"Capacity Building and Strengthening Institutional Arrangement"

Workshop: "Environmental Impact Assessment (EIA) (for Assessors)"

EIA of a Cement Industry

Evaluation of Impact Assessment in cement sector

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Cement

Cement is a basic material for building and civil engineering construction. Use of cement and concrete (a mixture of cement, aggregates, sand and water) in large civic works can be traced back to antiquity. Portland cement, the most widely used cement in concrete construction, was patented in 1824.

Output from the cement industry is directly related to the state of the construction business in general and therefore tracks the overall economic situation closely.

Cement

Cement is a finely ground, non-metallic, inorganic powder: when mixed with water forms a paste that sets and hardens.

This hydraulic hardening is primarily due to the formation of calcium silicate hydrates as a result of the reaction between mixing water and the constituents of the cement.

Raw Materials

- 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.

Raw Materials

- Power station ash, blast furnace slag, and other process residues can also be used as partial replacements for the natural raw materials, depending on their chemical suitability.
- Winning of nearly all of the natural raw materials involves quarrying and mining operations

Origin of raw material

The materials are most often obtained from open surface quarries. The operations necessary include rock drilling, blasting, excavation, hauling and crushing.

Main raw materials, like limestone, chalk marl and shale or clay, are extracted from quarries. In most cases the quarry is close to the plant. After primary crushing the raw materials are transported to the cement plant for storage and further preparation.

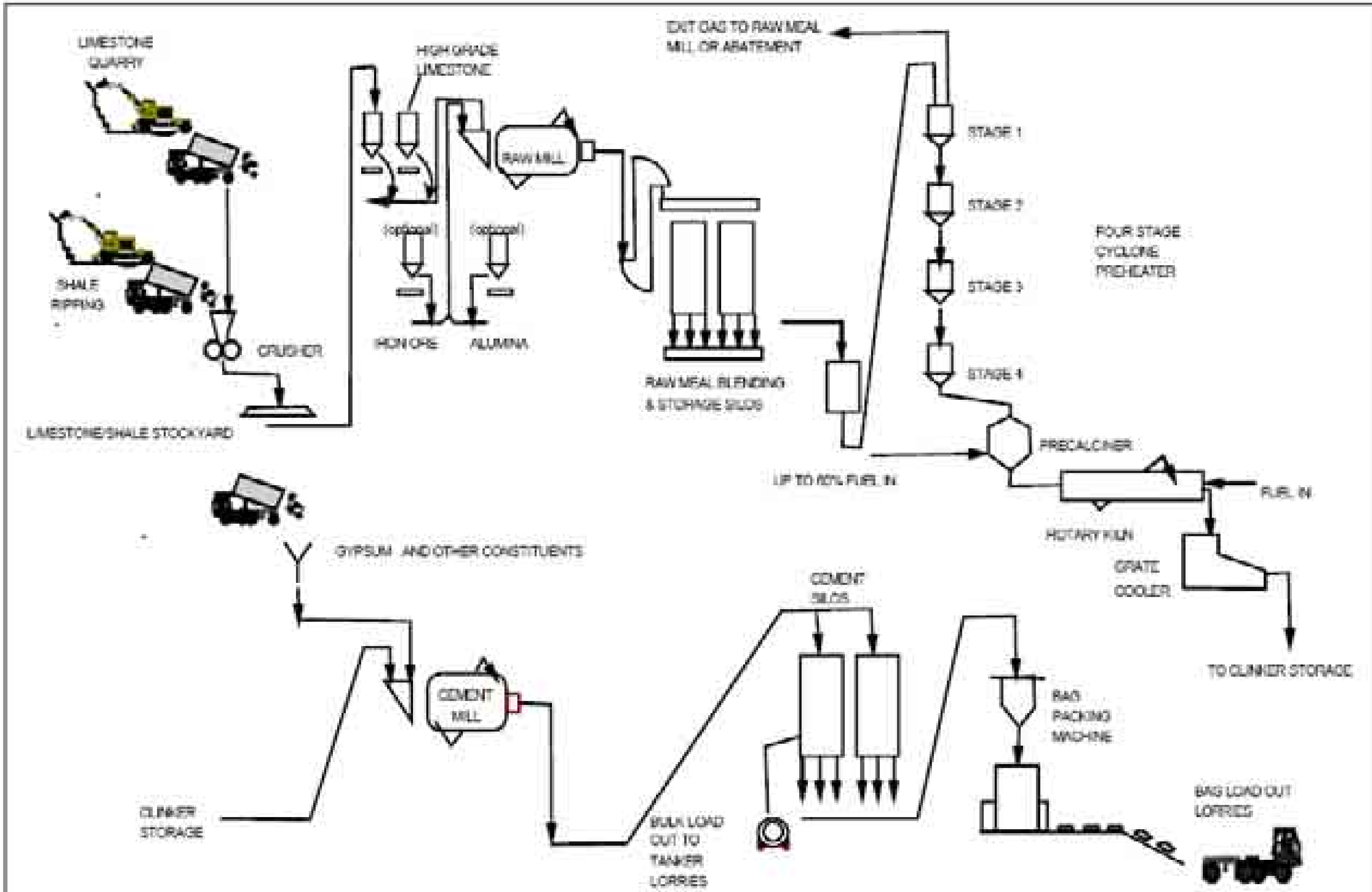


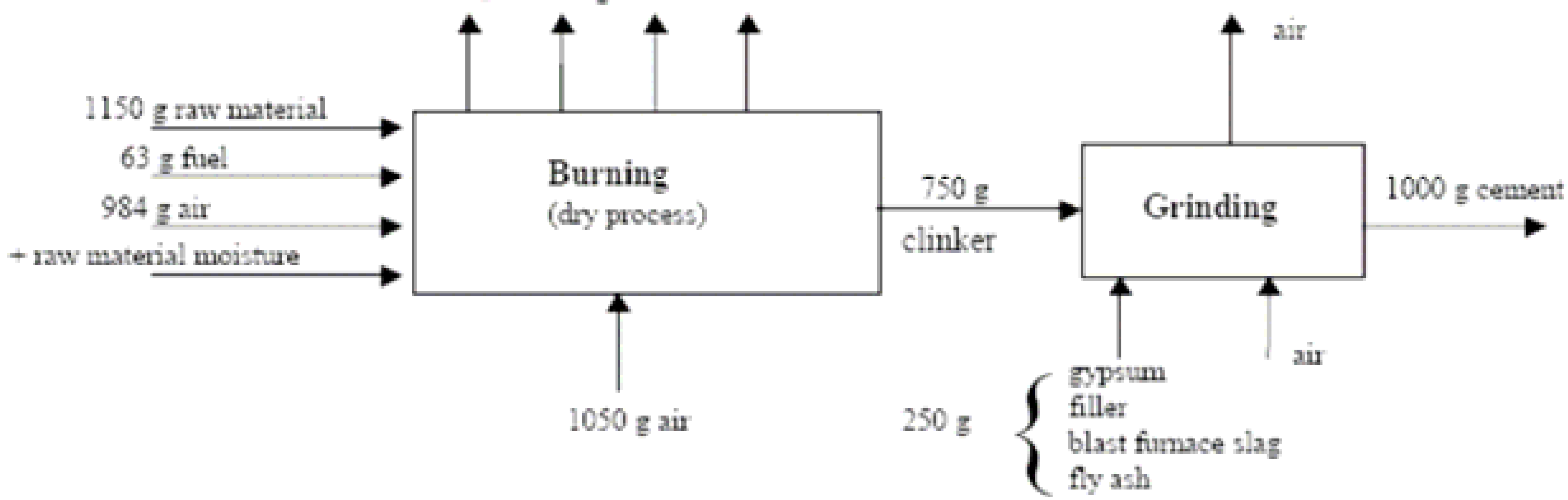
Figure shows an overview of a dry process precalciner

Mass Balance for 1 kg Cement

Raw meal factor: 1.54
Clinker factor: 0.75
Specific energy: 3.35 MJ/kg Clinker
Air: 10 - 11 Vol. % O_2

Fuel: heavy fuel oil
Calorific value: 40000 kJ/kg (on a dry basis)
10 % excess air

Emissions :
CO_2 600 g (404 g CO_2 from raw material, 196 g CO_2 from burning)
N_2 1566 g
O_2 262 g
H_2O 69 g + raw material moisture



Emissions from cement manufacturing plant

Relevant emissions from cement manufacturing plant are:

- \- Nitrogen oxides (NOx) and other nitrogen compounds;
- \- Sulphur dioxide (SO2) and other sulphur compounds;
- \- Dust.

Cement plant operation on air pollution and abatement techniques generally focus on these three pollutants.

Emissions from cement manufacturing plant

The following pollutants are also considered to be of concern for the production of cement:

- Carbon monoxide (CO)
- Volatile Organic Compounds (VOC).

Emissions from cement manufacturing plant

Other pollutants also to be considered in relation to the production of cement are:

- -Polychlorinated dibenzodioxins and dibenzofurans (PCDDs and PCDFs)
- Metals and their compounds
- HF, HCl

Emissions from cement manufacturing plant

Not mentioned in the list, but considered to be relevant for cement production is carbon dioxide (CO_2).

Other emissions, the effect of which is normally slight and/or local, are

- Waste
- Noise
- Odour

Emission ranges from European cement kilns

	mg/Nm^3	kg/tonne clinker	tonnes/year
NO_x (as NO_2)	<200–3000	<0.4-6	400-6000
SO_2	<10–3500	<0.02-7	<20-7000
Dust	5–200	0.01-0.4	10-400
CO	500–2000	1-4	1000-4000
CO_2	400-520 g/Nm^3	800-1040	0.8-1.04 million
TOC	5-500	0.01–1	10-1000
HF	<0.4-5	<0.8-10 g/t	<0.8-10
HCl	<1-25	<2-50 g/t	<2-50
PCDD/F	<0.1-0.5 ng/Nm^3	<200-1000 ng/t	<0.2-1 g/year
Metals:			
Σ (Hg, Cd, Tl)	0.01-0.3 (mainly Hg)	20-600 mg/t	20-600 kg/year
Σ (As, Co, Ni, Se, Te)	0.001-0.1	2-200 mg/t	2-200 kg/year
Σ (Sb, Pb, Cr, Cu, Mn, V, Sn, Zn)	0.005-0.3	10-600 mg/t	10-600 kg/year

Note: Mass figures are based on 2000 m^3/tonne clinker and 1 million tonnes clinker/year. Emission ranges are one-year averages and are indicative values based on various measurement techniques. O_2-content is normally 10%.

Table 1.8: Emission ranges data from European cement kilns
Based on [Cembureau report, 1997], [Cembureau], [Dutch report, 1997], [Haug], [Lohse]

Dust

Traditionally the emission of dust, particularly from kiln stacks, has been the main environmental concern in relation to cement manufacture. The main sources of dust are kilns, raw mills, clinker coolers and cement mills. In all these processes large volumes of gases are flowing through dusty materials.

Dust

The design and reliability of modern electrostatic precipitators and bag filters ensure dust releases can be reduced to levels where they cease to be significant.

Emission levels below 10 mg/m3 are achieved in some installations.

Dust

Fugitive dust emissions can arise during the storage and handling of materials and solid fuels, and also from road surfaces. Particulate releases from packing and dispatch of clinker/cement can also be significant.

The impact of fugitive emissions can be a local increase in levels of dust, whereas process dust emissions (generally from high stacks) can have impact on the air quality over a much larger area.

Dust

Dust may be generated during construction of and in the operation of a cement manufacturing plant.

During construction dust most often arises from vehicle movements on unsealed roads and from earth moving operations using construction plant such as excavators.

Dust

During operation of a cement manufacturing plant dust particles may be emitted from the following processes/activities:

- Quarrying operations of raw Materials
- Grinding and blending operations
- Stacks from the kiln operation
- Raw material storage
- Packing
- Transport between the processes
- Transport to and from the site

Dust

The accurate prediction of dust impacts is very difficult given the changing natural dust levels; an appropriate way of dealing with this subject is:

- To identify the main sources of dust attributable to the development and the scale on which dust may arise;
- To identify the people or resources that may be affected by this dust and the level of any nuisance caused; and
- To consider what measures should be taken to reduce dust from sources associated with the development to an acceptable level.

Dust

This approach is effectively based on reducing any emissions to a level which will not cause nuisance rather than attempting to predict impacts with precision. Data programmes modelling the dispersion can be an efficient tool when predicting the future impact from cement manufacturing plants.

Carbon oxides (CO_2, CO)

- The emission of CO_2 is estimated at 900 to 1000 kg/tonne clinker, related to a specific heat demand of approximately 3500 to 5000 MJ/tonne clinker, but also depending on fuel type.
- Due to cement grinding with mineral additions the emission of CO_2 is reduced when related to tonnes of cement (compare to Figure 1.7). Approximately 60% originates in the calcining process and the remaining 40% is related to fuel combustion. The CO_2 emissions resulting from the combustion of the carbon content of the fuel is directly proportional to the specific heat demand as well as the ratio of carbon content to the calorific value of the fuel.

Volatile Organic Compounds (VOCs)

- In heat (combustion) processes in general, the occurrence of volatile organic compounds (and carbon monoxide) is often associated with incomplete combustion.
- In cement kilns, the emission will be low under normal steady-state conditions, due to the large residence time of the gases in the kiln, the high temperature and the excess oxygen conditions. Concentrations may increase during start-up or upset conditions. These events can occur with varying frequency, for example between once or twice per week to once per two or three months.

Volatile Organic Compounds (VOCs)

Emissions of volatile organic compounds (VOCs) can occur in the primary steps of the process (preheater, precalciner), when organic matter that is present in the raw materials is volatilised as the feed is heated.

The organic matter is released between temperatures of 400 and 600 oC. The VOC content of the exhaust gas from cement kilns typically lies between 10 and 100 mg/Nm3, in rare cases emissions can reach as much as 500 mg/Nm3 because of the raw material characteristics.

Polychlorinated dibenzodioxins (PCDDs) and dibenzofurans (PCDFs)

- Any chlorine input in the presence of organic material may potentially cause the formation of polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in heat (combustion) processes.

- PCDDs and PCDFs can be formed in/after the preheater and in the air pollution control device if chlorine and hydrocarbon precursors from the raw materials are available in sufficient quantities. (Use of waste as fuel).

Polychlorinated dibenzodioxins (PCDDs) and dibenzofurans (PCDFs)

- The reformation of dioxins and furans is known to occur by de novo synthesis within the temperature window of cooling from 450 to 200 oC. Thus it is important that as the gases are leaving the kiln system they should be cooled rapidly through this range.
- Due to the long residence time in the kiln and the high temperatures, emissions of PCDDs and PCDFs is generally low during steady kiln conditions.
- The reported data indicate that cement kilns can mostly comply with an emission concentration of 0.1 ng TEQ/Nm3, which is the limit value in the European legislation for hazardous waste incineration plants (Council Directive 94/67/EC).

Metals and their compounds

- Raw materials and fuels will always contain metals. The concentrations vary widely from one location to another.
- Metal compounds can be categorised into three classes, based on the volatilities of the metals and their salts:

1. Metals which are or have compounds that are refractory or non-volatile: Ba, Be, Cr, As, Ni, V, Al, Ti, Ca, Fe, Mn, Cu and Ag;
2. Metals that are or have compounds that are semi-volatile: Sb, Cd, Pb, Se, Zn, K and Na;
3. Metals that are or have compounds that are volatile: Hg and Tl.

Waste

- Waste produced during clinker production consists basically of unwanted rocks, which are removed from the raw materials during the preparation of the raw meal, and kiln dust removed from the by-pass flow and the stack, which is not recycled.
- Filtrate from the filter presses used in the semi-wet process is fairly alkaline and contains suspended solids

Noise

- The heavy machinery and large fans used in cement manufacture can give rise to emissions of noise and/or vibration.

Odour

- Odour emissions are very rarely a problem with a well operated plant. If the raw material contain combustible components (kerogens) which do not burn when they are heated in the preheater, but instead only pyrolise, emissions of hydrocarbons can occur.
- This hydrocarbon emission can be seen above the stack as a ‘blue haze’ or plume and can cause unpleasant smell around the cement plant under unfavourable weather conditions.
- Burning of sulphur containing fuels and/or use of sulphur containing raw materials can lead to odour emissions (a problem especially encountered in shaft kilns).

Best available techniques for the cement industry

The techniques and associated emission and/or consumption levels, or ranges of levels, presented in this chapter have been assessed through an iterative process involving the following steps:

- identification of the key environmental issues for the sector; for the manufacture of cement these are energy use and emissions to air. The emissions to air from cement plants include nitrogen oxides (NOx), sulphur dioxide (SO_2) and dust;
- examination of the techniques most relevant to address those key issues;
- identification of the best environmental performance levels, on the basis of the available data in the European Union and world-wide;
- examination of the conditions under which these performance levels were achieved; such as costs, cross-media effects, main driving forces involved in implementation of this techniques;
- selection of the best available techniques (BAT) and the associated emission and/or consumption levels for this sector.

Impatto Ambientale/ Emissione	Misura	Livello di emissione associato alle BAT
Consumo di materie prime	Utilizzo di rifiuti per: ▪recupero di materia ▪recupero di energia	
	Riciclo nel processo della polvere captata dai presidi tecnici di abbattimento	
Consumo di energia termica	Preriscaldamento e precalcinazione, tenendo conto della configurazione del forno	
	Uso di moderni raffreddatori del clinker che consentano di massimizzare il recupero di calore	
	Recupero di calore dei gas esausti	
Consumo di energia elettrica	Sistemi automatici di gestione dell'energia	
	Uso di apparecchiature di macinazione e di altre apparecchiature elettriche ad elevato rendimento energetico (rulli di macinazione ad alta pressione, ecc.)	

Emissioni acustiche	Adeguati interventi tecnici e gestionali	
Scarichi Idrici	Riutilizzo acque di raffreddamento (impianti a ciclo chiuso)	
Produzione di rifiuti	Adeguati interventi tecnici e gestionali	
Ossidi di azoto	Misure primarie generali: ▪ ottimizzazione del controllo di processo (sistemi di controllo automatici computerizzati) ▪ uso di moderni sistemi gravimetrici per l'alimentazione del combustibile solido ▪ attenta scelta e controllo adeguato delle sostanze (materie prime e combustibili) che vengono immesse nel forno	
	Impianti a via semisecca (forni lunghi, forni Lepol) Impianti a via secca (forni lunghi): ▪ raffreddamento della fiamma ▪ uso di bruciatori *LowNO_x*	**≤ 1.400 mgNO_x/Nm^3 (*) espressi come NO_2 su base media giornaliera**
	Impianti a via secca (forni con preriscaldatore in sospensione e forni con preriscaldatore in sospensione/precalcinatore): ▪ raffreddamento della fiamma ▪ uso di bruciatori *LowNO$_x$* ▪ combustione a stadi ▪ riduzione selettiva non catalitica (SNCR)	**≤ 800 mg NO_x/Nm^3 (*) espressi come NO_2 su base media giornaliera**

Impatto Ambientale/ Emissione	Misura	Livello di emissione associato alle BAT
Ossidi di zolfo	Misure primarie generali: ▪ ottimizzazione del controllo di processo (sistemi di controllo automatici computerizzati); ▪ uso di moderni sistemi gravimetrici per l'alimentazione del combustibile solido; ▪ attenta scelta e controllo adeguato delle sostanze (materie prime e combustibili) che vengono immesse nel forno.	
	Impianti a via semisecca (forni lunghi, forni Lepol) Impianti a via secca (forni lunghi): (Per livelli iniziali di emissione <1200 mg SO_2/Nm^3) ▪ Aggiunta di adsorbenti (Per livelli iniziali di emissione >1200 mg SO_2/Nm^3) ▪ Scrubber a via umida	**$\leq$ 600 mg SO_2/Nm^3 (*) espressi come SO_2 su base media giornaliera**
	Impianti a via secca (forni con preriscaldatore in sospensione e forni con preriscaldatore in sospensione/precalcinatore): (Per livelli iniziali di emissione <1200 mg SO_2/Nm^3) ▪ Aggiunta di adsorbenti (Per livelli iniziali di emissione >1200 mg SO_2/Nm^3) ▪ Scrubber a via umida ▪ Scrubber a via secca	**$\leq$ 400 mg SO_2/Nm^3 (*) espressi come SO_2 su base media giornaliera**
Polveri derivanti dal processo (forno, molini, essiccatoi, .)	Precipitatori elettrostatici (con apparecchiature di monitoraggio ed analisi veloci per minimizzare il numero delle "fughe" di CO) e filtri a tessuto	**$\leq$ 30 mg/Nm^3 su media giornaliera**
Polveri secondarie (trasporti, stoccaggio, movimentazione materie prime, etc.)	Filtri a tessuto	**$\leq$ 20 mg/Nm^3**

Monitoring of emissions

Optimization of management and control of an industrial process is necessary in order to achieve general objectives of environmental protection.

It can be distinguished two main types of actions:

- Process monitoring (chemical, physical parameters like pressure, temperature, flow rates, etc.), aimed at controlling the performance of the plant, within fixed values;
- Monitoring of source emissions;
- Monitoring of the impacts (level of pollutants and their effects in the infuenced area, inside and outside the factory.

Monitoring

To control kiln process, continuous measurements are recommended for the following parameters:

- Pressure, temperature,
- O2-content
- NOx
- CO, and possibly when the SOx concentration is high
- SO2

Monitoring

To accurately quantify the emissions, continuous measurements are recommended for the following parameters (these may need to be measured again if their levels can change after the point where they are measured to be used for control):

- Exhaust volume, humidity, temperature,
- Dust,
- O_2
- NO_x
- SO_2
- CO

Monitoring

Regular periodical monitoring is appropriate to carry out for the following substances:

- Metals and their compounds,
- TOC,
- HCl, HF,
- NH3
- PCDD/Fs

It is especially important to measure metals when wastes with enhanced metals contents are used as raw materials or fuels.