ANNEX

BAT CONCLUSIONS FOR THE PRODUCTION OF CEMENT, LIME AND MAGNESIUM OXIDE

BAT CONCLUSIONS

1.1 General BAT conclusions

The BAT mentioned in this section apply to all installations covered by these BAT conclusions (cement, lime and magnesium oxide industry).

The process-specific BAT included in Sections 1.2 - 1.4 apply in addition to the general BAT mentioned in this section.

1.1.1 *Environmental management systems (EMS)*

1. In order to improve the overall environmental performance of the plants/installations producing cement, lime and magnesium oxide, production BAT is to implement and adhere to an environmental management system (EMS) that incorporates all of the following features:

i. commitment of the management, including senior management;

ii. definition of an environmental policy that includes the continuous improvement of the installation by the management;

iii. planning and establishing the necessary procedures, objectives and targets, in conjunction with financial planning and investment;

iv. implementation of procedures paying particular attention to:

- (a) structure and responsibility
- (b) training, awareness and competence
- (c) communication
- (d) employee involvement
- (e) documentation
- (f) efficient process control
- (g) maintenance programmes
- (h) emergency preparedness and response
- (i) safeguarding compliance with environmental legislation;

v. checking performance and taking corrective action, paying particular attention to:

- (a) monitoring and measurement (see also the Reference Document on the General Principles of Monitoring)
- (b) corrective and preventive action
- (c) maintenance of records

(d) independent (where practicable) internal and external auditing in order to determine whether or not the EMS conforms to planned arrangements and has been properly implemented and maintained;

vi. review of the EMS and its continuing suitability, adequacy and effectiveness by senior management;

vii. following the development of cleaner technologies;

viii. consideration for the environmental impacts from the eventual decommissioning of the installation at the stage of designing a new plant, and throughout its operating life;

ix. application of sectoral benchmarking on a regular basis.

Applicability

The scope (e.g. level of details) and nature of the EMS (e.g. standardised or non-standardised) will generally be related to the nature, scale and complexity of the installation, and the range of environmental impacts it may have.

1.1.2 *Noise*

2. In order to reduce/minimise noise emissions during the manufacturing processes for cement, lime and magnesium oxide, BAT is to use a combination of the following techniques:

	Technique
a	Select an appropriate location for noisy operations
b	Enclose noisy operations/units
c	Use vibration insulation of operations/units
d	Use internal and external lining made of impact-absorbent material
e	Use soundproofed buildings to shelter any noisy operations involving material transformation equipment
f	Use noise protection walls and/or natural noise barriers
g	Use outlet silencers to exhaust stacks
h	Lag ducts and final blowers which are situated in soundproofed buildings
i	Close doors and windows of covered areas
j	Use sound insulation of machine buildings
k	Use sound insulation of wall breaks, e.g. by installation of a sluice at the entrance point of a belt conveyor
l	Install sound absorbers at air outlets, e.g. the clean gas outlet of dedusting units

m	Reduce flow rates in ducts
n	Use sound insulation of ducts
o	Apply the decoupled arrangement of noise sources and potentially resonant components, e.g. of compressors and ducts
p	Use silencers for filter fans
q	Use soundproofed modules for technical devices (e.g. compressors)
r	Use rubber shields for mills (avoiding the contact of metal against metal)
s	Construct buildings or growing trees and bushes between the protected area and the noisy activity

1.2 BAT conclusions for the cement industry

Unless otherwise stated, the BAT conclusions presented in this section can be applied to all installations in the cement industry.

1.2.1 *General primary techniques*

3. In order to reduce emissions from the kiln and use energy efficiently, BAT is to achieve a smooth and stable kiln process, operating close to the process parameter set points by using the following techniques:

	Technique
a	Process control optimisation, including computer-based automatic control
b	Using modern, gravimetric solid fuel feed systems

4. In order to prevent and/or reduce emissions, BAT is to carry out a careful selection and control of all substances entering the kiln.

Description

Careful selection and control of substances entering the kiln can reduce emissions. The chemical composition of the substances and the way they are fed in the kiln are factors that should be taken into account during the selection. Substances of concern may include the substances mentioned in BAT 11 and in BAT 24 to 28.

1.2.2 *Monitoring*

5. BAT is to carry out the monitoring and measurements of process parameters and emissions on a regular basis and to monitor emissions in accordance with the relevant EN standards or, if EN standards are not available, ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality, including the following:

	Technique	Applicability
a	Continuous measurements of process parameters demonstrating the process stability, such as temperature, O_2 content, pressure and flowrate	Generally applicable
b	Monitoring and stabilising critical process parameters, i.e. homogenous raw material mix and fuel feed, regular dosage and excess oxygen	Generally applicable
c	Continuous measurements of NH_3 emissions when SNCR is applied	Generally applicable
d	Continuous measurements of dust, NO_x, SO_x, and CO emissions	Applicable to kiln processes
e	Periodic measurements of PCDD/F and metal emissions	
f	Continuous or periodic measurements of HCl, HF and TOC emissions.	
g	Continuous or periodic measurements of dust	Applicable to non-kiln activities. For small sources (< 10 000 Nm^3/h) from dusty operations other than cooling and the main milling processes, the frequency of measurements or performance checks should be based on a maintenance management system.

Description

The selection between continuous or periodic measurements mentioned in BAT 5(f) is based on the emission source and the type of pollutant expected.

1.2.3 *Energy consumption and process selection*

1.2.3.1 *Process selection*

6. In order to reduce energy consumption, BAT is to use a dry process kiln with multistage preheating and precalcination.

Description

In this type of kiln system, exhaust gases and recovered waste heat from the cooler can be used to preheat and precalcine the raw material feed before entering the kiln, providing significant savings in energy consumption.

Applicability

Applicable to new plants and major upgrades, subject to raw materials moisture content.
BAT-associated energy consumption levels

See Table 1.

TABLE 1

BAT-associated energy consumption levels for new plants and major upgrades using dry process kiln with multistage preheating and precalcination

Process	Unit	BAT-associated energy consumption levels[a]
Dry process with multistage preheating and precalcination	MJ/tonne clinker	2 900 – 3 300[bc]

a Levels do not apply to plants producing special cement or white cement clinker that require significantly higher process temperatures due to product specifications.

b Under normal (excluding, e.g. start-ups and shutdowns) and optimised operational conditions.

c The production capacity has an influence on the energy demand, with higher capacities providing energy savings and smaller capacities requiring more energy. Energy consumption also depends on the number of cyclone preheater stages, with more cyclone preheater stages leading to lower energy consumption of the kiln process. The appropriate number of cyclone preheater stages is mainly determined by the moisture content of raw materials.

1.2.3.2 *Energy consumption*

7. In order to reduce/minimise thermal energy consumption, BAT is to use a combination of the following techniques:

	Technique	Applicability
a	Applying improved and optimised kiln systems and a smooth and stable kiln process, operating close to the process parameter set points by applying: I. process control optimisation, including computer-based automatic control systems II. modern, gravimetric solid fuel feed systems III. preheating and precalcination to the extent possible, considering the existing kiln system configuration	Generally applicable. For existing kilns, the applicability of preheating and precalcination is subject to the kiln system configuration
b	Recovering excess heat from kilns, especially from their cooling zone. In particular,	Generally applicable in the cement industry.

	the kiln excess heat from the cooling zone (hot air) or from the preheater can be used for drying raw materials	Recovery of excess heat from the cooling zone is applicable when grate coolers are used. Limited recovery efficiency can be achieved on rotary coolers
c	Applying the appropriate number of cyclone stages related to the characteristics and properties of raw material and fuels used	Cyclone preheater stages are applicable to new plants and major upgrades.
d	Using fuels with characteristics which have a positive influence on the thermal energy consumption	The technique is generally applicable to the cement kilns subject to fuel availability and for existing kilns subject to the technical possibilities of injecting the fuel into the kiln
e	When replacing conventional fuels by waste fuels, using optimised and suitable cement kiln systems for burning wastes	Generally applicable to all cement kiln types
f	Minimising bypass flows	Generally applicable to the cement industry

Description

Several factors affect the energy consumption of modern kiln systems such as raw materials properties (e.g. moisture content, burnability), the use of fuels, with different properties, as well as the use of a gas bypass system. Furthermore, the production capacity of the kiln has an influence on the energy demand.

Technique 7c: the appropriate number of cyclone stages for preheating is determined by the throughput and the moisture content of raw materials and fuels which have to be dried by the remaining flue-gas heat because local raw materials vary widely regarding their moisture content or burnability

Technique 7d: conventional and waste fuels can be used in the cement industry. The characteristics of the fuels used, such as adequate calorific value and low moisture content, have a positive influence on the specific energy consumption of the kiln.

Technique 7f: the removal of hot raw material and hot gas leads to a higher specific energy consumption of about 6 – 12 MJ/tonne clinker per percentage point of removed kiln inlet gas. Hence, minimising the use of gas bypass has a positive effect on energy consumption.

8. In order to reduce primary energy consumption, BAT is to consider the reduction of the clinker content of cement and cement products.

Description

The reduction of the clinker content of cement and cement products can be achieved by adding fillers and/or additions, such as blast furnace slag, limestone, fly ash and pozzolana in the grinding step in accordance with the relevant cement standards.

Applicability

Generally applicable to the cement industry, subject to (local) availability of fillers and/or additions and local market specificities.

9. In order to reduce primary energy consumption, BAT is to consider cogeneration/combined heat and power plants.

Description

The employment of cogeneration plants for the production of steam and electricity or combined heat and power plants can be applied in the cement industry by recovering waste heat from the clinker cooler or kiln flue-gases using the conventional steam cycle processes or other techniques. Furthermore, excess heat can be recovered from the clinker cooler or kiln flue-gases for district heating or industrial applications.

Applicability

The technique is applicable in all cement kilns if sufficient excess heat is available, if appropriate process parameters can be met, and if economic viability is ensured.

10. In order to reduce/minimise electrical energy consumption, BAT is to use one or a combination of the following techniques:

	Technique
a	Using power management systems
b	Using grinding equipment and other electricity based equipment with high energy efficiency
c	Using improved monitoring systems
d	Reducing air leaks into the system
e	Process control optimisation

1.2.4 *Use of waste*

1.2.4.1 *Waste quality control*

11. In order to guarantee the characteristics of the wastes to be used as fuels and/or raw materials in a cement kiln and reduce emissions, BAT is to apply the following techniques:

	Technique
a	Apply quality assurance systems to guarantee the characteristics of wastes and to analyse any waste that is to be used as raw material and/or fuel in a cement kiln for: I. constant quality II. physical criteria, e.g. emissions formation, coarseness, reactivity, burnability, calorific value

	III. chemical criteria, e.g. chlorine, sulphur, alkali and phosphate content and relevant metals content
b	Control the amount of relevant parameters for any waste that is to be used as raw material and/or fuel in a cement kiln, such as chlorine, relevant metals (e.g. cadmium, mercury, thallium), sulphur, total halogen content
c	Apply quality assurance systems for each waste load

Description

Different types of waste materials can replace primary raw materials and/or fossil fuels in cement manufacturing and will contribute to saving natural resources.

1.2.4.2 *Waste feeding into the kiln*

12. In order to ensure appropriate treatment of the wastes used as fuel and/or raw materials in the kiln, BAT is to use the following techniques:

	Technique
a	Use appropriate points to feed the waste into the kiln in terms of temperature and residence time depending on kiln design and kiln operation
b	To feed waste materials containing organic components that can be volatilised before the calcining zone into the adequately high temperature zones of the kiln system
c	To operate in such a way that the gas resulting from the co-incineration of waste is raised in a controlled and homogeneous fashion, even under the most unfavourable conditions, to a temperature of 850 °C for 2 seconds
d	To raise the temperature to 1 100 °C, if hazardous waste with a content of more than 1 % of halogenated organic substances, expressed as chlorine, are co-incinerated
e	To feed wastes continuously and constantly
f	Delay or stop co-incinerating waste for operations such as start-ups and/or shutdowns when appropriate temperatures and residence times cannot be reached, as noted in a) to d) above

1.2.4.3 *Safety management for the use of hazardous waste materials*

13. BAT is to apply safety management for the storage, handling and feeding of hazardous waste materials, such as using a risk-based approach according to the source and type of waste, for the labelling, checking, sampling and testing of waste to be handled.

1.2.5 *Dust emissions*

1.2.5.1 *Diffuse dust emissions*

14. In order to minimise/prevent diffuse dust emissions from dusty operations, BAT is to use one or a combination of the following techniques:

	Technique	Applicability
a	Use a simple and linear site layout of the installation	Applicable to new plants only
b	Enclose/encapsulate dusty operations, such as grinding, screening and mixing	Generally applicable
c	Cover conveyors and elevators, which are constructed as closed systems, if diffuse dust emissions are likely to be released from dusty material	
d	Reduce air leakages and spillage points	
e	Use automatic devices and control systems	
f	Ensure trouble-free operations	
g	Ensure proper and complete maintenance of the installation using mobile and stationary vacuum cleaning. — During maintenance operations or in cases of trouble with conveying systems, spillage of materials can take place. To prevent the formation of diffuse dust during removal operations, vacuum systems should be used. New buildings can easily be equipped with stationary	

	vacuum cleaning piping, while existing buildings are normally better fitted with mobile systems and flexible connections — In specific cases, a circulation process could be favoured for pneumatic conveying systems
h	Ventilate and collect dust in fabric filters: — As far as possible, all material handling should be conducted in closed systems maintained under negative pressure. The suction air for this purpose is then dedusted by a fabric filter before being emitted into the air
i	Use closed storage with an automatic handling system: — Clinker silos and closed fully automated raw material storage areas are considered the most efficient solution to the problem of diffuse dust generated by high volume stocks. These types of storage are equipped with one or more fabric filters to prevent diffuse dust formation in loading and unloading operations — Use storage silos with adequate capacities, level indicators with cut

	out switches and with filters to deal with dust-bearing air displaced during filling operations	
j	Use flexible filling pipes for dispatch and loading processes, equipped with a dust extraction system for loading cement, which are positioned towards the loading floor of the lorry	

15. In order to minimise/prevent diffuse dust emissions from bulk storage areas, BAT is to use one or a combination of the following techniques:

	Technique
a	Cover bulk storage areas or stockpiles or enclose them with screening, walling or an enclosure consisting of vertical greenery (artificial or natural wind barriers for open pile wind protection)
b	Use open pile wind protection: — Outdoor storage piles of dusty materials should be avoided, but when they do exist it is possible to reduce diffuse dust by using properly designed wind barriers
c	Use water spray and chemical dust suppressors: — When the point source of diffuse dust is well localised, a water spray injection system can be installed. The humidification of dust particles aids agglomeration and so helps dust settle. A wide variety of agents is also available to improve the overall efficiency of the water spray
d	Ensure paving, road wetting and housekeeping: — Areas used by lorries should be paved when possible and the surface should be kept as clean as possible. Wetting the roads can reduce diffuse dust emissions, especially during dry weather. They also can be cleaned with road sweepers. Good housekeeping practices should be used in order

	to keep diffuse dust emissions to a minimum
e	Ensure humidification of stockpiles: — Diffuse dust emissions at stockpiles can be reduced by using sufficient humidification of the charging and discharging points, and by using conveyor belts with adjustable heights
f	Match the discharge height to the varying height of the heap, automatically if possible or by reduction of the unloading velocity, when diffuse dust emissions at the charging or discharging points of storage sites cannot be avoided

1.2.5.2 *Channelled dust emissions from dusty operations*

This section concerns dust emissions arising from dusty operations other than those from kiln firing, cooling and the main milling processes. This covers processes such as the crushing of raw materials; raw material conveyors and elevators; the storage of raw materials, clinker and cement; the storage of fuels and the dispatch of cement.

16. In order to reduce channelled dust emissions, BAT is to apply a maintenance management system which especially addresses the performance of filters applied to dusty operations, other than those from kiln firing, cooling and main milling processes. Taking this management system into account, BAT is to use dry flue-gas cleaning with a filter.

Description

For dusty operations, dry flue-gas cleaning with a filter usually consists of a fabric filter. A description of fabric filters is provided in Section 1.5.1.

BAT-associated emission levels

The BAT-AEL for channelled dust emissions from dusty operations (other than those from kiln firing, cooling and the main milling processes) is < 10 mg/Nm^3, as the average over the sampling period (spot measurement, for at least half an hour).

It should be noted that for small sources (< 10 000 Nm^3/h) a priority approach, based on the maintenance management system, regarding the frequency for checking the performance of the filter has to be taken into account (see also BAT 5).

1.2.5.3 *Dust emissions from kiln firing processes*

17. In order to reduce dust emissions from flue-gases of kiln firing processes, BAT is to use dry flue-gas cleaning with a filter.

	Technique[a]	**Applicability**
a	Electrostatic precipitators (ESPs)	Applicable to all kiln systems

a A description of the techniques is given in Section 1.5.1.

b	Fabric filters	
c	Hybrid filters	

a A description of the techniques is given in Section 1.5.1.

BAT-associated emission levels

The BAT-AEL for dust emissions from flue-gases of kiln firing processes is <10 – 20 mg/Nm^3, as the daily average value. When applying fabric filters or new or upgraded ESPs, the lower level is achieved.

1.2.5.4 *Dust emissions from cooling and milling processes*

18. In order to reduce dust emissions from the flue-gases of cooling and milling processes, BAT is to use dry flue-gas cleaning with a filter.

	Technique[a]	Applicability
a	Electrostatic precipitators (ESPs)	Generally applicable to clinker coolers and cement mills.
b	Fabric filters	Generally applicable to clinker coolers and mills
c	Hybrid filters	Applicable to clinker coolers and cement mills.

a A description of the techniques is given in Section 1.5.1

BAT-associated emission levels

The BAT-AEL for dust emissions from the flue-gases of cooling and milling processes is <10 – 20 mg/Nm^3, as the daily average value or average over the sampling period (spot measurements for at least half an hour). When applying fabric filters or new or upgraded ESPs, the lower level is achieved.

1.2.6 *Gaseous compounds*

1.2.6.1 *NO_x emissions*

19. In order to reduce the emissions of NO_x from the flue-gases of kiln firing and/or preheating/precalcining processes, BAT is to use one or a combination of the following techniques:

	Technique[a]	Applicability
a	Primary techniques	
	I. Flame cooling	Applicable to all types of kilns used for cement manufacturing. The degree of applicability can be limited by product quality

a A description of the techniques is provided in Section 1.5.2.

		requirements and potential impacts on process stability
	II. Low NO_x burners	Applicable to all rotary kilns, in the main kiln as well as in the precalciner
	III. Mid-kiln firing	Generally applicable to long rotary kilns
	IV. Addition of mineralisers to improve the burnability of the raw meal (mineralised clinker)	Generally applicable to rotary kilns subject to final product quality requirements
	V. Process optimisation	Generally applicable to all kilns
b	Staged combustion (conventional or waste fuels), also in combination with a precalciner and the use of optimised fuel mix	In general, can only be applied in kilns equipped with a precalciner. Substantial plant modifications are necessary in cyclone preheater systems without a precalciner. In kilns without precalciner, lump fuels firing might have a positive effect on NO_x reduction depending on the ability to produce a controlled reduction atmosphere and to control the related CO emissions
c	Selective non-catalytic reduction (SNCR)	In principle, applicable to rotary cement kilns. The injection zones vary with the type of kiln process. In long wet and long dry process kilns it may be difficult to obtain the right temperature and retention time needed. See also BAT 20
d	Selective catalytic reduction (SCR)	Applicability is subject to appropriate catalyst and process development in the cement industry

a A description of the techniques is provided in Section 1.5.2.

BAT-associated emission levels

See Table 2.

TABLE 2

BAT-associated emission levels for NO_x from the flue-gases of kiln firing and/or preheating/precalcining processes in the cement industry

Kiln type	Unit	BAT-AEL(daily average value)
Preheater kilns	mg/Nm^3	< 200 – 450[ab]
Lepol and long rotary kilns	mg/Nm^3	400 – 800[c]

a The upper level of the BAT-AEL range is 500 mg/Nm^3, if the initial NO_x level after primary techniques is > 1 000 mg/Nm^3.

b Existing kiln system design, fuel mix properties including waste and raw material burnability (e.g. special cement or white cement clinker) can influence the ability to be within the range. Levels below 350 mg/Nm^3 are achieved at kilns with favourable conditions when using SNCR. In 2008, the lower value of 200 mg/Nm^3 has been reported as a monthly average for three plants (easy burning mix used) using SNCR.

c Depending on initial levels and NH_3 slip.

20. When SNCR is used, BAT is to achieve efficient NO_x reduction, while keeping the ammonia slip as low as possible, by using the following technique:

	Technique
a	To apply an appropriate and sufficient NO_x reduction efficiency along with a stable operating process
b	To apply a good stoichiometric distribution of ammonia in order to achieve the highest efficiency of NO_x reduction and to reduce the NH_3 slip
c	To keep the emissions of NH_3 slip (due to unreacted ammonia) from the flue-gases as low as possible taking into account the correlation between the NO_x abatement efficiency and the NH_3 slip

Applicability

SNCR is generally applicable to rotary cement kilns. The injection zones vary with the type of kiln process. In long wet and long dry process kilns it may be difficult to obtain the right temperature and retention time needed. See also BAT 19.

BAT-associated emission levels

See Table 3.

TABLE 3

BAT-associated emission levels for NH_3 slip in the flue-gases when SNCR is applied

Parameter	Unit	BAT-AEL(daily average value)
NH_3 slip	mg/Nm^3	< 30 – 50[a]

a The ammonia slip depends on the initial NO_x level and on the NO_x abatement efficiency. For Lepol and long rotary kilns, the level may be even higher.

1.2.6.2 *SO_x emissions*

21. In order to reduce/minimise the emissions of SO_x from the flue-gases of kiln firing and/or preheating/precalcining processes, BAT is to use one of the following techniques:

	Technique[a]	Applicability
a	Absorbent addition	Absorbent addition is, in principle, applicable to all kiln systems, although it is mostly used in suspension preheaters. Lime addition to the kiln feed reduces the quality of the granules/nodules and causes flow problems in Lepol kilns. For preheater kilns it has been found that direct injection of slaked lime into the flue-gas is less efficient than adding slaked lime to the kiln feed
b	Wet scrubber	Applicable to all cement kiln types with appropriate (sufficient) SO_2 levels for manufacturing the gypsum

a A description of the techniques is provided in Section 1.5.3

Description

Depending on the raw materials and the fuel quality, levels of SO_x emissions can be kept low not requiring the use of an abatement technique.

If necessary, primary techniques and/or abatement techniques such as absorbent addition or wet scrubber can be used to reduce SO_x emissions.

Wet scrubbers have already been operated in plants with initial unabated SO_x levels higher than 800 – 1 000 mg/Nm^3.

BAT-associated emission levels

See Table 4.

TABLE 4

BAT-associated emission levels for SO_x from the flue-gases of kiln firing and/or preheating/precalcining processes in the cement industry

Parameter	**Unit**	**BAT-AEL[a][b](daily average value)**
SO_x expressed as SO_2	mg/Nm^3	< 50 – 400

a The range takes into account the sulphur content in the raw materials.

b For white cement and special cement clinker production, the ability of clinker to retain fuel sulphur might be significantly lower leading to higher SO_X emissions.

22. In order to reduce SO_2 emissions from the kiln, BAT is to optimise the raw milling processes.

Description

The technique consists of optimising the raw milling process so that the raw mill can be operated to act as SO_2 abatement for the kiln. This can be achieved by adjusting factors such as:

— raw material moisture
— mill temperature
— retention time in the mill
— fineness of the ground material.

Applicability

Applicable if the dry milling process is used in compound mode.

1.2.6.3 *CO emissions and CO trips*

1.2.6.3.1 Reduction of CO trips

23. In order to minimise the frequency of CO trips and keep their total duration to below 30 minutes annually, when using electrostatic precipitators (ESPs) or hybrid filters, BAT is to use the following techniques in combination:

	Technique
a	Manage CO trips in order to reduce the ESP downtime
b	Continuous automatic CO measurements by means of monitoring equipment with a short response time and situated close to the CO source

Description

For safety reasons, due to the risk of explosions, ESPs will have to shut down during elevated CO levels in the flue-gases. The following techniques prevent CO trips and, therefore, reduce ESP shutdown times:

— control of the combustion process
— control of the organic load of raw materials
— control of the quality of the fuels and fuel feeding system.

Disruptions predominantly happen during the start-up operation phase. For safe operation, the gas analysers for ESP protection have to be on-line during all operational phases and the ESP downtime can be reduced by using a backup monitoring system maintained in operation.

The continuous CO monitoring system needs to be optimised for reaction time and should be located close to the CO source, e.g. at a preheater tower outlet, or at a kiln inlet in the case of a wet kiln application.

When hybrid filters are used, the grounding of the bag support cage with the cell plate is recommended.

1.2.6.4 *Total organic carbon emissions (TOC)*

24. In order to keep the emissions of TOC from the flue-gases of the kiln firing processes low, BAT is to avoid feeding raw materials with a high content of volatile organic compounds (VOC) into the kiln system via the raw material feeding route.

1.2.6.5 *Hydrogen chloride (HCl) and hydrogen fluoride (HF) emissions*

25. In order prevent/reduce the emissions of HCl from flue-gases of the kiln firing processes, BAT is to use one or a combination of the following primary techniques:

	Technique
a	Using raw materials and fuels with a low chlorine content
b	Limiting the amount of chlorine content for any waste that is to be used as raw material and/or fuel in a cement kiln

BAT-associated emission levels

The BAT-AEL for the emissions of HCl is <10 mg/Nm^3, as the daily average value or average over the sampling period (spot measurements, for at least half an hour).

26. In order to prevent/reduce the emissions of HF from the flue-gases of the kiln firing processes, BAT is to use one or a combination of the following primary techniques:

	Technique
a	Using raw materials and fuels with a low fluorine content
b	Limiting the amount of fluorine content for any waste that is to be used as raw material and/or fuel in a cement kiln

BAT-associated emission levels

The BAT-AEL for the emissions of HF is <1 mg/Nm^3, as the daily average value or average over the sampling period (spot measurements, for at least half an hour).

1.2.7 *PCDD/F emissions*

27. In order to prevent emissions of PCDD/F or to keep the emissions of PCDD/F from the flue-gases of the kiln firing processes low, BAT is to use one or a combination of the following techniques:

	Technique	Applicability

a	Carefully selecting and controlling of kiln inputs (raw materials), i.e. chlorine, copper and volatile organic compounds	Generally applicable
b	Carefully selecting and controlling kiln inputs (fuels), i.e. chlorine and copper	Generally applicable
c	Limiting/avoiding the use of wastes which contain chlorinated organic materials	Generally applicable
d	Avoid feeding fuels with a high content of halogens (e.g. chlorine) in secondary firing	Generally applicable
e	Quick cooling of kiln flue-gases to lower than 200 °C and minimising residence time of flue-gases and oxygen content in zones where the temperatures range between 300 and 450 °C	Applicable to long wet kilns and long dry kilns without preheating. In modern preheater and precalciner kilns, this feature is already inherent
f	Stop co-incinerating waste for operations such as start-ups and/or shutdowns	Generally applicable

BAT-associated emission levels

The BAT-AEL for the emissions of PCDD/F from the flue-gases of the kiln firing processes is <0,05 – 0,1 ng PCDD/F I-TEQ/Nm^3, as the average over the sampling period (6 – 8 hours).

1.2.8 *Metal emissions*

28. In order to minimise the emissions of metals from the flue-gases of the kiln firing processes, BAT is to use one or a combination of the following techniques:

	Technique
a	Selecting materials with a low content of relevant metals and limiting the content of relevant metals in materials, especially mercury
b	Using a quality assurance system to guarantee the characteristics of the waste materials used
c	Using effective dust removal techniques as set out in BAT 17

BAT-associated emission levels

See Table 5.

TABLE 5

BAT-associated emission levels for metals from the flue-gases of kiln firing processes

Metals	Unit	BAT-AEL(average over the sampling period (spot measurements, for at least half an hour))
Hg	mg/Nm^3	< 0,05[b]
Σ (Cd, Tl)	mg/Nm^3	< 0,05[a]
Σ (As, Sb, Pb, Cr, Co, Cu, Mn, Ni, V)	mg/Nm^3	< 0,5[a]

a Low levels have been reported based on the quality of the raw materials and the fuels.

b Low levels have been reported based on the quality of the raw materials and the fuels. Values higher than 0,03 mg/Nm^3 have to be further investigated. Values close to 0,05 mg/Nm^3 require consideration of additional techniques (e.g. lowering of the flue-gas temperature, activated carbon).

1.2.9 *Process losses/waste*

29. In order to reduce solid waste from the cement manufacturing process along with raw material savings, BAT is to:

	Technique	Applicability
a	Reuse collected dusts in the process, wherever practicable	Generally applicable but subject to dust chemical composition
b	Utilise these dusts in other commercial products, when possible	The utilisation of the dusts in other commercial products may not be within the control of the operator

Description

Collected dust can be recycled back into the production processes whenever practicable. This recycling may take place directly into the kiln or kiln feed (the alkali metal content being the limiting factor) or by blending with finished cement products. A quality assurance procedure might be required when the collected dusts are recycled back into the production processes. Alternative uses may be found for material that cannot be recycled (e.g. additive for flue-gas desulphurisation in combustion plants).

1.3 **BAT conclusions for the lime industry**

Unless otherwise stated, the BAT conclusions presented in this section can be applied to all installations in the lime industry.

1.3.1 *General primary techniques*

30. In order to reduce all kiln emissions and use energy efficiently, BAT is to achieve a smooth and stable kiln process, operating close to the process parameter set points by using the following techniques:

	Technique
a	Process control optimisation, including computer-based automatic control
b	Using modern, gravimetric solid fuel feed systems and/or gas flow meters

Applicability

Process control optimisation is applicable to all lime plants to varying degrees. Complete process automation is generally not achievable due to the uncontrollable variables, i.e. quality of the limestone.

31. In order to prevent and/or reduce emissions, BAT is to carry out a careful selection and control of the raw materials entering the kiln.

Description

Raw materials entering the kiln have a significant effect on air emissions due to their impurities content; hence, a careful selection of raw materials may reduce these emissions at source. For example, the variations of sulphur and chlorine contents in the limestone/dolomite have an effect on the range of the SO_2 and HCl emissions in the flue-gas, while the presence of organic matter has an influence on TOC and CO emissions.

Applicability

The applicability depends on the (local) availability of raw materials with low impurities content. The type of final product and the type of kiln used may represent an additional constraint.

1.3.2 *Monitoring*

32. BAT is to carry out monitoring and measurements of process parameters and emissions on a regular basis and to monitor emissions in accordance with the relevant EN standards or, if EN standards are not available, ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality, including the following:

	Technique	**Applicability**
a	Continuous measurements of process parameters demonstrating the process stability, such as temperature, O_2 content, pressure, flow rate and CO emissions	Applicable to kiln processes
b	Monitoring and stabilising of critical process parameters, e.g. fuel feed, regular dosage and excess oxygen	
c	Continuous or periodic measurements of dust, NO_x, SO_x, CO emissions and NH_3 emissions when SNCR is applied	Applicable to kiln processes

d	Continuous or periodic measurements of HCl and HF emissions in case wastes are co-incinerated	Applicable to kiln processes
e	Continuous or periodic measurements of TOC emissions or continuous measurements in case wastes are co-incinerated	Applicable to kiln processes
f	Periodic measurements of PCDD/F and metal emissions	Applicable to kiln processes
g	Continuous or periodic measurements of dust emissions	Applicable to non-kiln processes For small sources (<10 000 Nm^3/h) the frequency of the measurements should be based on a maintenance management system

Description

The selection between continuous or periodic measurements mentioned in BAT 32(c) to 32(f) is based on the emission source and the type of pollutant expected.

For periodic measurements of dust, NO_x, SO_x and CO emissions, a frequency of once a month and up to once a year at the time of normal operating conditions is given as an indication.

For periodic measurements of PCDD/F, TOC, HCl, HF, metal emissions, a frequency appropriate to the raw materials and fuels that are used in the process should be applied.

1.3.3 *Energy consumption*

33. In order to reduce/minimise thermal energy consumption, BAT is to use a combination of the following techniques:

	Technique	Description	Applicability
a	Applying improved and optimised kiln systems and a smooth and stable kiln process, operating close to the process parameter set points, through: I. process control optimisation II. heat recovery from flue-gases (e.g. use of	Maintaining kiln control parameters close to their optimum values has the effect of reducing all consumption parameters due to, among other things, reduced numbers of shutdowns and upset conditions. The use of optimised grain size of stone is subject to raw material availability	Technique (a) II is applicable only to long rotary kilns (LRK)

	surplus heat from rotary kilns to dry limestone for other processes such as limestone milling) III. modern, gravimetric solid fuel feed systems IV. maintenance of the equipment (e.g. air tightness, erosion of refractory) V. the use of optimised grain size of stone		
b	Using fuels with characteristics which have a positive influence on thermal energy consumption	The characteristics of fuels, e.g. high calorific value and low moisture content can have a positive effect on the thermal energy consumption	The applicability depends on the technical possibility to feed the selected fuel into the kiln and on the availability of suitable fuels (e.g. high calorific value and low humidity) which may be impacted by the energy policy of the Member State
c	Limiting excess air	A decrease of excess air used for combustion has a direct effect on fuel consumption since high percentages of air require more thermal energy to heat up the excess volume. Only in LRK and PRK the limitation of excess air has an	Applicable to LRK and PRK within the limits of a potential overheating of some areas in the kiln with consequent deterioration of the refractory lifetime

		impact on thermal energy consumption. The technique has a potential of increasing TOC and CO emission	

BAT-associated consumption levels

See Table 6.

TABLE 6

BAT-associated levels for thermal energy consumption in the lime and dolime industry

Kiln type	Thermal energy consumption[a] GJ/tonne of product
Long rotary kilns (LRK)	6,0 – 9,2
Rotary kilns with preheater (PRK)	5,1 – 7,8
Parallel flow regenerative kilns (PFRK)	3,2 – 4,2
Annular shaft kilns (ASK)	3,3 – 4,9
Mixed feed shaft kilns (MFSK)	3,4 – 4,7
Other kilns (OK)	3,5 – 7,0

a Energy consumption depends on the type of product, the product quality, the process conditions and the raw materials

34. In order to minimise electrical energy consumption, BAT is to use one or a combination of the following techniques:

	Technique
a	Using power management systems
b	Using optimised grain size of limestone
c	Using grinding equipment and other electricity based equipment with high energy efficiency

Description – Technique (b)

Vertical kilns can usually burn only coarse limestone pebbles. However, rotary kilns with higher energy consumption can also valorise small fractions and new vertical kilns can burn small granules from 10 mm. The larger granules of kiln feed stone are used more in vertical kilns than in rotary kilns.

1.3.4 *Consumption of limestone*

35. In order to minimise limestone consumption, BAT is to use one or a combination of the following techniques:

	Technique	Applicability

a	Specific quarrying, crushing and well directed use of limestone (quality, grain size)	Generally applicable in the lime industry; however, stone processing is dependent on the limestone quality
b	Selecting kilns applying optimised techniques which allow for operating with a wider range of limestone grain sizes to make optimum use of quarried limestone	Applicable to new plants and major upgrades of kiln. Vertical kilns can in principle only burn coarse limestone pebbles. Fine lime PFRK and/or rotary kilns can operate with smaller limestone grain sizes

1.3.5 *Selection of fuels*

36. In order to prevent/reduce emissions, BAT is to carry out a careful selection and control of fuels entering the kiln.

Description

Fuels entering the kiln may have a significant effect on air emissions due to their impurities content. The content of sulphur (for long rotary kilns in particular), nitrogen and chlorine have an effect on the range of the SO_x, NO_x and HCl emissions in the flue-gas. Depending on the chemical composition of the fuel and the type of kiln used, the choice of appropriate fuels or a fuel mix can lead to emissions reductions.

Applicability

Except for mixed feed shaft kilns, all types of kilns can operate with all types of fuels and fuel mixtures subject to fuels availability which may be impacted by the energy policy of the Member State. The selection of fuel also depends on the desired quality of the final product, the technical possibility to feed the fuel into the selected kiln, and economic considerations.

1.3.5.1 *Use of waste fuels*

1.3.5.1.1 Waste quality control

37. In order to guarantee the characteristics of waste to be used as fuel in a lime kiln, BAT is to apply the following techniques:

	Technique
a	Apply a quality assurance system to guarantee and control the characteristics of wastes and to analyse any waste that is to be used as fuel in the kiln for: I. constant quality II. physical criteria, e.g. emissions formation, coarseness, reactivity, burnability, calorific value III. chemical criteria, e.g. total chlorine content, sulphur, alkali, and phosphate content and relevant metals content (e.g. total chromium, lead, cadmium, mercury, thallium)

b	Control the amount of relevant components for any waste that is to be used as fuel, such as total halogen content, metals (e.g. total chromium, lead, cadmium, mercury, thallium) and sulphur

1.3.5.1.2 Waste feeding into the kiln

38. In order to prevent/reduce emissions occurring from the use of waste fuels into the kiln, BAT is to use the following techniques:

	Technique
a	To use appropriate burners for feeding suitable wastes depending on kiln design and kiln operation
b	To operate in such a way that the gas resulting from the co-incineration of waste is raised in a controlled and homogeneous fashion and even under the most unfavourable conditions, to a temperature of 850 °C for 2 seconds
c	To raise the temperature to 1 100 °C if hazardous wastes with a content of more than 1 % of halogenated organic substances, expressed as chlorine, are co-incinerated
d	To feed wastes continuously and constantly
e	To stop feeding waste for operations such as start-ups and/or shutdowns when appropriate temperatures and residence times cannot be reached, as mentioned in (b) and (c) above

1.3.5.1.3 Safety management for the use of hazardous waste materials

39. In order to prevent accidental emissions, BAT is to use safety management for the storage, handling and feeding into the kiln of hazardous waste materials.

Description

The use of a safety management for the storage, handling and feeding of hazardous waste materials consists of a risk-based approach according to the source and type of waste, for the labelling, checking, sampling and testing of waste to be handled.

1.3.6 *Dust emissions*

1.3.6.1 *Diffuse dust emissions*

40. In order to minimise/prevent diffuse dust emissions from dusty operations, BAT is to use one or a combination of the following techniques:

	Technique

a	Enclosure/encapsulation of dusty operations, such as grinding, screening and mixing
b	Use of covered conveyors and elevators, which are constructed as closed systems, if dust emissions are likely to be released from dusty material
c	Use of storage silos with adequate capacity, level indicators with cut out switches and with filters to deal with dust-bearing air displaced during filling operations
d	Use of a circulation process which is favoured for pneumatic conveying systems
e	Material handling in closed systems maintained under negative pressure and dedusting of the suction air by a fabric filter before being emitted into the air
f	Reduction of air leakage and spillage points, completion of installation
g	Proper and complete maintenance of the installation
h	Use of automatic devices and control systems
i	Use of continuous trouble-free operations
j	Use of flexible filling pipes equipped with a dust extraction system for loading lime which are positioned at the loading floor of the lorry

Applicability

In raw material preparation operations, like crushing and sieving, dust separation is not normally needed, because of the moisture content of the raw material.

41. In order to minimise/prevent diffuse dust emissions from bulk storage areas, BAT is to use one or a combination of the following techniques:

	Technique
a	Enclose storage locations using screening, walling or vertical greenery (artificial or natural wind barriers for open pile wind protection)
b	Use product silos and closed, fully-automated raw material storages. These types of storage are equipped with one or more fabric filters to prevent diffuse dust formation in loading and unloading operations
c	Reduce diffuse dust emissions at stockpiles by using sufficient humidification of

	stockpile charging and discharging points and the use of conveyor belts with adjustable height. When using humidification or spraying measures/techniques, the ground can be sealed and the surplus water can be gathered, and if necessary this can be treated and used in closed cycles
d	Reduce diffuse dust emissions at charging or discharging points of storage sites if they cannot be avoided, by matching the discharge height to the varying height of the heap, if possible automatically, or by reduction of the unloading velocity
e	Keep the locations wet, especially dry areas, using spraying devices and clean them by cleaning lorries
f	Use vacuum systems during removal operations. New buildings can easily be equipped with stationary vacuum cleaning systems, while existing buildings are normally better fitted with mobile systems and flexible connections
g	Reduce diffuse dust emissions arising in areas used by lorries, by paving these areas when possible and keeping the surface as clean as possible. Wetting the roads can reduce diffuse dust emissions, especially during dry weather. Good housekeeping practices can be used in order to keep diffuse dust emissions to a minimum

1.3.6.2 *Channelled dust emissions from dusty operations other than those from kiln firing processes*

42. In order to reduce channelled dust emissions from dusty operations other than those from kiln firing processes, BAT is to use one of the following techniques and to use a maintenance management system which specifically addresses the performance of filters:

	Technique[a][b]	**Applicability**
a	Fabric filter	Generally applicable to milling and grinding plants and subsidiary processes in the lime industry; material transport; and storage and loading facilities. The applicability of fabric filters

a A description of the techniques is provided in Section 1.6.1.

b If necessary, centrifugal separators/cyclones can be used as pretreatment of the flue-gases.

		in hydrating lime plants may be limited by the high moisture and low temperature of the flue-gases
b	Wet scrubbers	Mainly applicable to hydrating lime plants

a A description of the techniques is provided in Section 1.6.1.

b If necessary, centrifugal separators/cyclones can be used as pretreatment of the flue-gases.

BAT-associated emission levels

See Table 7.

TABLE 7

BAT-associated emission levels for channelled dust emissions from dusty operations other than those from kiln firing processes

Technique	**Unit**	**BAT-AEL(daily average or average over the sampling period (spot measurements for at least half an hour))**
Fabric filter	mg/Nm^3	< 10
Wet scrubber	mg/Nm^3	< 10 – 20

It should be noted that for small sources (< 10 000 Nm^3/h) a priority approach regarding the frequency for checking the performance of the filter has to be taken into account (see BAT 32).

1.3.6.3 *Dust emissions from kiln firing processes*

43. In order to reduce dust emissions from the flue-gases of kiln firing processes, BAT is to use flue-gas cleaning with a filter. One or a combination of the following techniques can be used:

	Technique[a]	**Applicability**
a	ESP	Applicable to all kiln systems
b	Fabric filter	Applicable to all kiln systems
c	Wet dust separator	Applicable to all kiln systems
d	Centrifugal separator/cyclone	Centrifugal separators are only suitable as pre-separators and can be used to pre-clean the flue-gases from all kiln systems

a A description of the techniques is provided in Section 1.6.1.

BAT-associated emission levels

See Table 8.

TABLE 8

BAT-associated emission levels for dust emissions from the flue-gases of kiln firing processes

Technique	Unit	BAT-AEL(daily average value or average over the sampling period (spot measurements for at least half an hour))
Fabric filter	mg/Nm^3	< 10
ESP or other filters	mg/Nm^3	< 20[a]

a In exceptional cases where the resistivity of dust is high, the BAT-AEL could be higher, up to 30 mg/Nm^3, as the daily average value.

1.3.7 *Gaseous compounds*

1.3.7.1 *Primary techniques for reducing emissions of gaseous compounds*

44. In order to reduce the emissions of gaseous compounds (i.e. NO_x, SO_x, HCl, CO, TOC/VOC, volatile metals) from the flue-gases of kiln firing processes, BAT is to use one or a combination of the following techniques:

	Technique	Applicability
a	Careful selection and control of substances entering the kiln	Generally applicable
b	Reducing the pollutant precursors in fuels and, if possible, in raw materials, i.e. I. selecting fuels, where available, with low contents of sulphur (for long rotary kilns in particular), nitrogen and chlorine II. selecting raw materials, if possible, with low contents of organic matter III. selecting suitable waste fuels for the process and the burner	Generally applicable in the lime industry subject to local availability of raw materials and fuels, the type of kiln used, the desired product qualities and the technical possibility of feeding the fuels into the selected kiln
c	Using process optimisation techniques to ensure an efficient absorption of sulphur dioxide (e.g. efficient	Applicable to all lime plants. In general, complete process automation is not achievable due to uncontrollable

	contact between the kiln gases and the quicklime)	variables, i.e. quality of the limestone

1.3.7.2 *NO_x emissions*

45. In order to reduce the emissions of NO_X from the flue-gases of kiln firing processes, BAT is to use one or a combination of the following techniques:

	Technique		Applicability
a	Primary techniques		
	I.	Appropriate fuel selection along with limitation of nitrogen content in the fuel	Generally applicable in the lime industry subject to fuel availability which may be impacted by the energy policy of the Member State and to the technical possibility to feed a certain type of fuel into the selected kiln
	II.	Process optimisation including flame shaping and temperature profile	Optimisation of process and process control can be applied in lime manufacturing but is subject to the final product quality
	III.	Burner design (low NO_X burner)[a]	Low NO_X burners are applicable to rotary kilns and to annular shaft kilns presenting conditions of high primary air. PFRKs and other shaft kilns have flameless combustion, thus rendering low NO_X burners not applicable to this kiln type
	IV.	Air staging[a]	Not applicable to shaft kilns. Applicable only to PRK but not when hard burned lime is produced. The applicability may be limited by constraints imposed by the type of final product, due to possible overheating in some areas of the kiln and consequent deterioration of the refractory lining
b	SNCR[a]		Applicable to Lepol rotary kilns. See also BAT 46

a A description of the techniques is provided in Section 1.6.2

BAT-associated emission levels

See Table 9.

TABLE 9

BAT-associated emission levels for NO_x from flue-gases of kiln firing processes in the lime industry

Kiln type	Unit	BAT-AEL(daily average value or average over the sampling period (spot measurements for at least half an hour), stated as NO_2)
PFRK, ASK, MFSK, OSK	mg/Nm^3	100 – 350[ac]
LRK, PRK	mg/Nm^3	< 200 – 500[ab]

a The higher ends of the ranges are related to the production of dolime and hard burned lime. Higher levels than the upper end of the range may be associated with the production of sintered dolime.

b For LRK and PRK with shaft producing hard burned lime, the upper level is up to 800 mg/Nm^3

c Where primary techniques as indicated in BAT 45 (a)I are not sufficient to reach this level and where secondary techniques are not applicable to reduce the NO_x emissions to 350 mg/Nm^3, the upper level is 500 mg/Nm^3, especially for hard burned lime and for the use of biomass as fuel.

46. When SNCR is used, BAT is to achieve efficient NO_x reduction, while keeping the ammonia slip as low as possible, by using the following technique:

	Technique
a	To apply an appropriate and sufficient reduction efficiency along with a stable operating process
b	To apply a good stoichiometric ratio and distribution of ammonia in order to achieve the highest efficiency of NO_x reduction and to reduce the ammonia slip
c	To keep the emissions of NH_3 slip (due to unreacted ammonia) from the flue-gases as low as possible, taking into account the correlation between the NO_x abatement efficiency and the NH_3 slip.

Applicability

Applicable only to Lepol rotary kilns, where the ideal temperature range of 850 to 1 020 °C is accessible. See also BAT 45, technique (b).

BAT-associated emission levels

The BAT-AEL for the emissions of NH_3 slip from the flue-gases is <30 mg/Nm^3, as the daily average value or average over the sampling period (spot measurements for at least half an hour).

1.3.7.3 *SO_x emissions*

47. In order to reduce the emissions of SO_x from the flue-gases of kiln firing processes, BAT is to use one or a combination of the following techniques:

	Technique	Applicability
a	Process optimisation to ensure an efficient absorption of sulphur dioxide (e.g. efficient contact between the kiln gases and the quicklime)	Process control optimisation is applicable to all lime plants
b	Selecting fuels with a low sulphur content	Generally applicable, subject to fuel availability in particular for use in long rotary kilns (LRK), due to high SO_x emissions
c	Using absorbent addition techniques (e.g. absorbent addition, dry flue-gas cleaning with a filter, wet scrubber, or activated carbon injection)[a]	Absorbent addition techniques are, in principle, applicable in the lime industry; however, this technique had not yet been applied in the lime sector in 2007. Particularly for rotary lime kilns further investigation is required in order to assess its applicability

a A description of the techniques is provided in Section 1.6.3

BAT-associated emission levels

See Table 10.

TABLE 10

BAT-associated emission levels for SO_x from flue-gases of kiln firing processes in the lime industry

Kiln type	Unit	BAT-AEL[ab](daily average value or average over the sampling period (spot measurements for at least half an hour), SO_x expressed as SO_2)
PFRK, ASK, MFSK, OSK, PRK	mg/Nm^3	< 50 – 200

a The level depends on the initial SO_x level in the flue-gas and on the reduction technique used.

b For the production of sintered dolime using the ‘double- pass process’, SO_x emissions might be higher than the upper end of the range.

LRK	mg/Nm^3	< 50 – 400

a The level depends on the initial SO_x level in the flue-gas and on the reduction technique used.

b For the production of sintered dolime using the 'double- pass process', SO_x emissions might be higher than the upper end of the range.

1.3.7.4 *CO emissions and CO trips*

1.3.7.4.1 CO emissions

48. In order to reduce the emissions of CO from the flue-gases of kiln firing processes, BAT is to use one or a combination of the following techniques:

	Technique	Applicability
a	Selecting, raw materials with a low content of organic matter	Generally applicable to the lime industry within the constraints of the local availability and composition of raw materials, the type of kiln used and the quality of the final product
b	Using process optimisation techniques to achieve a stable and complete combustion	Applicable to all lime plants. In general, complete process automation is not achievable due to uncontrollable variables, i.e. quality of the limestone

In this context, see also BAT 30 and 31 in Section 1.3.1 and BAT 32 in Section 1.3.2.
BAT-associated emission levels

See Table 11.

TABLE 11

BAT-associated emission levels for CO from the flue-gas of kiln firing processes

Kiln type	Unit	BAT-AEL[ab](daily average value or average over the sampling period (spot measurements for at least half an hour))
PFRK, OSK, LRK, PRK	mg/Nm^3	< 500

a Emissions can be higher depending on raw materials used and/or type of lime produced, e.g. hydraulic lime.

b BAT-AEL does not apply to MFSK and ASK.

1.3.7.4.2 Reduction of CO trips

49. In order to minimise the frequency of CO trips when using electrostatic precipitators, BAT is to use the following techniques:

	Technique
a	Manage CO trips in order to reduce the ESP downtime
b	Continuous automatic CO measurements by means of monitoring equipment with a short response time and situated close to the CO source

Description

For safety reasons, due to the risk of explosions, ESPs will have to shut down during elevated CO levels in the flue-gases. The following techniques prevent CO trips and, therefore, reduce ESP shutdown times:

— control of the combustion process
— control of the organic load of raw materials
— control of the quality of the fuels and fuel feeding system.

Disruptions predominantly happen during the start-up operation phase. For safe operation, the gas analysers for ESP protection have to be online during all operational phases and the ESP downtime can be reduced by using a backup monitoring system maintained in operation.

The continuous CO monitoring system needs to be optimised for reaction time and should be located close to the CO source, e.g. at a preheater tower outlet, or at a kiln inlet in the case of a wet kiln application.

Applicability

Generally applicable to rotary kilns fitted with electrostatic precipitators (ESPs).

1.3.7.5 *Total organic carbon emissions (TOC)*

50. In order to reduce the emissions of TOC from the flue-gases of kiln firing processes, BAT is to use one or a combination of the following techniques:

	Technique
a	Applying general primary techniques and monitoring (see also BAT 30 and 31 in Section 1.3.1, and BAT 32 in Section 1.3.2)
b	Avoid feeding raw materials with a high content of volatile organic compounds into the kiln system (except for hydraulic lime production)

Applicability

For applicability of general primary techniques and monitoring see BAT 30 and 31 in Section 1.3.1, and BAT 32 in Section 1.3.2.

Technique (b) is generally applicable to the lime industry, subject to local raw materials availability and/or the type of lime produced.

BAT-associated emission levels

See Table 12.

TABLE 12

BAT-associated emission levels for TOC from the flue-gas of kiln firing processes

Kiln type	Unit	BAT-AEL[a](daily average value or average over the sampling period (spot measurements for at least half an hour))
LRK, PRK	mg/Nm^3	< 10
ASK, MFSK[b], PFRK[b]	mg/Nm^3	< 30

a Level can be higher depending on the content of organic matter of raw materials used and/or the type of lime produced, in particular for the production of natural hydraulic lime.

b In exceptional cases, the level can be higher.

1.3.7.6 *Hydrogen chloride (HCl) and hydrogen fluoride (HF) emissions*

51. In order to reduce the emissions of HCl and the emissions of HF from the flue-gas of kiln firing processes, when using waste, BAT is to use the following primary techniques:

	Technique
a	Using conventional fuels with a low chlorine and fluorine content
b	Limiting the amount of chlorine and fluorine content for any waste that is to be used as fuel in a lime kiln

Applicability

The techniques are generally applicable in the lime industry but subject to local availability of suitable fuel.

BAT-associated emission levels

See Table 13.

TABLE 13

BAT-associated emission levels for HCl and HF emissions from the flue-gas of kiln firing processes, when using wastes

Emission	Unit	BAT-AEL(daily average value or the average value over the sampling period (spot measurements, for at least half an hour))
HCl	mg/Nm^3	< 10
HF	mg/Nm^3	< 1

1.3.8 *PCDD/F emissions*

52. In order to prevent or reduce the emissions of PCDD/F from the flue-gas of kiln firing processes, BAT is to use one or a combination of the following primary techniques:

	Technique
a	Selecting fuels with a low chlorine content
b	Limiting the copper input through the fuel
c	Minimising the residence time of the flue-gases and the oxygen content in zones where the temperatures range between 300 and 450 °C

BAT-associated emission levels

The BAT-AELs are < 0,05 – 0,1 ng PCDD/F I-TEQ/Nm^3, as the average over the sampling period (6 – 8 hours).

1.3.9 *Metal emissions*

53. In order to minimise the emissions of metals from the flue-gases of kiln firing processes, BAT is to use one or a combination of the following techniques:

	Technique
a	Selecting fuels with a low content of metals
b	Using a quality assurance system to guarantee the characteristics of the waste fuels used
c	Limiting the content of relevant metals in materials, especially mercury
d	Using one or a combination of dust removal techniques as set out in BAT 43

BAT-associated emission levels

See Table 14.

TABLE 14

BAT associated emission levels for metals from the flue-gases of kiln firing processes, when using wastes

Metals	**Unit**	**BAT-AEL(average over the sampling period (spot measurements for at least half an hour))**
Hg	mg/Nm^3	< 0,05
Σ (Cd, Tl)	mg/Nm^3	< 0,05
NB: Low levels were reported when applying techniques as mentioned in BAT 53 (a) – (d).		

Σ (As, Sb, Pb, Cr, Co, Cu, Mn, Ni, V)	mg/Nm^3	< 0,5
NB: Low levels were reported when applying techniques as mentioned in BAT 53 (a) – (d).		

Furthermore in this context, see also BAT 37 (Section 1.3.5.1.1) and BAT 38 (Section 1.3.5.1.2).

1.3.10 *Process losses/waste*

54. In order to reduce the solid wastes from the lime manufacturing processes and to save raw materials, BAT is to use the following techniques:

	Technique	Applicability
a	Reuse the collected dust or other particulate matter (e.g. sand, gravel) in the process	Generally applicable whenever practicable
b	Utilise dust, off-specification quicklime and off-specification hydrated lime in selected commercial products	Generally utilised in different kinds of selected commercial products, whenever practicable

1.4 **BAT conclusions for the magnesium oxide industry**

Unless otherwise stated, the BAT conclusions presented in this section can be applied to all installations in the magnesium oxide industry (dry process route).

1.4.1 *Monitoring*

55. BAT is to carry out monitoring and measurements of process parameters and emissions on a regular basis and to monitor emissions in accordance with the relevant EN standards or, if EN standards are not available, ISO, national or other international standards that ensure the provision of data of an equivalent scientific quality, including the following:

	Technique	Applicability
a	Continuous measurements of process parameters demonstrating the process stability, such as temperature, O_2 content, pressure, flow rate	Generally applicable to kiln processes
b	Monitoring and stabilising critical process parameters, i.e. raw material and fuel feed, regular dosage and excess oxygen	
c	Continuous or periodic measurements of dust, NO_x, SO_x and CO emissions	Generally applicable to kiln processes

d	Continuous or periodic measurements of dust emissions	Applicable to non-kiln processes. For small source (< 10 000 Nm^3/h) the frequency of the measurements or performance check should be based on a maintenance management system

Description

The selection between continuous or periodic measurements mentioned in BAT 55 (c) is based on the emission source and the type of pollutant expected.

For periodic measurements for dust, NO_x, SO_x and CO emissions from kiln processes, a frequency of once a month and up to once a year and at the time of normal operating conditions is given as an indication.

1.4.2 *Energy consumption*

56. In order to reduce thermal energy consumption, BAT is to use a combination of the following techniques:

	Technique	Description	Applicability
a	Applying improved and optimised kiln systems and a smooth and stable kiln process by applying: I. process control optimisation II. heat recovery from flue-gases from kiln and coolers	Heat recovery from flue-gases by the preliminary heating of the magnesite can be used in order to reduce fuel energy use. Heat recovered from the kiln can be used for drying fuels, raw materials and some packaging materials	Process control optimisation is applicable to all kiln types used in the magnesia industry.
b	Using fuels with characteristics which have a positive influence on thermal energy consumption	The characteristics of fuels, e.g. high calorific value and low moisture content have a positive effect on the thermal energy consumption	Generally applicable subject to availability of the fuels, the type of kilns used, the desired product qualities and the technical possibilities of injecting the fuels into the kiln.
c	Limiting excess air	The excess oxygen level to obtain the required quality of the products and for optimal combustion	Generally applicable

		is usually in practice about 1 – 3 %	

BAT-associated consumption levels

The BAT-associated thermal energy consumption is 6 – 12 GJ/t, depending on the process and the products[(1)].

57. In order to minimise electrical energy consumption, BAT is to use one or a combination of the following techniques:

	Technique
a	Using power management systems
b	Using grinding equipment and other electricity based equipment with high energy efficiency

1.4.3 *Dust emissions*

1.4.3.1 *Diffuse dust emissions*

58. In order to minimise/prevent diffuse dust emissions from dusty operations, BAT is to use one or a combination of the following techniques:

	Technique
a	Simple and linear site layout
b	Good housekeeping of buildings and roads, along with proper and complete maintenance of the installation
c	Watering of raw material piles
d	Enclosure/encapsulation of dusty operations, such as grinding and screening
e	Use of covered conveyors and elevators, which are constructed as closed systems, if dust emissions are likely to be released from dusty material
f	Use of storage silos with adequate capacities and equipping them with filters to deal with dust-bearing air displaced during filling operations
g	A circulation process is favoured for pneumatic conveying systems
h	Reduction of air leakage and spillage points
i	Use of automatic devices and control systems
k	Use of continuous trouble-free operations

1.4.3.2 *Channelled dust emissions from dusty operations other than kiln firing processes*

59. In order to reduce channelled dust emissions from dusty operations other than those from kiln firing processes, BAT is to use flue-gas cleaning with a filter by applying one or a combination of the following techniques, and to use a maintenance management system which specifically addresses the performance of techniques:

	Technique[a]	**Applicability**
a	Fabric filters	Generally applicable to all units in the magnesium oxide manufacturing process, especially for dusty operations, screening, grinding and milling
b	Centrifugal separators/ cyclones	Because of the system-dependent limited degree of separation, cyclones are mainly applicable as preliminary separators for coarse dust and flue-gases
c	Wet dust separators	Generally applicable

a A description of the techniques is provided in Section 1.7.1

BAT-associated emission levels

The BAT-AEL for channelled dust emissions from dusty operations other than those from kiln firing processes is < 10 mg/Nm^3, as daily average or average over the sampling period (spot measurements, for at least half an hour).

It should be noted that for small sources (< 10 000 Nm^3/h) a priority approach, based on a maintenance management system regarding the frequency for checking the performance of the filter has to be taken into account (see BAT 55).

1.4.3.3 *Dust emissions from the kiln firing process*

60. In order to reduce dust emissions from the flue-gases of kiln firing processes, BAT is to use flue-gas cleaning with a filter by applying one or a combination of the following techniques:

	Technique[a]	**Applicability**
a	Electrostatic precipitators (ESPs)	ESPs are mainly applicable in rotary kilns. They are applicable for flue-gas temperatures above the dew point and up to 370 – 400 °C
b	Fabric filters	Fabric filters for dust removal from flue-gases can, in principle, be applied for all units in the magnesium

a A description of the techniques is provided in Section 1.7.1.

		oxide manufacturing process. They can be used for flue-gas temperatures above the dew point and up to 280 °C. For the production of caustic calcined magnesia (CCM) and sintered/dead burned magnesia (DBM), due to the high temperatures, the corrosive nature and the high volume of the flue-gases occurring from the kiln firing process, special fabric filters with high temperature-resistant filter material have to be used. However, experience from the magnesia industry producing DBM shows that no suitable equipment is available for flue-gas temperatures of approximately 400 °C for magnesia production
c	Centrifugal separators/ cyclones	Because of the system-dependent limited degree of separation, cyclones are mainly applicable as preliminary separators for coarse dust and flue-gases
d	Wet dust separators	Generally applicable

a A description of the techniques is provided in Section 1.7.1.

BAT-associated emission levels

The BAT-AEL for dust emissions from the flue-gases of kiln firing processes is < 20 – 35 mg/Nm^3 as the daily average value or average over the sampling period (spot measurements, for at least half an hour).

1.4.4 *Gaseous compounds*

1.4.4.1 *General primary techniques for reducing emissions of gaseous compounds*

61. In order to reduce the emissions of gaseous compounds (i.e. NO_x, HCl, SO_x, CO) from flue-gases of kiln firing processes, BAT is to use one or a combination of the following primary techniques:

	Technique	Applicability
a	Careful selection and control of the substances entering the kiln in order to reduce the pollutant precursors, i.e.:	Generally applicable subject to availability of raw materials and fuels, the type of kiln used, the desired product qualities and

	I. selecting fuels with low contents of sulphur, if available, chlorine and nitrogen II. selecting raw materials with low contents of organic matter III. selecting suitable waste fuels for the process and the burner	the technical possibility of injecting the fuels into the selected kiln. Waste materials can be considered as fuels in the magnesia industry but had not yet been applied in the magnesia industry in 2007
b	Using process optimisation measures/techniques to ensure a smooth and stable kiln process, operating close to the stoichiometric required air	Process control optimisation is applicable to all kiln types used in the magnesia industry. However, a highly sophisticated process control system may be necessary

1.4.4.2 *NO_x emissions*

62. In order to reduce the emissions of NO_x from the flue-gases of kiln firing processes, BAT is to use a combination of the following techniques:

	Technique	Applicability
a	Appropriate fuel selection along with a limited nitrogen content in the fuel	Generally applicable subject to fuels availability
b	Process optimisation and improved firing technique	Generally applicable in the magnesia industry

BAT-associated emission levels

The BAT-AEL for the emissions of NO_X from the flue-gases of kiln firing processes is < 500 – 1 500 mg/Nm^3, as the daily average value or average over the sampling period (spot measurements for at least half an hour) stated as NO_2. The higher values are related to the high temperature DBM process.

1.4.4.3 *CO emissions and CO trips*

1.4.4.3.1 CO emissions

63. In order to reduce the emissions of CO from the flue-gases of kiln firing processes, BAT is to use a combination of the following techniques:

	Technique	Description
a	Selecting raw materials with a low content of organic matter	A part of CO emissions results from the organic matter of raw materials thus selection of raw materials

		with low organic content can reduce CO emissions
b	Process control optimisation	A complete and correct combustion is essential to reduce CO emissions. Air supply from cooler and primary air as well as the draught of the stack fan can be controlled in order to keep an oxygen level of between 1 (sinter) and 1,5 % (caustic) during the combustion. A change of air and fuel charge can reduce CO emissions. Furthermore, CO emissions can be decreased by changing the depth of the burner
c	Feeding fuels controlled, constantly and continuously	Controlled fuel addition includes, e.g.: — using weight feeders and precision rotary valves for petcoke feeding and/or — using flow meters and precision valves for heavy oil or gas feeding regulation to the kiln burner

Applicability

The techniques for the reduction of CO emissions are generally applicable to the magnesia industry. The selection of raw materials with a low content of organic matter is subject to raw materials availability.

BAT-associated emission levels

The BAT-AEL for the emissions of CO from the flue-gases of kiln firing processes is < 50 – 1 000 mg/Nm^3, as the daily average value or average over the sampling period (spot measurements for at least half an hour).

1.4.4.3.2 Reduction of CO trips

64. In order to minimise the number of CO trips when applying ESPs, BAT is to use the following techniques:

	Technique
a	Manage CO trips in order to reduce the ESP downtime
b	Continuous automatic CO measurements by means of monitoring equipment with a short

	response time and situated close to the CO source

Description

For safety reasons, due to the risk of explosions, ESPs will have to shut down during elevated CO levels in the flue-gases. The following techniques prevent CO trips and, therefore, reduce ESP shutdown times:

— control of the combustion process
— control of the organic load of raw materials
— control of the quality of the fuels and fuel feeding system.

Disruptions predominantly happen during the start-up operation phase. For safe operation, the gas analysers for ESP protection have to be online during all operational phases and the ESP downtime can be reduced by using a backup monitoring system maintained in operation.

The continuous CO monitoring system needs to be optimised for reaction time and should be located close to the CO source, e.g. at a preheater tower outlet, or at a kiln inlet in the case of a wet kiln application.

Applicability

Generally applicable to kilns fitted with electrostatic precipitators (ESPs).

1.4.4.4 *SO_x emissions*

65. In order to reduce the emissions of SO_x from the flue-gases of kiln firing processes, BAT is to use a combination of the following primary and secondary techniques:

	Technique	Applicability
a	Process optimisation techniques	Generally applicable
b	Selecting fuels with a low sulphur content	Generally applicable subject to availability of low sulphur fuels which may be impacted by the energy policy of the Member State. The selection of fuel also depends on the quality of the final product, technical possibilities and economic considerations
c	A dry absorbent addition technique (sorbent addition into the flue gas stream such as reactive MgO grades, hydrated lime, activated carbon, etc.), in combination with a filter[a]	Generally applicable
d	Wet scrubber[a]	The applicability may be limited in arid areas by the large volume of water

a A description of the measure/technique is provided in Section 1.7.2

Changes to legislation: *There are currently no known outstanding effects for the Commission Implementing Decision of 26 March 2013 establishing the best available techniques (BAT) conclusions under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions for the production of cement, lime and magnesium oxide (notified under document C(2013) 1728) (Text with EEA relevance) (2013/163/EU), BAT CONCLUSIONS. (See end of Document for details)*

		necessary and the need for waste water treatment and the related cross-media effects

a A description of the measure/technique is provided in Section 1.7.2

BAT-associated emission levels

See Table 15.

TABLE 15

BAT-associated emission levels for SO_x from flue-gases of kiln firing processes in the magnesia industry

Parameter	**Unit**	**BAT-AEL[ab](daily average value or average over the sampling period (spot measurements for at least half an hour))**
SO_X expressed as SO_2	mg/Nm^3	< 50 – 400[c]

a The BAT-AELs depend on the content of sulphur in the raw materials and fuels. The lower end of the range is associated with the use of raw materials with low sulphur content and the use of natural gas; the upper end of the range is associated with the use of raw materials with higher sulphur content and/or the use of sulphur-containing fuels.

b Cross-media effects should be taken into account to assess the best combination of BAT to reduce SO_x emissions.

c When a wet scrubber is not applicable, BAT-AELs depend on the sulphur content of raw materials and fuels. In this case, the BAT-AEL is < 1 500 mg/Nm^3 while ensuring a SO_X emissions removal efficiency of at least 60 %.

1.4.5 *Process losses/waste*

66. In order to reduce/minimise process losses/waste, BAT is to reuse various types of collected magnesium carbonate dusts in the process.

Applicability

Generally applicable, subject to dust chemical composition.

67. In order to reduce/minimise process losses/waste, BAT is to utilise the various types of collected magnesium carbonate dusts in other marketable products when these are not recyclable.

Applicability

The utilisation of magnesium carbonate dusts in other marketable products may not be within the control of the operator.

68. In order to reduce/minimise process losses/waste, BAT is to reuse sludge resulting from the wet process of the flue-gas desulphurisation in the process or in other sectors.

Applicability

The utilisation of sludge resulting from the wet process of the flue-gas desulphurisation in other sectors may not be within the control of the operator.

1.4.6 *Use of wastes as fuels and/or raw materials*

69. In order to guarantee the characteristics of waste to be used as fuels and/or raw materials in magnesium oxide kilns, BAT is to use the following techniques:

	Technique
a	To select suitable wastes for the process and the burner
b	To apply quality assurance systems to guarantee and control the characteristics of wastes and to analyse any waste that is to be used for: I. availability II. constant quality III. physical criteria, e.g. emissions formation, coarseness, reactivity, burnability, calorific value IV. chemical criteria, e.g. chlorine, sulphur, alkali and phosphate content and relevant metals (e.g. total chromium, lead, cadmium, mercury, thallium) content
c	To control the amount of relevant parameters for any waste that is to be used, such as total halogen content, metals (e.g. total chromium, lead, cadmium, mercury, thallium) and sulphur

Applicability

Wastes may be used as fuels and/or raw materials in the magnesia industry (although they had not yet been applied in the magnesia industry in 2007) subject to availability, the type of kiln used, the desired product qualities and the technical possibility of feeding the fuels into the kiln.

(**1**) This range only reflects information provided for the magnesium oxide chapter of the BREF. More specific information about best performing techniques along with the products produced was not provided.

Changes to legislation:
There are currently no known outstanding effects for the Commission Implementing Decision of 26 March 2013 establishing the best available techniques (BAT) conclusions under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions for the production of cement, lime and magnesium oxide (notified under document C(2013) 1728) (Text with EEA relevance) (2013/163/EU), BAT CONCLUSIONS.