide a basis for the strategic plan

↓

Step II: Describe the context

→ What is the physical and social environment of your activities?

→ When have you started, or are you just starting?

→ Is this an initial assessment or are you trying to verify the appropriateness of your activities?

↓

Step III: Identify needs

→ Describe circumstances / problems of the stakeholders

→ Suggest possible solutions to their needs and analyse likely effectiveness, feasibility and sustainability

↓

Step IV: Meet needs and communicate results

→ Recommend actions based on the needs, problems, and solutions identified

→ Communicate the results of the assessment to your stakeholders

General and chemical abbreviations

General abbreviations

AFR	Alternative fuels and raw materials
ASR	Automotive shredder residues
BAT	Best Available Technology
BEP	Best Environmental Practice
BpD	Bypass dust (can in some cases be produced by SP/PC kilns)
BSE	Mad cow disease (Bovine Spongiform Encephalopathy)
CKD	Cement kiln dust (can in some cases be produced by long dry and wet (chain) kilns)
CP	Cleaner Production
CSI	Cement Sustainability Initiative
DRE	Destruction and Removal Efficiency
EC	European Community
EMR	Emission Monitoring and Reporting
ELV	Emission Limit Value
EPA	Environmental Protection Agency
ESP	Electrostatic Precipitator
HHV	High Heating Value
IGO	International governmental organizations
LCA	Life Cycle Analysis
MBI	Market-based instruments
NGO	Non-Governmental Organization
OEL	Occupational exposure limits
OH&S	Operational Health and Safety
POPs	Persistent organic pollutants
RDF	Refuse derived fuels
SNCR	Selective non-catalytic reduction
SP/PC	SP = Suspension (or cyclone) preheater kiln PC = Precalciner kiln (also includes a cyclone preheater)
TOC	Total organic carbon
UNEP	United Nations Environment Programme
VDI	German Association of Engineers
WBCSD	World Business Council for Sustainable Development
µS	µ-Sievert

General and chemical abbreviations

Chemical abbreviations

Al_2O_3	Aluminum oxide
As	Arsenic
BTX (C_6H_6)	Benzene
BTX	Benzene, toluene, xylene
$CaCO_3$	Calcium carbonate
Cd	Cadmium
Co	Cobalt
CO	Carbon monoxide
CO_2	Carbon dioxide
Cr	Chromium
Cu	Copper
Fe_2O_3	Iron oxide
HCB	Hexachlorobenzene
HCl	Hydrogen chloride
HF	Hydrogen fluoride
Hg	Mercury
CH_4	Methane
Mn	Manganese
NH_3	Ammonia
NO_x	Nitrogen oxides
Ni	Nickel
O_2	Oxygen
PAH	Polyaromatic hydrocarbons
Pb	Lead
PCBs	Polychlorinated biphenyls
PCDDs	Polychlorinated dibenzodioxins
PCDFs	Polychlorinated dibenzofurans
Sb	Antimony
SO_2	Sulfur dioxide
SO_x	Sulfur oxides
SiO_2	Silicon dioxide
TCE	Trichlorethylene
TCM	Tetrachloromethane
Tl	Tallium
V	Vanadium
VOC	Volatile organic compound
Zn	Zinc

Glossary

Alternative fuels and raw materials (AFR)
Inputs to clinker production derived from waste streams that contribute energy and raw material.

Clinker
An intermediate product in cement manufacturing produced by decarbonizing, sintering and fast-cooling ground limestone.

Concrete
A material produced by mixing cement, water and aggregates. The cement acts as a binder, and the average cement content in concrete is about 15%.

Corporate social responsibility (CSR)
The commitment of business to contribute to sustainable development, working with employees, their families, the local community and society at large to improve their quality of life.

Dust
Total clean gas dust after de-dusting equipment. (In the case of cement kiln main stacks, more than 95% of the clean gas dust has PM10 quality, i.e. is particulate matter (PM) smaller than 10 microns.)

Eco-efficiency
Reduction in the resource intensity of production, i.e. the input of materials, natural resources and energy compared with the output: essentially, doing more with less.

Electronic waste
This is waste from electrical and electronic equipment including all components, subassemblies and consumables which are part of the product at the time of discarding (def. according to EU-Directive 2002/96/EC from January 2003).

End-of-life application
Concrete debris which is not reused but disposed of in a landfill ("end of life").

Fossil fuels
Non-renewable carbon-based fuels traditionally used by the cement industry, including coal and oil.

Industrial ecology
Framework for improvement in the efficiency of industrial systems by imitating aspects of natural ecosystems, including the transformation of wastes to input materials; one industry's waste becomes another industry's input.

Kiln
Large industrial oven for producing clinker used in the manufacture of cement. In this report, "kiln" always refers to a rotary kiln.

Leaching
The extraction, by a leachant (de-mineralized water or others) of inorganic and/or organic components of a solid material, into a leachate by one or more physical-chemical transport mechanisms.

Lost time injury
A work-related injury after which the injured person cannot work for at least one full shift or full working day.

Occupational health and safety (OH&S)
Policies and activities to promote and secure the health and safety of all employees, subcontractors, third parties and visitors.

Quality
Quality is defined as the degree to which a set of inherent characteristics fulfils requirements (def. according to ISO 9000).

Stakeholder
A group or an individual who can affect or is affected by an organization or its activities.

Stakeholder dialogue
The engagement of stakeholders in a formal and/or informal process of consultation to explore specific stakeholder needs and perceptions.

Waste
Any substance or object that the holder discards or intends or is required to discard or has to be treated in order to protect the public health or the environment.

Notes

Notes

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