巻末付属資料２

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GUIDELINES ON ENVIRONMENTALLY SOUND CO-PROCESSING OF SCHEDULED WASTES IN CEMENT INDUSTRY IN MALAYSIA

DEPARTMENT OF ENVIRONMENT MALAYSIA

GUIDELINES ON ENVIRONMENTALLY SOUND CO-PROCESSING OF SCHEDULED WASTES IN CEMENT INDUSTRY IN MALAYSIA

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1.0 INTRODUCTION

1.1 Management of scheduled wastes in Malaysia has been implemented based on the cradle to grave principle. However, in line with the development of new technology and current practice in the waste management hierarchy which promote reuse or recycling or reutilization of waste, a transformation in the waste management to another process-integrated technology, advocated as cradle to cradle approach has emerged. This approach promotes the use of waste whenever possible, as alternative raw material or alternative fuel to substitute the raw material, without jeopardizing the quality of the same product. This will subsequently eliminate the need for waste disposal to landfills.

1.2 Shifting attitudes and better understanding from all stakeholders with regards to the importance of conserving the natural resource and pollution prevention to protect the environment, this waste to wealth practice has shown an increasing trend globally, as well as in Malaysia. Nowadays, industries in Malaysia have shown their interest to choose the disposal of waste to landfills as the last option, by sending the scheduled waste to recovery facilities to recover the valuable components, as well as to be co-processed in cement industries as alternative raw material and cement additives.

1.3 Co-processing is the use of scheduled waste as a raw material or as a source of energy or both as an alternative to natural mineral resources and fossil fuel in cement production.

1.4 Co-processing of wastes in properly controlled cement kilns provides energy and materials recovery while cement is being produced, offering an environmentally sound recovery option for many waste materials. Properly controlled co-processing can provide a practical, cost-effective and environmentally preferred option to landfill and incineration. In general, co-processing of waste in resource-intensive processes can be an important element in a more sustainable system of managing raw materials and energy.

1.5 Scheduled wastes to be used as alternative raw material or alternative fuel or additives in cement industries have certain components or characteristics that make them suitable for such purpose. Examples of scheduled waste which has been approved by Department of Environment to be co-processed by cement plant in Malaysia are as in **Table 1**:

Purpose of co-processing	**Waste code under First Schedule, Environmental Quality (Scheduled Waste) Regulations 2005**	**Type of waste**
Alternative raw material	SW 104	Used copper slag Used garnets Spent pot linings

	SW 204	Sludges containing one or several metals including chromium, copper, nickel, zinc, lead, cadmium, aluminium, tin, vanadium and beryllium
	SW 207	Sludges containing flouride
Cement additive	SW 104	Fly ash from coal-based powerplant
	SW 205	FGD gypsum from coal-based power plant Gypsum from chemical plant

Table 1: Examples of scheduled wastes approved for co-processed in cement industry

2.0 SCOPE

These guidelines are prepared to promote and facilitate the cement industry to plan and implement co-processing activities in their premise in an environmentally sound manner, without jeopardising the quality of cement.

3.0 OBJECTIVE

These guidelines are prepared as a guidance document for cement plants who intend to use scheduled wastes as alternative raw material and/or alternative fuel and/or cement additive in the production of cement product, in an environmentally sound manner.

These guidelines will also:

(a) Promote waste-to-wealth concept.

(b) Outline the legal requirement and procedure to implement co-processing activity in cement plant.

(c) Ensure the implementation of co-processing activity in cement plant is in compliance with Environmental Quality Act 1974 and all Regulations, Order and Rules under the Act.

4.0 DEFINITION

For the purpose of these guidelines, the definitions of terms used are as follows:

Aggregates	Particulate materials used in construction such as sand, gravel, crushed stone and crushed slag
Alkali bypass	A duct located between the feed end of the kiln and the preheater tower. A portion of the kiln exit gas is withdrawn through this and quickly cooled by air or water to avoid excessive alkali, chloride and sulphur build-up on the raw feed. This is also known as kiln exhaust gas bypass.
Alternative fuels and raw materials (AFR)	Inputs to clinker production derived from waste streams that contribute energy and/or raw material.
Alternative fuels	Wastes with recoverable energy value, used as fuels in a cement kiln, replacing a portion of conventional fossil fuels such as coal. Other terms include: secondary, substitute or waste derived fuels.
Alternative raw materials	Waste materials containing useable minerals such as calcium, silica, alumina and iron, which can be used in the kiln to replace raw materials such as clay, shale and limestone. Also known as secondary or substitute raw materials.
Best available techniques (BAT)	The most effective methods of reducing emissions and the impact on the environment as a whole.
Bypass dust	Dust discarded from the bypass systems of the suspension preheater, precalciner and grate preheater kilns, consisting of fully calcined, kiln feed material.
Calcination	Heat-induced removal, or loss of chemically-bound volatiles other than water. In cement manufacture this is the thermal decomposition of calcite (calcium carbonate) and other carbonate minerals that gives a metallic oxide (mainly CaO) plus carbon dioxide.
Cement kiln dust (CKD)	The fine-grained, solid, highly alkaline material removed from cement kiln exhaust gas by air pollution control devices. Much of the CKD material is unreacted raw material, including raw mix at various stages of burning and particles of clinker. The term can be used to denote any dust from cement kilns, such as that coming from bypass systems.
Cement	Finely ground inorganic material that, when mixed with water, forms a paste that sets and hardens by means of hydration reactions and processes and that, after hardening, retains its strength and stability under water.

Clinkering	The thermo-chemical formation of clinker minerals, especially to those reactions occurring above about 1,300° C; also the zone in the kiln where this occurs. Also known as sintering or burning.
Co-processing	The use of suitable waste materials in manufacturing processes for the purpose of energy and/or resource recovery and resultant reduction in the use of conventional fuels and/or raw materials through substitution.
Destruction and removal efficiency (DRE)	Efficiency in destruction and removal of a given organic compound. Mathematically, DRE is calculated as follows: DRE = [(*W*in – *W*out stack)/*W*in] × 100 where *W*in is the mass feed rate of one principal organic hazardous constituent (POHC) in the waste stream fed to the kiln, and *W*out stack is the mass emission rate of the same POHC in the exhaust emissions prior to release to the atmosphere.
Destruction efficiency (DE):	A measure of the percentage of a given organic compound that is destroyed by the combustion process. Mathematically, DE is calculated as follows: DE = [(*W*in – *W*out combustion chamber)/*W*in] × 100 where *W*in is the mass feed rate of one principal organic hazardous constituent (POHC) in the waste stream fed to the kiln, and *W*out combustion chamber is the mass emission rate of the same POHC leaving the kiln (upstream of all air pollution control equipment). The DE represents the fraction of the organics entering a kiln, which is actually destroyed; the DRE represents the fraction of the organics entering a kiln and emitted from the stack to the atmosphere
Dry process	Process technology for cement production. In the dry process, the raw materials enter the cement kiln in a dry condition after being ground to a fine powder called the raw meal. The dry process consumes less energy than the wet process, where water is added to the raw materials during grinding to form slurry.
Emissions testing	Manual collection of stack gas samples, followed by chemical analysis to determine pollutant concentrations.
Heating (calorific) value	The heat per unit mass produced by complete combustion of a given substance. Calorific values are used to express the energy values of fuels, usually expressed in megajoules per kilogram (MJ/kg).

Kiln line The part of the cement plant that manufactures clinker; comprises the kiln itself, any preheaters and precalciners and the clinker cooler apparatus.

Kiln The heating apparatus in a cement plant for manufacturing clinker. Unless otherwise specified, it may be assumed to refer to a rotary kiln.

Precalciner A kiln line apparatus, usually combined with a preheater, in which partial to almost complete calcination of carbonate minerals is achieved ahead of the kiln itself, and which makes use of a separate heat source. A precalciner reduces fuel consumption in the kiln, and allows the kiln to be shorter, as it no longer has to perform the full calcination function.

Preheater An apparatus for heating the raw mix before it reaches the dry kiln itself. In modern dry kilns, the preheater is commonly combined with a precalciner. Preheaters use hot exit gases from the kiln as their heat source.

Pre-processing Alternative fuels and/or raw materials not having uniform characteristics must be prepared from different waste streams before being used as such in a cement plant. The preparation process, or pre-processing, is needed to produce a waste stream that complies with the technical and administrative specifications of cement production and to guarantee that environmental standards are met.

Raw mix/meal/feed The crushed, ground, proportioned, and thoroughly mixed raw material-feed to the kiln line.

Recovery Any operation where waste is serving a useful purpose by replacing other materials that would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy.

Rotary kiln A kiln consisting of a gently inclined, rotating steel tube lined with refractory brick. The kiln is fed with raw materials at its upper end and heated by flame from, mainly, the lower end, which is also the exit end for the product (clinker).

Trial burn Emissions testing performed for demonstrating compliance with the destruction and removal efficiency (DRE) and destruction efficiency (DE) performance standards and regulatory emission limits; is used as the basis for establishing allowable operating limits.

5.0 OVERVIEW OF CEMENT MANUFACTURING

5.1 The crucial constituent in concrete is cement. It is a non-metallic, inorganic fine powder, which will forms into paste, set and harden when mixed with water.

5.2 Cement production involves the heating, calcining and sintering of an accurate mix of calcareous and argillaceous materials, usually limestone and clay. This produces cement clinker, which is then cooled and ground with additives such as gypsum to make cement.

5.3 The most widely used production process is for Portland cement clinker, described in more detail in **Annex 1** of these guidelines.

5.4 Cement manufacturing is a resource intensive industry. It require about 1.5–1.7 tonnes of quarried raw material to produce a tonne of clinker, and the cement kilns require substantial energy with temperatures of over 2,000° C . Each tonne of cement produced typically requires 60–130 kilograms of fuel oil, or its equivalent, and about 105 KWh of electricity (Loréa, 2007). On average, energy costs of fuel and electricity represent 40 per cent of cement manufacturing costs (EIPPCB, 2010).

5.5 Clinker burning is the most important phase of the production process in terms of the environmental impact associated with cement manufacture. Depending on the specific production processes, cement plants cause emissions to air and waste emissions to land such as cement kiln dust (CKD). Other impacts to the environment are discharge to water, noise and odour pollution.

5.6 The pollutants released to air are particulates, nitrogen oxides (NO_X) and sulphur dioxide (SO_2), carbon oxides (CO, CO_2), polychlorinated dibenzo-p-dioxins and dibenzofurans (PCCDs/PCDFs), volatile organic compounds (VOC), metals and their compounds, hydrogen chloride (HCl) and hydrogen fluoride (HF). The type and quantity of air emissions depend on varying parameters, for example, the raw materials and fuels used and the type of process.

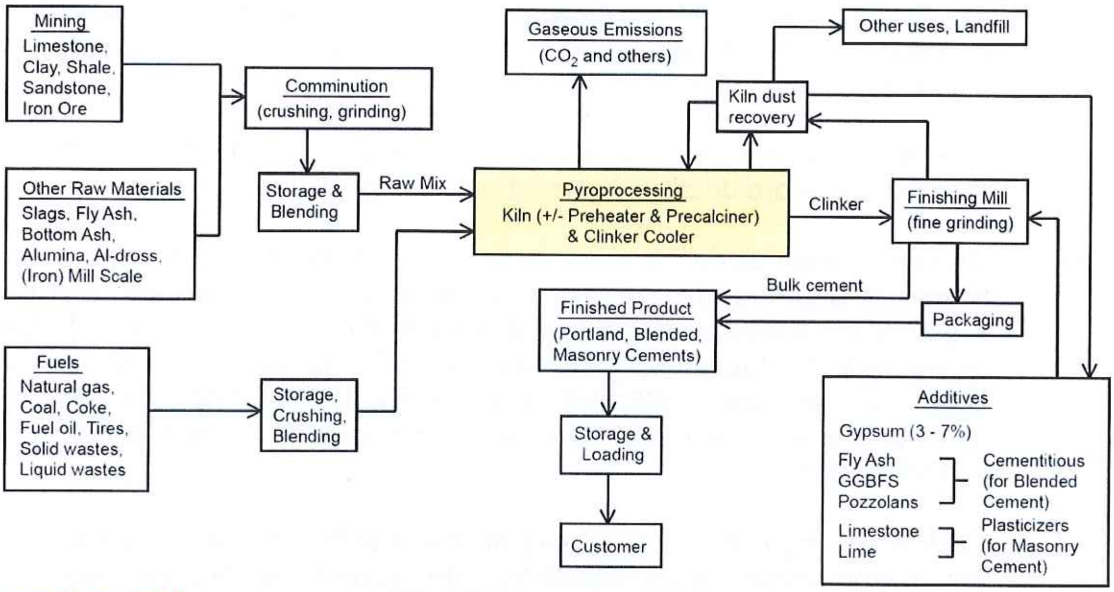
5.7 Cement manufacturing is also associated with impacts of resource extraction (fossil fuel, limestone and other minerals) upon environmental quality, biodiversity, landscape aesthetics and the depletion of non-renewable or slowly renewable resources, such as fossil fuels or groundwater (Battelle, 2002).

6.0 CO-PROCESSING OF SCHEDULED WASTE IN CEMENT KILNS

6.1 Overview

6.1.1 Co-processing involves the use of waste in manufacturing processes for the purpose of energy and resource recovery by substituting or reducing the use of conventional fuels and raw materials. In particular, the co-processing of scheduled waste in cement kilns allows the recovery of the energy and mineral value from waste while cement is being produced. Co-processing wastes serve a useful purpose in replacing materials that would have otherwise been used in cement manufacturing, thereby conserving natural resources. **Figure 1** provides a process flow diagram of the general cement manufacturing process

Figure 1 - General cement manufacturing process



Source: van Oss (2005)

Note:

1. *Fly ash used as other raw material referred to fly ash from incinerators, emission control equipments and etc. That fulfilled the Waste Acceptance Criteria for alternative raw material.*
2. *Fly ash used as additive referred to fly ash coal-based power plant that fulfilled the Waste Acceptance Criteria for cement additive.*

6.1.2 Cement manufacture generally can consume significant quantities of wastes as fuel and alternative raw materials. This consumption reflects the process characteristics in clinker kilns, which ensure the complete breakdown of the raw materials into their component oxides and the recombination of the oxides into the clinker minerals. The essential process characteristics for the use of hazardous and other wastes, fed to the kiln via appropriate feed points, can be summarized as follows (EIPPCB, 2010):

(a) Maximum temperatures of approximately 2,000° C (main firing system, flame temperature) in rotary kilns;

(b) Gas retention times of about 8 seconds at temperatures above 1,200° C in rotary kilns;

(c) Material temperatures of about 1,450° C in the sintering zone of rotary kilns;

(d) Oxidising gas atmosphere in rotary kilns;

(e) Gas retention time in the secondary firing system of more than 2 seconds at temperatures above 850° C; in the pre-calciner, the retention times are correspondingly longer and temperatures are higher;

(f) Solids temperatures of 850° C in the secondary firing system and/or the calciner;

(g) Uniform burnout conditions for load fluctuations due to the high temperatures at sufficiently long retention times;Destruction of organic pollutants because of high temperatures at sufficiently long retention times;

(h) Sorption of gaseous components such as HF, HCl, and SO_2 on alkaline reactants;

(i) High retention capacity for particle-bound heavy metals;\

(j) Short retention times of exhaust gases in the temperature range known to lead to formation of PCDDs/PCDFs;

(k) Simultaneous material recycling and energy recovery through the complete use of fuel ashes as clinker components;

(l) Product-specific wastes are not generated due to a complete material use into the clinker matrix (although some cement plants dispose of CKD or bypass dust);

(m) Chemical-mineralogical incorporation of non-volatile heavy metals into the clinker matrix.

6.1.3 Potential benefits possible through the use of hazardous and other wastes in cement manufacturing are the recovery of the energy content of waste, conservation of non-renewable fossil fuels and natural resources, reduction of CO_2 emissions, reduction in production costs, and use of an existing technology to treat hazardous wastes (see, for example, Mantus, 1992; Battelle, 2002; WBCSD, 2005; Karstensen, 2007b).

6.1.4 Co-processing of scheduled wastes in cement kilns shall be carried out only according to best available techniques (BAT) while meeting requirements set out for input, process and emission. **Table 2** outlined the general principles for co-processing of scheduled wastes and other wastes in cement kilns.

Principle	Description
The waste management hierarchy should be respected	– Waste should be co-processed in cement kilns where more ecologically and economically robust methods of recovery are not available – Co-processing should be considered an integrated part of waste management

Principle	Description
	– Co-processing should be in line with the Basel and Stockholm Conventions and other relevant international environmental agreements
Additional emissions and negative impacts on human health must be avoided	– Negative effects of pollution on the environment and human health must be prevented or kept at a minimum – Air emissions from cement kilns co-processing waste cannot be statistically higher than those not involved in co-processing waste
The quality of the cement must remain unchanged	– The product (clinker, cement, concrete) must not be used as a sink for heavy metals – The product must not have any negative impacts on the environment (for example, as determined by leaching tests) – The quality of the product must allow for end-of-life recovery
Companies that co-process must be qualified	– Assure compliance with all laws and regulations – Have good environmental and safety compliance records – Have personnel, processes, and systems in place committed to protecting the environment, health, and safety – Be capable of controlling inputs to the production process – Maintain good relations with public and other parties involved in local, national and international waste management schemes

Table 2 - the general principles for co-processing of hazardous and other wastes in cement kilns
Source: GTZ (2006)

6.2 Selection Of Wastes For Co-Processing

6.2.1 Co-processing should include a thorough selection of waste to avoid and/or reduce emissions and risk of damage to the environment or public health as well as to maintain the quality of cement products.

6.2.2 The use of scheduled wastes in cement manufacturing should add value to the process, for example the heating value and the material value of the mineral composition, while in compliance to the relevant regulations and permit requirements as well as the plant's ability to handle any particular waste stream. The use of cement kilns as a disposal operation not leading to resource recovery (i.e., the destruction or irreversible transformation of scheduled wastes constituents), should be considered only if there are environmental benefits : for example, NOx reduction through flame cooling or when there is no other cost-effective and environmentally sound disposal option at the local level.

6.2.3 Blending and mixing of different scheduled wastes streams may be required to ensure a homogeneous feedstock of alternative raw material that meets specifications for use in a cement kiln. Blending of scheduled wastes should not, however, be conducted with the aim of lowering the concentration of hazardous constituents to circumvent regulatory requirements. As a general principle, the mixing of wastes should be prevented from leading to the application of an unsuitable (non-environmentally sound) disposal operation (EIPPCB, 2006) .

6.3 Scheduled Wastes Suitable For Co-Processing In Cement Kilns

6.3.1 The selection of suitable scheduled wastes to be used as alternative raw material in co-processing is influenced by various factors includes:

(a) the nature of the waste;

(b) its hazardous characteristics;

(c) available waste management operations;

(d) kiln operation; raw material and fuel compositions; waste feed points;

(e) exhaust gas cleaning process;

(f) resulting clinker quality;

(g) general environmental impacts;

(h) probability of formation and release of POPs;

(i) particular waste management considerations; and

(j) regulatory compliance; and public and government acceptance (Van Oss and Padovani, 2003; GTZ, 2006; UNEP, 2007; EIPPCB, 2010).

6.3.2 The operator should develop a waste evaluation procedure to assess potential impacts on the health and safety of workers and the public, plant emissions, operations and product quality, by taking the recommended variables as in **Table 3**, into consideration when selecting the waste (WBCSD, 2005; UNEP, 2007):

Variables		Explanation
Kiln operation	Alkali (sodium, potassium, etc.), sulphur and chloride content	• Excessive inputs of these compounds may lead to build-up and blockages in the kiln system. Where these cannot be captured in the cement clinker or kiln dust, a bypass may be required to remove excess compounds from preheater/precalciner kiln systems. High alkali content may also limit recycling of CKD in the kiln itself
	Heating (calorific) value	• The key parameter for the energy provided to the process
	Water content	• Overall moisture content may affect productivity, efficiency and also increase energy consumption. The water content of waste needs to be considered in conjunction with that of conventional fuels and/or raw feed materials
	Ash content	• The ash content affects the chemical composition of the cement and may require an adjustment of the composition of the raw mix
	Exhaust gas flow rate and waste feed rate	• Sufficient residence time is needed for the destruction of organics and to prevent incomplete combustion due to waste overcharging
	Others	• Stability of operation (for example, duration and frequency of CO trips) and the waste's state (liquid, solid), preparation (shredded, milled) and homogeneity
Emissions	Organic content	• Organic constituents are associated with emissions of CO_2 and may result in emissions of CO and other products of incomplete combustion (PICs) if waste is

		fed through unsuitable points or during unstable operating conditions
	Chloride content	• Chlorides may combine with alkalis to form fine, difficult to control particulate matter. In some cases, chlorides have combined with ammonia present in the limestone feed. This produces highly visible detached plumes of fine particulate with a high ammonium chloride content
	Metals content	• The non-volatile behaviour of most heavy metals allows most to pass straight through the kiln system and be incorporated into the clinker. • Introduced volatile metals will partly be recycled internally by evaporation and condensation until equilibrium is reached, the other part being emitted in the exhaust gas. • Thallium, mercury and their compounds are highly volatile as to a lesser extent are cadmium, lead, selenium and their compounds. • The fact that dust control devices can only capture the particle-bound fraction of heavy metals and their compounds needs to be taken into account. • Wood treated with preservatives containing copper, chromium and arsenic also requires special consideration with regard to the efficiency of the exhaust gas cleaning system. • Mercury is a highly volatile metal, which, depending on the exhaust gas temperature is present in both particle-borne and vapour forms in the air pollution control equipment (EIPPCB, 2010).

	Alkali bypass exhaust gas	• Alkali bypass exhaust gas can be released from either a separate exhaust stack or from the main kiln stack in systems equipped with an appropriate bypass. • According to the United States Environmental Protection Agency (1998) the same hazardous air pollutants are found in both the main and alkali bypass stacks. Where an alkali bypass system is installed, appropriate control of the exhaust to atmosphere also needs to be provided on the bypass exhaust, similar to that mandated for the main exhaust stack (UNEP, 2007)
	Sulphur content	• High sulphur content in raw materials, fuel and waste may result in the release of SO_2
Clinker, cement and final product quality	Phosphate content	• High levels of phosphate may delay setting time
	Flourine content	• High levels of fluorine will affect setting time and strength development
	Chlorine, sulphur and alkali content	• High levels chlorine, sulphur and alkali may affect overall product quality
	Thallium and chromium content	• Thallium and chromium content can adversely affect cement quality and may cause allergic reactions in sensitive users. • Leaching of chromium from concrete debris may be more prevalent than leaching of other metals (Van der Sloot et al., 2008). • Limestone, sand and clay contain chromium, making its content in cement both unavoidable and highly

		variable. The Norwegian National Institute of Occupational Health (Kjuus et al., 2003) reviewed several studies of chromate allergy, especially those involving construction workers. It found that the main sources of chromium in cement came from raw materials, refractory bricks in the kiln and chromium steel grinders. The relative contribution of these factors may vary depending on the chromium content of the raw materials and the manufacturing conditions. Minor sources include both conventional and alternative fuels (EIPPCB, 2010). • Cement eczema can be caused by exposure to wet cement with a high pH, which induces irritant contact dermatitis and by an immunological reaction to chromium that elicits allergic contact dermatitis (Kjuus et al., 2003). • Where there is a possibility of contact with the skin, cement and cement-containing preparations may not be used or placed on the market in the European Union, if they contain, when hydrated, more than 0.0002 per cent soluble chromium (VI) of the total dry weight of the cement. • As the main chromate source is from the raw material, a reduction in chromium levels (VI) in cement requires that a reducing agent is added to the finished product. The main reducing agents used in Europe are ferrous sulphate and tin sulphate (EIPPCB, 2010)
	Leachable trace elements:	• Heavy metals are present in all

		feed materials, conventional and otherwise. However under certain test conditions, leached concentrations from concrete of other metals besides chromium may approach drinking water standards (GTZ, 2006).

Table 3: Variables that should be taken in consideration when selecting Scheduled Wastes for co-processing

6.3.3 Only waste of known composition, energy and mineral value is suitable for co-processing in cement kilns. To verify the suitability of a particular scheduled wastes stream to be used in co-processing at their cement plant, the operators should develop a specific Waste Acceptance Criteria for each of the following purposes:

(a) Scheduled wastes used as alternative raw material;

(b) Scheduled wastes used as alternative fuel; and

(c) Scheduled wastes used as cement additive.

6.3.4 In order to ensure the use of scheduled wastes as raw material does not affect the quality of raw meal which consists of blended scheduled wastes and other raw material, a specific Raw Meal Acceptance Criteria should be established.

6.3.5. The Waste Acceptance Criteria and Raw Meal Acceptance Criteria should at least include the following parameter and the limit for each parameter should be specified:

Waste Acceptance Criteria for alternative raw material:

(a) Major oxides – Silica (SiO_2), calcium oxide (CaO), alumina (Al_2O_3), and iron oxide (Fe_2O_3) in dry basis

(b) Moisture content

(c) Metal content

(d) Alkali, Sulphur, Flourine and Chloride Content

(e) Other related concerned parameters (if any)

-TO BE DISCUSSED FURTHER WITH CEMENT INDUSTRY-

Waste Acceptance Criteria for alternative fuel:

- Water content, calorific heating value, flash point, SG, sulphur content, heavy metal content

-KIV: TO BE DISCUSSED FURTHER WITH CEMENT INDUSTRY-

Waste Acceptance Criteria for cement additive

-KIV: TO BE DISCUSSED FURTHER WITH CEMENT INDUSTRY-

Raw Meal Acceptance Criteria

-KIV: TO BE DISCUSSED FURTHER WITH CEMENT INDUSTRY-

The cement plant shall ensure that the scheduled wastes received to be co-processed and the raw meal fulfilled the requirements specified in the Waste Acceptance Criteria and Raw Meal Acceptance Criteria.

6.3.6 The following scheduled wastes are not allowed for co-processing in cement kilns:

(a) Radioactive or nuclear waste;

Cement plants are not designed or operated to meet safety and health requirements for radioactive waste management. The preferred disposal approach is concentration (reduction of volume) and containment of radionuclides through a conditioning process to prevent or substantially reduce dispersion in the environment.

(b) Electric and electronic waste;

Electric and electronic waste contains valuable resources, such as precious metals and recycling should be the preferred option. Co-processing of plastic components might be an option but only after appropriate disassembly and sorting.

(c) Whole batteries;

Co-processing of batteries would lead to concentrations of pollutants in the cement and air emissions. Batteries contain valuable resources such as lead and recycling should be the preferred waste management option.

(d) Corrosive waste, including mineral acids;

Corrosive wastes may cause corrosion and fouling problems in equipment not specifically designed for this type of waste. This being usually the case with pre-processing, storage and injection systems. Wastes with high chlorine and sulphur contents such as some mineral acids may also have a negative effect on clinker production or product quality. High sulphur contents may also result in the release of sulphur oxides (UNEP, 2007).

(e) Explosives;

Explosive waste should not be co-processed in the cement kiln given the adverse effects on process stability. There are also occupational safety concerns due to the risk of uncontrolled explosions during transport and pre-processing activities.

(f) Cyanide bearing waste;

(g) Asbestos-containing waste;

(h) Infectious medical waste;

(i) Chemical or biological weapons destined to destruction;

(j) Waste consisting of, containing or contaminated with mercury above permitted limits;

The high volatility of mercury poses a problem regarding air emissions. Inputs of wastes consisting of, containing or contaminated with mercury to the kiln should be controlled and kept to a minimum

(k) Waste of unknown or unpredictable composition, including unsorted municipal waste.

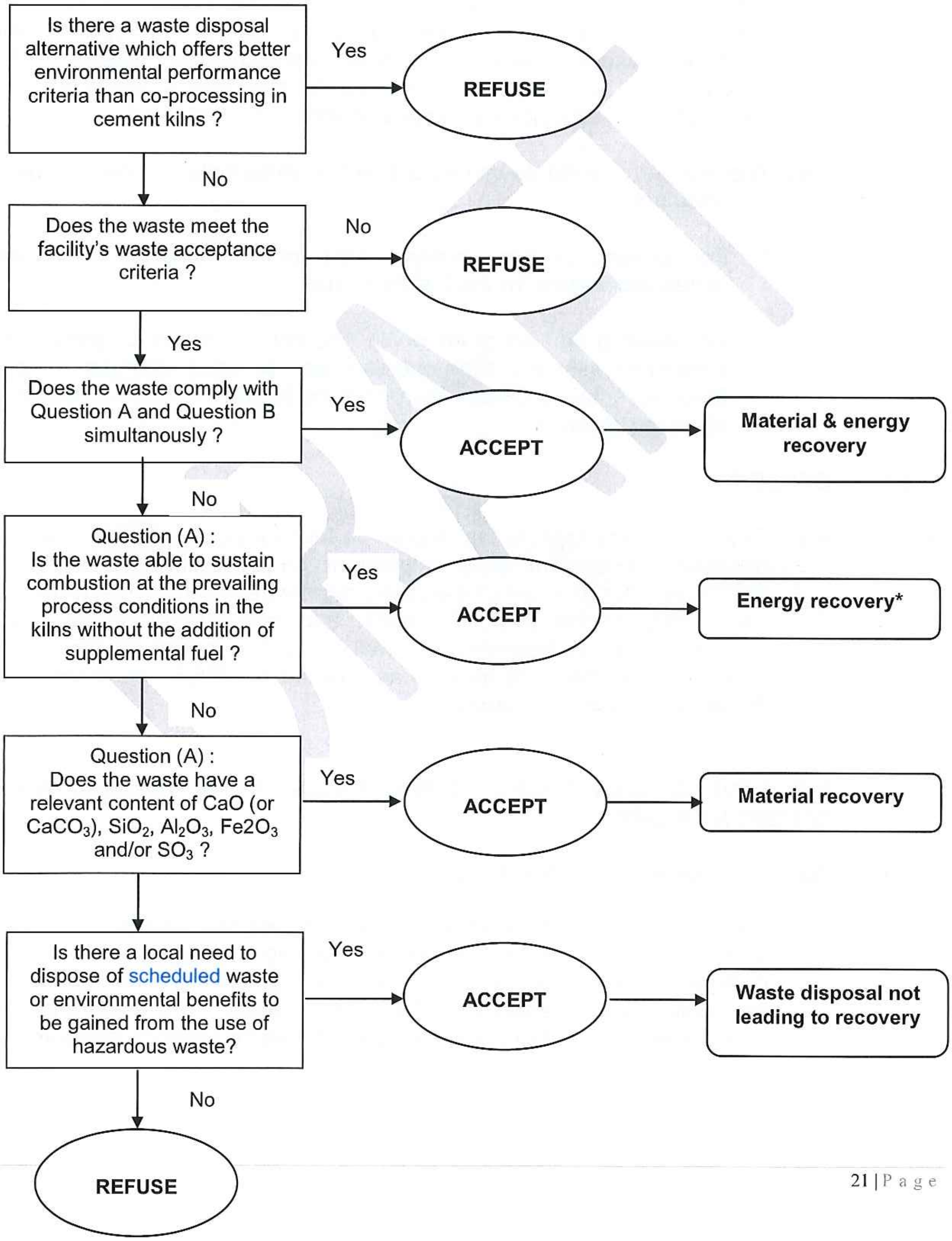
In general these wastes are not recommended because of health and safety concerns, potentially negative impacts on kiln operation, clinker quality and air emissions, and when a preferable alternative waste management option is available

6.3.7 Scheduled wastes that are, in principle, well-suited for co-processing in cement kilns include: tank bottom sludges, acid alkyl sludges, oil spills and acid tars from petroleum refining, natural gas purification and pyrolytic treatment of coal; waste machining oils; waste hydraulic oils and brake fluids; bilge oils; oil/water separator sludges, solids or emulsions; washing liquids and mother liquors,still bottoms and reaction residues from the manufacture, formulation, supply and use of basic organic chemicals, plastics, synthetic rubber, man-made fibres, organic dyes, pigments, organic pesticides andpharmaceuticals; waste ink; wastes from the photographic industry; tars and other carbon-containing wastes from anode manufacture (aluminium thermal metallurgy); wastes from metal degreasing and machinery maintenance; wastes from textile cleaning and degreasing of natural products; process wastes from the electronic industry (GTZ/Holcim, 2006).

6.3.8 Waste streams with recoverable energy value meet specifications can be used as fuels in a cement kiln to replace a portion of conventional fuels and waste streams containing useful components such as calcium, silica, alumina and iron can be used to replace raw materials such as clay, shale and limestone. Wastes meeting both sets of requirements may be suitable for processing for both energy and materials recovery.

6.3.9 **Figure 2** outlined the decision to distinguish between operations that lead to resource recovery and disposal.

Figure 2: Decision to distinguish between operations that lead to resource recovery and/or disposal.



6.4 Trial Burns Of Scheduled Wastes For Co-Processing In Cement Kilns

6.4.1 A trial burn is used to determine the facility's destruction and removal efficiency (DRE) or destruction efficiency (DE), to verify its ability to efficiently destroy POPs in an irreversible and environmentally sound manner. This involves the selection, sampling and analysis of a principal organic hazardous constituent (POHC) in the waste feed to determine its input and emission rates. A trial burn typically consists of a series of tests, one for each set of operating conditions in the facility. Three runs are normally performed for each test. During the trial burn, the operator should establish the operating limits for maximum scheduled wastes feed and maximum kiln production rate. The operator shall also schedule a sampling and analysis of emission by competent and accredited party.

6.4.2 The trial burn should be carried out by the cement plant under the following circumstances:

(a) For existing or new cement plant implementing co-processing of scheduled wastes for the first time; and

(b) For existing cement plant which already implement co-processing of scheduled wastes in their operation and to make changes in the Raw Meal Acceptance Criteria meant for the blended scheduled wastes and other raw material.

6.5 OTHERS

6.5.1 Other important aspects that should be taken into considerations when the operators of cement plant implement co-processing activity are the requirement for (i) a comprehensive programme on quality assurance (QA) and quality control (QC); (ii) health and safety program; and (iii) the involvement of stakeholders as well as public communication. Further information on three (3) aspects as outlined by UNEP are detailed out in **Annex 2**, **Annex 3** and **Annex 4.**

7.0 ENVIRONMENTALLY SOUND CO-PROCESSING OF SCHEDULED WASTES IN CEMENT KILNS

7.1 Waste Acceptance And Pre-Processing

7.1.1 Before a cement plant decide to receive scheduled wastes to be used as alternative raw material, the operator should investigate the nature and composition associated with the waste, and all relevant information should be passed by the waste generator to the operator. The waste should also be sampled and sent to accredited laboratories for chemical analysis.