

SNAP CODE: **030312**
040614

SOURCE ACTIVITY TITLE: **PROCESSES WITH CONTACT**
Lime
Lime (decarbonizing)

NOSE CODE: **104.01.02**

NFR CODE: **1 A 2 f**
2 A 2

ISIC: **2394**

1 ACTIVITIES INCLUDED

This chapter includes information on atmospheric emissions during lime work operations. Lime (CaO) is the high-temperature product of the calcination of limestone. The production occurs in vertical and rotary kilns fired by coal, oil or natural gas. Calcium limestone contains between 97 and 98 % of calcium carbonate on a dry basis. The rest includes magnesium carbonate, aluminium oxide, iron oxide and silica. However, some limestone contains as much as 35 to 45 % magnesium carbonate and is classified as dolomite.

2 CONTRIBUTIONS TO TOTAL EMISSIONS

Atmospheric emissions in the lime manufacturing industry include particulate emissions from the mining, handling, crushing, screening, and calcining of the limestone and emissions of air pollutants generated during fuel combustion in kilns. These emissions are not very significant on global or even regional scale. However, lime works can be an important emission source of air pollutants on a local scale.

Table 2.1: Contribution to total emissions of the CORINAIR90 inventory (28 countries)

Source-activity	SNAP-code	Contribution to total emissions [%]											
		SO ₂	NO _x	NMVOC	CH ₄	CO	CO ₂	N ₂ O	NH ₃	TSP*	PM ₁₀ *	PM _{2.5} *	
Lime	030312												
Typical contribution		0.1	0.2	0	0	0.3	0.3	-	-	5.98	5.24	1.85	
Highest value										33.0	32.2	12.0	
Lowest value										0.05	0.05	0.02	

* EU PM_{2.5} Inventory project for EU25 for the year 2000 (TNO, 2006), contribution to total national emissions, excluding agricultural soils

0 = emissions are reported, but the exact value is below the rounding limit (0.1 per cent)

- = no emissions are reported

3 GENERAL

3.1 Description

Two major types of processes can be considered within the lime work operations: quarrying, crushing, and size grading of minerals and then combustion of fuels in lime kilns. Limestone quarries are usually developed in a number of benches or lifts. For primary blasting of the limestone, holes are made by drills operated by compressed air (Parker, 1978). The excavated limestone is transferred for crushing and grinding. There are several types of crushing and grinding machines to produce limestone of sizes suitable for several designs of kilns.

During the kiln operations the limestone reaches temperatures as high as 900° C, and carbon dioxide is driven off limestone to leave so-called quicklime. The quicklime descends through the cooling zone and is discharged at the base of the kiln. Obviously, various air pollutants are generated during combustion of fuels in the kiln. At present two major types of kilns are in use: vertical and rotary kilns. The vertical kilns, because of larger size of charge material, lower air velocities, and less agitation emit lower amounts of particles but higher amounts of sulfur dioxide and carbon monoxide. However, in recent years there have been important developments in the design and use of rotary kilns. They require a more carefully classified and smaller size of limestone than for the vertical kilns.

Hydrated lime is made by adding water to crushed or ground quicklime and thoroughly mixing the quicklime and the water. Milk of lime can be produced either by slaking quicklime with an excess of water or by mixing hydrated lime with water.

In Table 3.1 was reported the number of kilns for types in Europe in 1995 (EUROPEAN COMMISSION, 2001).

Table 3.1: Number of operational lime kilns, not including captive kilns, in EU Member States 1995 (EUROPEAN COMMISSION, 2001)

Country	Rotary	Annular shaft	Regener. shaft	Other shaft	Other kilns	Total
Austria	0	2	6	3	1	12
Belgium	8	5	14	0	2	29
Denmark	2	0	0	0	0	2
Finland	5	0	0	0	0	5
France	4	21	20	18	1	64
Germany	7	31	12	74	12	136
Greece	1	2	1	39	1	44
Ireland	1	0	1	3	0	5
Italy	0	5	25	30	0	60
Luxembourg	0	0	0	0	0	0
Netherlands	0	0	0	0	0	0
Portugal	0	0	2	1	9	12
Spain	4	1	21	16	0	42
Sweden	5	0	3	2	0	10
UK	8	0	7	10	1	26
Total	45	67	114	196	27	449

3.2 Definitions

Lime the high-temperature product of the calcination of limestone.

3.3 Emissions

Pollutants released are sulphur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (non-methane VOC and methane (CH₄)), carbon monoxide (CO), carbon dioxide (CO₂), nitrous oxide (N₂O) and particulate matter. According to CORINAIR90 the main relevant pollutants are SO₂, NO_x, CO and CO₂ (see also table 3).

Sulphur dioxide emissions are influenced by several factors, including the sulphur content of the fuel, the sulphur content and mineralogical form (metal sulphide like pyrite, or sulphates like gypsum) of the stone feed, the quality of lime being produced, and the type of kiln. Due to variations in these factors, plant-specific SO₂ emission factors are likely to vary significantly from the average emission factors presented here. The dominant source of sulphur emissions is the kiln's fuel, particularly coal and petroleum derived coke, where the levels of sulphur may be as high as 5 % by weight. The amount of sulphur present will vary widely according to the nature of the deposits used. During the calcining operation, sulphide and sulphates are decomposed to yield sulphur dioxide. On combustion of the fuel, the sulphur compounds present in the fuel are oxidised to sulphur dioxide, and pass through the burning zone of the kiln with the exhaust gases (EPA, 1995; HSMO, 1992).

When sulphur containing fuels are burnt, for practical purposes sulphur in the kiln exhaust may be assumed to be emitted as sulphur dioxide, although there is usually some sulphur trioxide formed. In the case of lime manufacture in shaft kilns, much of the sulphur recombines with the burnt lime and the emissions of sulphur dioxide are subsequently reduced. In the case of rotary and rotating hearth kilns, combinations of process design and combustion conditions can be selected to ensure that most of the sulphur is expelled as sulphur dioxide in the kiln gases (HSMO, 1992).

The oxides of nitrogen are produced through the reaction of the nitrogen and oxygen in the air and through the oxidation of the nitrogen compounds contained in the fuel. There is a significant increase in the amount of oxides of nitrogen (mainly nitric oxide) which is formed at temperatures above 1,400 °C. The formation of nitric oxide is also a function of the excess air. When operating near to stoichiometric conditions in the kiln, there is localised generation of carbon monoxide. This acts as a reducing agent so that any nitric oxide which may be present is converted to nitrogen. Some oxides of nitrogen are also formed in electrostatic precipitators (HSMO, 1992).

Carbon dioxide and carbon monoxide are formed as main products of the combustion process. Carbon monoxide is formed by the incomplete combustion of carbonaceous fuels and even with good combustion control small amounts of carbon monoxide will be present in combustion gases.

The dissociation of limestone produces up to 0.75 tonne of carbon dioxide (CO₂) per tonne of quicklime, depending on the composition of the limestone and the degree of calcination.

The amount of carbon dioxide produced by combustion depends on the chemical composition of the fuel and on the heat use per tonne of quicklime, generally it is in the range 0.2 to 0.45 tonne CO₂ per tonne of quicklime (EUROPEAN COMMISSION, 2001).

3.4 Controls

Emissions of sulphur oxide can be reduced by using low sulphur fuels and by limiting the sulphur contents of the fuel and raw materials. Sulphur dioxide emissions may be further reduced if the polluting equipment is fitted to desulphurise the exhaust gases (e.g. by using a wet process) (EPA, 1995; HMSO, 1992).

The design of kiln and combustion conditions may be selected to ensure that most of the sulphur is retained in the burnt lime. In most circumstances, especially in shaft kilns, only a small fraction of the sulphur dioxide generated within the kiln (whether originating from the raw materials or from the fuel) is released to atmosphere, since it is mainly incorporated into the lime by chemical combination (HSMO, 1992).

The following techniques can be reasonably applied to reduce oxides of nitrogen discharges to the atmosphere:

- the use of low-NO_x-burners where practicable, the principle of which is the avoidance of localised hot spots, and
- the use of very finely pulverised coal so that complete combustion can be achieved with low excess air.

Modern lime works are equipped with electrostatic precipitators that remove at least 98 % of the particulate matter from exhaust gases. Other control devices are also used including multiple cyclones, wet scrubbers, and baghouses.

4 SIMPLER METHODOLOGY

Emissions can be estimated at different levels of complexity; it is useful to think in terms of three tiers¹:

Tier 1: a method using readily available statistical data on the intensity of processes (“activity rates”) and default emission factors. These emission factors assume a linear relation between the intensity of the process and the resulting emissions. The Tier 1 default emission factors also assume an average or typical process description.

Tier 2: is similar to Tier 1 but uses more specific emission factors developed on the basis of knowledge of the types of processes and specific process conditions that apply in the country for which the inventory is being developed.

Tier 3: is any method that goes beyond the above methods. These might include the use of more detailed activity information, specific abatement strategies or other relevant technical information.

¹ The term “Tier” is used in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories and adopted here for easy reference and to promote methodological harmonization.

By moving from a lower to a higher Tier it is expected that the resulting emission estimate will be more precise and will have a lower uncertainty. Higher Tier methods will need more input data and therefore will require more effort to implement.

For the simpler methodology (equivalent to Tiers 1 and 2), where limited information is available, a default emission factor can be used together with production capacity information for the country or region of interest without further specification on the type of industrial technology or the type and efficiency of control equipment.

Consequently the simplified methodology is to combine an activity rate (AR) with a comparable, representative, value of the emissions per unit activity, the emission factors (EF). The basic equation is:

$$\text{Emission} = \text{AR} \times \text{EF}$$

In the energy sector, for example, fuel consumption would be activity data and mass of material emitted per unit of fuel consumed would be a compatible emission factor.

NOTE: The basic equation may be modified, in some circumstances, to include emission reduction efficiency (abatement factors).

Default emission factors for this purpose are provided in Section 8.1. However, it should be admitted that the chemical composition of fuel used in kilns is one of the factors affecting the amount of these emissions.

5 DETAILED METHODOLOGY

The detailed methodology (equivalent to Tier 3), to estimate emissions of gaseous pollutants from the cement production is based on measurements or estimations using plant specific emission factors - guidance on determining plant specific emission factors is given in Measurement Protocol Annex.

In this case, different emission factors for different types of kilns should be used. An account of the effect of emission controls should be considered. The different emission factors will have to be evaluated through measurements at representative sites.

6 RELEVANT ACTIVITY STATISTICS

Information on the production of lime, suitable for estimating emissions using of the simpler estimation methodology (Tier 1 and 2), is widely available from UN statistical yearbooks or national statistics.

The detailed methodology (Tier 3) requires more detailed information. For example, the quantities of lime produced by various types of industrial technologies employed in the lime industry at plant level. However, in most cases, no information is available from the statistical yearbooks on the quantities of lime produced in vertical and rotary kilns.

Further guidance is provided in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, volume 3 on Industrial Processes and Product Use (IPPU), chapter 2.2.1.3 "Choice of activity statistics".

7 POINT SOURCE CRITERIA

Lime works should be regarded as point sources if plant specific data are available.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

8.1 Default Emission Factors For Use With Simpler Methodology

A summary of default emission factors for use with a simpler methodology for estimating emissions are provided in Table 8.1 and Table 8.2. The emission factors of Table 8.1 are mainly extracted from the Integrated Pollution Prevention and Control Reference Document on Best Available Techniques [IPPC, BREF] (European Commission, 2001). Care should be taken not to double-count emissions reported in 0301 Combustion in boilers, gas turbines and stationary engines, and emissions reported here in activity 030312; fuel used in the process does not have to be taken into account in 0301.

Table 8.1: Emission factors for lime production

Pollutant	Emission factor ⁽¹⁾	Units
Particulate matter ⁽²⁾		
TSP	0.5	kg/Mg lime
PM ₁₀	0.2	kg/Mg lime
PM _{2.5}	0.04	kg/Mg lime
Nitrogen oxides ⁽³⁾	1,4	kg/Mg lime
Sulphur oxides ⁽³⁾	1,0	kg/Mg lime
Carbon monoxide ⁽³⁾	5,0	kg/Mg lime

⁽¹⁾ EUROPEAN COMMISSION, 2001

⁽²⁾ CEPMEIP, Moderate collection of fugitive dust, for uncertainty information see table 8.2e

⁽³⁾ Average value for shaft kiln, the most used (see Table 4)

8.2 Reference Emission Factors For Use With Detailed Methodology

Limited information is available on emission factors for various air pollutants emitted from lime works. A collection of emission factors was performed for World Health Organization (Economopoulos, 1993). The results of this work are presented in table 8.2a.

Table 8.2a: Emission factors for selected air pollutants emitted during lime production, in kg/Mg of lime produced, after Economopoulos (1993)

Operation	Total suspended particles	SO ₂	NO _x	CO
Coal Storage and Processing (If Coal is used as fuel)				
Coal Storage				
Open Piles	0.5			
Semi-Enclosed Piles	0.25			
Compartments	0.1			
Silos	0.1			
Coal Crushing and Screening				
Uncontrolled	0.18			
Fabric Filter	0.002			
Coal Grinding				
(Semi) Direct Fired System	0.0			
Indirect Fired System				
Uncontrolled	10.0			
Fabric Filter	0.1			
Raw Material Storage	0.16			
Crushing & Screening				
Uncontrolled	1.5			
Fabric Filter	0.0005			
Crushed Material Storage				
Open Piles	1.0			
Semi-Enclosed Piles	0.5			
Compartments	0.2			
Silos	0.2			
Raw Material Conveying				
Uncontrolled	1.2			
Fabric Filter	0.01			
Raw Material Calcining				
Vertical Shaft Kiln				
Uncontrolled	3.0	0.9S	0.1	2.0
Cyclone	1.0	0.9S	0.1	2.0
Multicyclones	0.75	0.9S	0.1	2.0
Vertical Double Inclined Kilns				
Uncontrolled	10.5	0.9S	0.1	2.0
Cyclone	3.6	0.9S	0.1	2.0
Multicyclones	2.6	0.9S	0.1	2.0
Parallel Flow/Counterflow Regenerative Kilns				
Uncontrolled	8.0	0.9S	0.1	2.0
Cyclone	2.8	0.9S	0.1	2.0
Multicyclones	2.0	0.9S	0.1	2.0
Annular Kilns				
Uncontrolled	12.0	0.9S	0.1	2.0
Cyclone	4.2	0.9S	0.1	2.0
Multicyclones	3.0	0.9S	0.1	2.0

Operation	Total suspended particles	SO ₂	NO _x	CO
Rotary Short Kiln/Air Suspension Preheater				
Uncontrolled	40.0	0.36S	1.5	1.0
Cyclone	14.0	0.36S	1.5	1.0
Multicyclones	9.0	0.36S	1.5	1.0
ESP	0.6	0.36S	1.5	1.0
Fabric Filter	0.2	0.36S	1.5	1.0
Rotary Long Kiln				
Uncontrolled	140.0	0.36S	1.5	1.0
Cyclone	49.0	0.36S	1.5	1.0
Multicyclones	35.0	0.36S	1.5	1.0
ESP	2.0	0.36S	1.5	1.0
Fabric Filter	0.4	0.36S	1.5	1.0
Calcimatic Kiln				
Uncontrolled	25.0	0.9S	0.1	1.0
Cyclone	8.7	0.9S	0.1	1.0
Multicyclones	6.2	0.9S	0.1	1.0

Lime Cooling				
Grate Cooler				
Uncontrolled	20.0			
Cyclone	4.0			
Multicyclones	2.0			
Fabric Filters	0.1			
Planetary, Rotary, or Vertical Shaft Coolers	0.0			
Lime Packaging/Shipping				
	0.12			
Lime Hydration				
Uncontrolled	35.0			
Scrubber	0.04			

“S” is the sulfur percent in the fuel.

Table 8.2b contains fuel related emission factors for lime works based on CORINAIR90 data in [g/GJ]. Technique related emission factors, mostly given in other units (e.g. g/Mg product), are listed in footnotes. In the case of using production statistics the specific energy consumption (e.g. GJ/Mg product) has to be taken into account, which is process and country specific. Within CORINAIR90 a range for the specific energy consumption of 3 up to 4.7 GJ/Mg product has been reported. In each case, care should be taken not to double-count emissions reported in 0301 Combustion in boilers, gas turbines and stationary engines, and emissions reported here in activity 030312.

Table 8.2b: Emission Factors for Lime Works⁸⁾

Type of fuel				NAPFUE	Emission factors						
				code	SO ₂ ³⁾ [g/GJ]	NO _x ⁴⁾ [g/GJ]	NMVOC ⁵⁾ [g/GJ]	CH ₄ ⁶⁾ [g/GJ]	CO ⁷⁾ [g/GJ]	CO ₂ [kg/GJ]	N ₂ O [g/GJ]
s	Coal	Hc	steam	102	33-786 ¹⁾	150-340 ¹⁾	15-40 ¹⁾	0.3-15 ¹⁾	10-6000 ¹⁾	92-98 ¹⁾	4-14 ¹⁾
s	Coal	Hc	brown coal/lignite	105	25 ¹⁾ , 80 ²⁾	140 ¹⁾ , 300 ²⁾	15 ¹⁾²⁾	15 ¹⁾²⁾	100 ¹⁾ , 15 ²⁾	113 ¹⁾ , 100 ²⁾	3.5 ¹⁾ , 3 ²⁾
s	Coal	Hc	briquettes	106	11 ¹⁾	140 ¹⁾	15 ¹⁾	15 ¹⁾	6000 ¹⁾	95-98 ¹⁾	3.5 ¹⁾
s	coke	Hc	coke oven	107	25-400 ¹⁾	40-300 ¹⁾	0.5-15 ¹⁾	0.5-15 ¹⁾	70-6000 ¹⁾	45-200 ¹⁾	4-12 ¹⁾
s	coke	Bc	coke oven	108	650 ¹⁾	220 ¹⁾	5 ¹⁾	15 ¹⁾	90 ¹⁾	86 ¹⁾	3 ¹⁾
s	coke		petroleum	110	275 ¹⁾	300 ¹⁾	1.5 ¹⁾	1.5 ¹⁾	70-75 ¹⁾	97-99 ¹⁾	10-14 ¹⁾
					120-2,852 ²⁾	200-300 ²⁾	1.5-112 ²⁾	1.5-15 ²⁾	10-133 ²⁾	95-105 ²⁾	3-14 ²⁾

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ic030312

s	biomass	wood	111	5.2 ¹⁾	103-200 ¹⁾	48-50 ¹⁾	30-32 ¹⁾	1430-6772 ¹⁾	92 ¹⁾	4-14 ¹⁾
s	waste	industrial	116	5.2 ¹⁾	115 ¹⁾	48 ¹⁾	32 ¹⁾	1430 ¹⁾ , 15 ²⁾	83 ¹⁾ , 76-92 ²⁾	4 ¹⁾ , 6-14 ²⁾
l	oil	residual	203	47-1,470 ¹⁾ 94-1,712 ²⁾	100-310 ¹⁾ 170-215 ²⁾	3-4 ¹⁾ 3-46 ²⁾	3-8 ¹⁾ 1-3 ²⁾	12-6000 ¹⁾ 7-94 ²⁾	73-78 ¹⁾ 75-78 ²⁾	2-14 ¹⁾ 2.5-14 ²⁾
l	oil	gas	204	85-305 ¹⁾ 26 ²⁾	70-310 ¹⁾ 313 ²⁾	1.5-2.5 ¹⁾	1-8 ¹⁾	10-20 ¹⁾ , 76 ²⁾	72-74 ¹⁾	2-14 ¹⁾
g	gas	natural	301	0.1-8 ¹⁾ 0.9 ²⁾	50-1111 ¹⁾ 14-100 ²⁾	2.5-10 ¹⁾ 2.5 ²⁾	0.4-4 ¹⁾	20-6000 ¹⁾ 13-17 ²⁾	55-56 ¹⁾ 53 ²⁾	1-3.7 ¹⁾ 1.5 ²⁾
g	gas	coke oven	304	15 ²⁾	83 ²⁾			84 ²⁾		
g	gas	blast furnace	305	63 ²⁾	286 ²⁾		2.5 ³⁾	286 ²⁾		
g	gas	coke oven and blast furnace gas	306	328 ²⁾	250 ²⁾	0.8 ²⁾	0.8 ³⁾	15 ²⁾	205 ²⁾	3 ²⁾

- 1) CORINAIR90 data, area sources
- 2) CORINAIR90 data, point sources
- 3) SO_x: 4,100 g/Mg product Calcining, vertical kiln (EPA, 1990)
2,550 g/Mg product Calcining, rotary kiln (EPA, 1990)
4,100 g/Mg product multiple hearth calciner (EPA, 1990)
- 4) NO_x: 1,500 g/Mg product General (Bouscaren, 1992)
1,400 g/Mg product Calcining: vertical kiln, rotary kiln and multiple hearth calciner
1,111 g/GJ Cement/lime industry, kilns: natural gas (IPCC, 1995)
527 g/GJ Cement/lime industry, kilns: oil (IPCC, 1995)
527 g/GJ Cement/lime industry, kilns: coal (IPCC, 1995)
- 5) VOC: 10 g/Mg product Calcining: vertical kiln (EPA, 1990)
30 g/Mg product Calcining: rotary kiln (EPA, 1990)
10 g/Mg product Calcining: multiple hearth calciner (EPA, 1990)
- 6) CH₄: 1.1 g/GJ Cement/lime industry, kilns: natural gas (IPCC, 1995)
1.0 g/GJ Cement/lime industry, kilns: oil (IPCC, 1995)
1.0 g/GJ Cement/lime industry, kilns: coal (IPCC, 1995)
- 7) CO: 83 g/GJ Cement/lime industry, kilns: natural gas (IPCC, 1995)
79 g/GJ Cement/lime industry, kilns: oil (IPCC, 1995)
79 g/GJ Cement/lime industry, kilns: coal (IPCC, 1995)
- 8) It is assumed, that emission factors cited within the table are related to combustion sources in lime works. Footnotes may also include emission factors for other process emissions (e.g. calcination).

Typical emissions of NO_x and SO₂ from various types of lime kiln coming from IPPC BREF document (EUROPEAN COMMISSION, 2001) are shown in Table 8.2c for Nitrogen Oxides.

Table 8.2c: Typical emissions of NO_x, SO_x and CO from some types of lime kiln from IPPC BREF document (EUROPEAN COMMISSION, 2001)

Kiln type	mg NO _x /Nm ³ 1	Kg NO _x /Mg lime 2	mg SO ₂ /Nm ³ 1	kg SO ₂ /Mg lime 2	g CO/Nm ³ 1	kg CO/Mg lime 2
Calcium quicklime, light- and hard-burned dolomite						
Mixed feed shaft kiln	<300	<1	<300	<1	12-37	42-130
Double-inclined shaft kiln	<500	<1.7	<500	<1.7	<1.4	<5
Multi-chamber shaft kiln	500-800	1.7-2.8	<500	<1.7	<1.4	<5
Annular shaft kiln	<500	<1.7	<300	<1	<1.4	<5
Parallel-flow regenerative shaft kiln	<400	<1.4	<300	<1	<1.4	<5
Other shaft kilns	<300	<1	<300	<1	<14	<50
Rotary kilns, soft burning	100-700	0.4-2.8	<800 ³	<3	1.2-12	5-50
Rotary kilns, hard burning	400-1800	1.6-7	<800 ³	<3	1.2-12	5-50
Travelling grate kiln	<300	<1	<300	<1	<1.3	<4
Dead-burned dolomite						
Mixed feed shaft kiln	<300	<1	<800	<1.5	37-63	70-120

Rotary kilns	2000-5000	15-45	<5000	<42.5	0.6-6	5-50
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1) Emission concentrations are one year averages, and are indicative values based on various measurement techniques. O₂ content normally 10%.

2) based on typical exhaust gas volumes (wet) of

3500 Nm³/Mg of lime for shaft and travelling grate kilns,

4000 Nm³/Mg of lime for rotary kilns calcining high-calcium limestone and dolomite,

1900 Nm³/Mg of lime for mixed feed shaft kilns dead-burning dolomite, and

8500 Nm³/Mg of lime for rotary kilns dead-burning dolomite.

3) May be higher with high-sulphur fuels.

Regarding PM, “dust” emissions factors from different process with and without control from the IPPC BREF document (EUROPEAN COMMISSION, 2001) are shown in Table 8.2d. For PM₁₀ and PM_{2.5}

Table 8.2d: Typical emissions of PM from some types of lime kiln from IPPC BREF document (EUROPEAN COMMISSION, 2001)

Process	Uncontrolled		Controlled	
	mg PM/Nm ³	kg PM/Mg lime	mg PM/Nm ³	kg PM/Mg lime
Calcining of limestone	500 - 5000	2- 20 ¹	30-200 ²	0.1- 0.8 ^{1,2}
Lime hydrating	2000	1,6 ³	20-200	0,016 - 0,16 ^{3,4}
Lime grinding	Not applicable ⁵		20 - 50	0.03 - 0.075 ⁶
Subsidiary operations ⁷	Not available		Not available	

1) Based on 4000 Nm³/Mg lime.

2) All rotary kilns are fitted with dust collection equipment, as are most shaft kilns. Because of the wide range of exhaust gas conditions, a variety of dust collectors are used, including cyclones, wet scrubbers, fabric filters, electrostatic precipitators and gravel bed filters.

3) The gaseous effluent from hydrating plants is rather small in volume; levels are around 800 m³/Mg of hydrated lime

4) Both wet scrubbers and bag filters are used to de-dust the emission.

5) Air is drawn through all of the grinding equipment to remove ground lime of the required particle size. The product is separated from the air in bag filters, often preceded by cyclones. Thus, dust collection is an integral part of the process.

6) At a typical air flow of 1500 Nm³/Mg of lime.

May include crushing, screening, conveying, slaking, storage and discharge.

Table 8.2e: Emission factors of PM in kg/ton lime produced with different abatement technologies (CEPMEIP)

Abatement technology	TSP	PM ₁₀	PM _{2.5}	Uncertainty factor
Effective control fugitive sources	0.3	0.15	0.03	10
Limited control fugitive sources	1.0	0.3	0.06	10
Moderate collection of fugitive dust	0.5	0.2	0.04	10

NOTE: The uncertainty range (95% confidence) in the emission factor is expressed as a factor. The lower limit of the uncertainty range can be found by dividing the emission factor by the uncertainty factor, whereas the upper limit of the uncertainty range can be found by multiplying the range with the uncertainty factor. Example (first row in Table 8.2e): The uncertainty in the emission factor for PM_{2.5} with effective control of fugitive

sources is 10. The emission factor with uncertainty range will therefore be 0.03 kg per ton lime produced with an uncertainty range of 0.003 (0.03 / 10) to 0.3 (0.03 x 10).

9 SPECIES PROFILES

Not available for particulate matter.

10 UNCERTAINTY ESTIMATES

It is difficult to assess current uncertainties of emission estimates for lime works operations. The difficulty results from a lack of emission measurements in these plants and thus the uncertainty of emission factors based on limited information.

11 WEAKEST ASPECTS/ PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

Improvement of emission factors is necessary in order to obtain more accurate emission estimates for lime works operations. This improvement should focus on preparing individual emission factors for different types of kiln operations. In this way, a detailed methodology for emission estimates can be applied. Obviously, it will be necessary to obtain relevant statistical data.

The fuel specific emission factors provided in Table 8.2b are related to point sources and area sources without specification. CORINAIR90 data can only be used in order to give a range of emission factors with respect to point and area sources. Further work should be invested to develop emission factors, which include technical or fuel dependent explanations concerning emission factor ranges.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

National emission estimates can be disaggregated on the basis of production, population or employment statistics.

13 TEMPORAL DISAGGREGATION CRITERIA

The production process in lime works is continuous.

14 ADDITIONAL COMMENTS

No additional comments.

15 SUPPLEMENTARY DOCUMENTS

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16 VERIFICATION PROCEDURES

Estimated emission factors could be best verified by measurements at respective plants.

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No additional documents.

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20 POINT OF ENQUIRY

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