SNAP CODE: **030318**

SOURCE ACTIVITY TITLE: **PROCESSES WITH CONTACT**
Mineral Wool

NOSE CODE: **104.11.09**

NFR CODE: **1 A 2 f**

1 ACTIVITIES INCLUDED

This chapter covers emissions released from combustion processes within mineral wool production.
A mixture of minerals and coke is heated until it is molten and can be spun into fibres. The fibres are treated with resins to form a wool-like product.

2 CONTRIBUTION TO TOTAL EMISSION

The contribution of fuel use related emissions released from the production of mineral wool to total emissions in countries of the CORINAIR90 inventory is minor, as indicated in table 1.

Table 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_2O	NH_3	PM*
Mineral Wool	0303018	0	0	-	-	0	0	-	-	-

0 = emissions are reported, but the exact value is below the rounding limit (0.1 per cent)
- = no emissions are reported
* = PM (inclusive of TSP, PM_{10} and $PM_{2.5}$) is <0.1% of total PM emissions

The emissions of phenol(s) is also relevant but no estimates are available at the European level.

3 GENERAL

3.1 Description of activities

Products manufactured from man-made mineral fibres (MMMF) generally consist of inorganic fibres produced from a silicate melt, and, depending on their application and use, contain binding agents, additives and filters. (VDI, 1994)

Whilst basically the melting technology closely resembles the technology commonly used in glass-works, there are considerable differences in the composition of the glass types which have to be adapted to meet the special demands made on the man-made mineral fibres with respect to processability, viscosity, melting range, hydrolytic class, heat resistance etc. In particular, special glasses containing boron and glasses with additives of volcanic rock (phonolite, basalt, diabase) are used. (VDI, 1994)

3.2 Definitions

3.3 Techniques

Cupola furnaces are used for the production of silicate melts. The starting materials for the production of MMMF are silicate rocks (e.g. basalt, diabase) or metallurgical slags with alkaline or acid additives (e.g. limestone, dolomite, sandstone). Coke, fuel oil or gas are used as fuels. (VDI, 1994)

In electric melting units, the mineral raw materials are melted by electric resistance heating. Units of fireproof (refractory) materials and water-cooled metal containers are in use. (VDI, 1994)

The silicate melt is fed either in covered or open channels (feeders, troughs) or directly to the processing units in which the fibres are produced. The most commonly employed processes are the bushing blowing process, the centrifugal process and the bushing drawing process. (VDI, 1994)

Man-made mineral fibres are generally processed by impregnation, soaking or coating and possibly with subsequent drying processes to form a wide range of finished products. (VDI, 1994)

The impregnated or coated semi-finished product is dried by intensive contact with hot air. Continuous pass driers, single or multi-layer and chamber drying kilns are used. The hot air temperature can be up to 300 °C. The hot air is generally circulated (circulation air process), whereby both direct and indirect heating (e.g. by means of heat transfer oil) processes are in use. (VDI, 1994) Hot pressing is commonly used for the manufacture of certain products, whereby the drying and hardening is performed by warming between heated moulds. (VDI, 1994)

Energy consumption is typically around 6 -10 GJ per ton produced.

3.4 Emissions

Dust emission can result from handling raw materials as well as from the melting process.

Other emissions result from the melting process, the spinning process as well as finishing the wool. Pollutants released are sulphur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (non-methane VOC and methane (CH_4)), carbon monoxide (CO), carbon dioxide (CO_2), and nitrous oxide (N_2O). According to CORINAIR90 the main relevant pollutants are SO_2, NO_x, CO and CO_2 (see also table 1).

The cupola is a source of CO, CO_2 and NO_x emissions; SO_2 and H_2S emissions also occur, because blast furnace slags contain sulphur /cf 4/.

Emissions of organic and inorganic substances arise from manufacturing products of man-made mineral fibres. The raw gas contents of the melting facilities are generally of a purely inorganic nature and free from fibrous constituents. Emissions of organic substances can arise preparating the binding agent. /cf. 3/
Where binding agents containing nitrogen (ammonia, aminoplasts) are processed, ammonia and/or organic compounds containing nitrogen may occur in the waste gases, depending on the operating conditions. /cf. 3/

No gaseous or particulate emissions arise during the actual production of the fibres (VDI, 1994).

3.5 Controls

Dust emissions from handling raw materials can be reduced using fabric filters or using different handling techniques.

Extraction systems and driers (hardening kilns, presses) should be designed with respect to the product throughput in such a way that overloading of the facilities by increased temperatures and excessive flow velocities or increased evaporation of constituents of the binding agents or the transport in the air current of droplets and fibrous dusts is prevented. (VDI, 1994)

The malodorous and organically contaminated waste gases from the drying and hardening kilns are transferred to waste gas treatment plants. Multistage wet separator systems (washers) can be used in conjunction with wet electrostatic precipitators or aerosol separators as well as catalytic and thermal post-combustion. Processes employing high-frequency drying result in neither malodorous or organic emissions. No significant dust emissions occur during the process stages drying and hardening. Waste gases are released by stack. /cf 3/

4 SIMPLER METHODOLOGY

The simpler methodology involves applying an appropriate emission factor to either production or energy consumption statistics.

N.B There are no emission factors available for $PM_{2.5}$. The source is <0.1% of the total PM emissions for most countries.

5 DETAILED METHODOLOGY

If an extensive measuring programme is available the emissions can be calculated on for an individual plant.

Should a key source analysis indicate this to be a major source of particulate matter (TSP, PM_{10} or $PM_{2.5}$) then installation level data should be collected using a measurement protocol such as that illustrated in Measurement Protocol Annex.

6 RELEVANT ACTIVITY STATISTICS

Standard production and energy statistics from national or international statistical publications.

7 POINT SOURCE CRITERIA

The production of mineral wool is a minor source of emissions and hence can be treated on an area basis. However, production usually connected to high chimneys can 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

Table 2: Emission factors (kg/Mg product) for mineral wool production (European Commission, 2001) (1)

Substance	Emission factor
NO_x	0,73
SO_x	4,1
PM	2,49
VOC	1,51
NH_3	3,16
CO	125

(1) Cupola furnace including non-melting activities

8.2 Reference Emission Factors For Use With Detailed Methodology

Reported emission levels from Integrated Pollution Prevention and Control Reference Document on Best Available Techniques [IPPC, BREF] (European Commission, 2001) are given in Table 3 and Table 4 (for melting) and Table 5 (for non melting activities). Table 2 shows the full range of melting emissions from mineral wool plants in the EU. Table 3 shows the estimated middle 80 % middle range (from Percentile 10 to Percentile 90) and is an indication of the performance of the majority of EU-wide installations.

Following the melting stage (European Commission, 2001) the processes and environmental issues are essentially the same as in glass wool (activity 030316).

Mineral wool products usually contain a proportion of phenolic resin based binder. The binder solution is applied to the fibres in the forming area and is cross-linked and dried in the curing oven. The forming area waste gas will contain particulate matter, phenol, formaldehyde and ammonia (European Commission, 2001).

The particulate matter consists of both organic and inorganic material, often with a very small particle size. Lower levels of VOCs and amines may also be detected if they are included in the binder system. Due to the nature of the process the gas stream has a high volume and high moisture content. The releases from the oven will consist of volatile binder materials, binder breakdown products, water vapour and combustion products from the oven burners. After exiting the oven the product is cooled by passing a large quantity of air through it. This gas is likely to contain mineral wool fibre and low levels of organic material. Product finishing involves cutting, handling and packaging, which can give rise to dust emissions (European Commission, 2001).

Table 3: Total emission ranges reported for mineral wool melting activities (European Commission, 2001)

Substance	Cupola Furnaces		Immersed Electric Arc Furnace		Flame Fired Furnaces	
	Mg/m3	kg/Mg of melt	mg/m3	Kg/Mg of melt	mg/m3	kg/Mg of melt
PM	10 - 3000	0.03 - 9.0	10 - 30	0.01 - 0.03	10 - 50	0.02 - 0.1
SO_2	150 - 3500	0.4 - 10.0	1000 - 3000	1.0 - 3.0	30 - 300	0.06 - 0.6
NO_2	50 - 400	0.14 - 1.1	50 - 200	0.05 - 0.2	800 – 1500	1.6 - 3.0
HF	1 - 30	0.003 - 0.09	1 - 5	0.001 - 0.005	0.5 - 5	0.002 - 0.02
HCl	10 - 150	0.03 - 0.4	10 - 50	0.01 - 0.05	1 - 30	0.002 - 0.02
H_2S	1 - 500	0.003 - 1.4	0 - 5	0 - 0.005		
CO	10 – 100000	0.03 - 300	30 - 100	0.03 - 0.1		
CO_2	130 – 260 * 10^3	400 - 800	20 - 200* 10^3	20 - 200	150- 200* 10^3	400 - 500
Metals[1]	0.1 - 30	0.0003 - 0.09				

[1] Metals are emitted mainly as particulate matter.

Table 4: Total emission ranges reported for Middle 80 % (P10 to P90) for mineral wool melting activities (European Commission, 2001)

Substance	Cupola Furnaces		Immersed Electric Arc Furnace		Flame Fired Furnaces	
	Mg/m3	Kg/Mg of melt	mg/m3	kg/Mg of melt	mg/m3	kg/Mg of melt
PM	20 - 100	0.06 - 0.3	10 - 30	0.01 - 0.03	10 - 50	0.02 - 0.1
SO_2	400 - 2500	1.1 - 7.1	1000 - 3000	1.0 - 3.0	30 - 250	0.06 - 0.5
NO_2	80 - 250	0.25 - 0.7	50 - 200	0.05 - 0.2	1150 - 1250	2.3 - 2.5
HF	1.0 - 15.0	0.003 - 0.03	1.0 - 5.0	0.001 - 0.005	1.0 - 5.0	0.004 - 0.02
HCl	10 - 50	0.03 - 0.2	10 - 50	0.01 - 0.05	1.0 - 25	0.002 - 0.015
H_2S	1.0 - 200	0.003 - 0.6	0 - 5.0	0 - 0.005		
CO	30 - 80000	0.1 - 250	30 - 100	0.03 - 0.1		

CO_2	130 – 260 * 10^3	400 - 800	20 - 200* 10^3	20 - 200	150- 200* 10^3	400 - 500
Metals[1]	0.1 - 2.0	0.0003 - 0.006				

[1] Metals are emitted mainly as particulate matter.

An important factor that has a major impact on emissions from forming, curing and cooling is the level of binder applied to the product, as higher binder content products will generally result in higher emission levels. Binder derived emissions depend essentially on the mass of binder solids applied over a given time, and therefore high binder content, and to a lesser extent high density products may give rise to higher emissions (European Commission, 2001).

Table 5 shows the full range of emissions from downstream operations of mineral wool plants in the EU, with figures for kg/Mg of product in brackets. Table 6 shows the estimated middle 80 % of the range.

Table 5: Total emission ranges reported for mineral wool after melting activities (European Commission, 2001)

Substance	Combined fiberising, forming and curing		Fiberising and forming		Product curing		Product cooling		Product finishing	
	mg/Nm	kg/Mg of product	mg/Nm	kg/Mg of product	mg/Nm	kg/Mg of product	mg/Nm	kg/Mg of product	mg/Nm	kg/Mg of product
PM	10 - 200	0.3 - 6.0	10 - 200	0.3 - 6.0	5.0 - 55	0.01 - 0.18	10 - 50	0.04 - 0.3	1.0 - 50	0.005 - 0.4
Phenol	2.0 - 50	0.05 - 1.6	2.0 - 50	0.05 - 1.5	2.0 - 40	0.004 - 0.11	1.0 - 10	0.004 - 0.06		
Formaldehyde	2.0 - 30	0.05 - 1.2	2.0 - 30	0.05 - 1.0	2.0 - 60	0.004 - 0.17	1.0 - 10	0.004 - 0.06		
Ammonia	20 - 250	0.6 - 8.8	20 - 250	0.5 - 7.6	30 - 460	0.06 - 1.9	1.0 - 50	0.004 - 0.3		
NO_x					50 - 200	0.1 - 0.6				
VOC	5.0 - 150	0.1 - 5.0	5.0-150	0.1 - 4.6	5.0 - 150	0.01 - 0.43	1.0 - 30	0.004 - 0.2		
CO2					20 – 80 * 10^3	40 - 230				
Amines	1.0 - 40	0.1 - 1.3	5.0 - 40	0.1 - 1.2	5.0 - 20	0.01 - 0.06	1.0 - 5.0	0.004 - 0.03		

Table 6: Total emission ranges reported for Middle 80 % (P10 to P90) for mineral wool after melting activities (European Commission, 2001)

Substance	Combined fiberising, forming and curing		Fiberising and forming		Product curing		Product cooling		Product finishing	
	mg/Nm	kg/Mg of product	mg/Nm	kg/Mg of product	mg/Nm	kg/Mg of product	mg/Nm	kg/Mg of product	mg/Nm	kg/Mg of product
PM	10 - 50	0.9 - 1.9	10 - 50	0.6 - 3.5	5.0 - 25	0.01 - 0.07	10 - 30	0.04 - 0.2	5.0 - 20	0.03 - 0.16
Phenol	5.0 - 25	0.2 - 1.3	5.0 - 25	0.1 - 0.8	5.0 - 15	0.01 - 0.04	1.0 - 5.0	0.004 - 0.03		
Formaldehyde	5.0 - 20	0.15 - 0.43	5.0 - 20	0.1 - 0.6	5.0 - 30	0.01 - 0.09	1.0 - 5.0	0.004 - 0.03		
Ammonia	40 - 150	1.8 - 5.4	40 - 150	1.0 - 4.5	50 - 200	0.1 - 0.6	2.0 - 20	0.007 - 0.12		
NO_x					50 - 150	0.1 - 0.4				

VOC	10 - 80	0.2 - 2.7	10 - 80	0.3 - 2.4	10 - 80	0.02 - 0.23	1.0 - 10	0.004 - 0.06		
CO2					20 – 80 * 10^3	40 - 230				
Amines	5.0 - 20	0.1 - 1.0	5.0 - 20	0.1 - 0.6	5.0 - 10	0.01 - 0.03	1.0 - 5.0	0.004 - 0.03		

For the situation in the Netherlands, the following emission factors in kg per ton wool can be proposed:

handling/shipping:

dust: 0.5 kg per ton wool

melting oven:

SO_2 1.5 kg per ton wool
CO_2 115 kg per ton wool
CO 3.2 kg per ton wool
F_g 0.008 kg per ton wool
dust 0.06 kg per ton wool (after dust collector)

spinning/wool manufacturing:

formaldehyde 0.2 kg per ton wool
phenol(s) 0.7 kg per ton wool
ammonia 1.8 kg per ton wool
VOS 1.0 kg per ton wool

fuel:

NO_x 1.1 kg per ton wool
CO_2 450 kg per ton wool

The following Table 7 contains fuel related emission factors for the production of mineral wool based on CORINAIR90 data in [g/GJ]. Technique related emission factors, mostly given in other units (e.g. g/Mg product, g/Mg charged), 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 7 - 5.000 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 contains the AP 42 emission factors for particulate matter (US EPA, 1996).

Table 7: Emission factors for the production of mineral wool[7)]

					Emission factors							
	Type of fuel			NAPFUE code	SO_2[2)] [g/GJ]	NO_x[3)] [g/GJ]	NMVOC[4)] [g/GJ]	CH_4[4)] [g/GJ]	CO[5)] [g/GJ]	CO_2[6)] [kg/GJ]	N_2O [g/GJ]	NH_3 [g/GJ]
s	coal	hc	steam	102	584-610[1)]	150-200[1)]	15[1)]	5-15[1)]	20-97[1)]	93-95[1)]	3-5[1)]	
s	coke	hc	coke oven	107	138-584[1)]	90-100[1)]	1.5-83[1)]	1.5[1)]	97[1)]	101-110[1)]	3[1)]	
s	coke	bc	coke oven	108	650[1)]	220[1)]	5[1)]	15[1)]	90[1)]	86[1)]	3[1)]	
s	biomass		wood	111	130[1)]	130[1)]	48[1)]	32[1)]	160[1)]	102[1)]	4[1)]	

l	oil	residual	203	143-1,030[1]	100-330[1]	3[1]	3-8[1]	12-20[1]	73-78[1]	2-10[1]
l	oil	gas	204	55-94[1]	100[1]	1.5-2[1]	1.5-8[1]	12-20[1]	73-74[1]	2[1]
g	gas	natural	301	0.3-8[1]	60-250[1]	4-10[1]	2-4[1]	13-20[1]	53-57[1]	1-3[1]
g	gas	liquified petroleum gas	303	0.04[1]	100[1]	2.1[1]	0.9	13[1]	65[1]	1[1]

[1)] CORINAIR90 data, area sources

[2)] SO_x:
8,480 g/Mg (1989) (Kaskens et al., 1992)
2,320 g/Mg (1991) (Kaskens et al., 1992)
10 g/Mg charged Cupola furnace (EPA, 1990)

[3)] NO_x:
210 g/Mg (1989) (Kaskens et al., 1992)
200 g/Mg (1991) (Kaskens et al., 1992)
800 g/Mg charged Cupola furnace (EPA, 1990)
80 g/Mg charged Curing furnace (EPA, 1990)

[4)] VOC:
450 g/Mg charged Blow chamber
500 g/Mg charged Curing oven

[5)] CO:
8,120 g/Mg (1989) (Kaskens et al., 1992)
< 7,400 g/Mg (1991) (Kaskens et al., 1992)

[6)] CO_2:
67.4 kg/Mg product General for 1989 (Kaskens et al., 1992)
168 kg/Mg product General for 1991 (Kaskens et al., 1992)

[7)] It is assumed, that emission factors cited within the table are related to combustion sources in mineral wool production. Footnotes may also include emission factors for other process emissions.

Table 8: AP 42 Particulate matter emission factors* for Mineral Wool (g/Mg) (US EPA, 1996)

Process	**PM (g/Mg)**	**Rating**
Cupola	8200	E
Cupola with fabric filter	51	D
Reverberatory furnace	2400	E
Batt curing oven	1800	E
Batt curing oven with ESP	360	D
Blow chamber	6000	E
Blow chamber with wire mesh filter	450	D
Cooler	1200	E

* = In the absence of more appropriate data use the AP 42 emission factors

9 SPECIES PROFILES

No general applicable profile for dust emissions available.

10 UNCERTAINTY ESTIMATES

The quality classification of the emission factors expressed per ton wool is estimated to be D.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

Knowledge about measurements related to abatement techniques is limited.

12 SPATIAL DISAGGREGATION CRITERIA FOR AREA SOURCES

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

13 TEMPORAL DISAGGREGATION CRITERIA

The production of mineral wool is a semi-continuous process but no further quantitative information is available.

14 ADDITIONAL COMMENTS

15 SUPPLEMENTARY DOCUMENTS

Emission inventory in The Netherlands, 1992. Emission to air and water.

Personal information and experience during emission inventories 1975 - 1995

Emission factors to be used for the building industry, TNO report 89/091 (1989 - in dutch)

Environmental Protection Agency

Compilation of Air Pollutant Emission Factors AP 42

16 VERIFICATION PROCESSES

Verification of the emissions can be done by comparing emission estimates with measurements at the individual plants.

17 REFERENCES

EPA (ed.): AIRS Facility Subsystem; EPA-Doc. 450/4-90-003; Research Triangle Park; 1990

EUROPEAN COMMISSION (2001), Integrated Pollution Prevention and Control (IPPC), Reference Document on Best Available Techniques (BREF) in the Cement and Lime Manufacturing Industries, December 2001

Kaskens, H. J. M.; Matthijsen, A. J. C. M.; Verburgh, J. J.: Productie van steenwol; RIVM-report 736301114; RIZA-report 92.0003/14; 1992

VDI (ed.): Emissionsminderungsanlagen zur Herstellung von Mineralfaser-produkten/Emission Control Facilities for the Production of Man-Made Mineral Fibres (MMMF); VDI 3457; Düsseldorf; 1994

US EPA (1996) Compilation of Air Pollutant Emission Factors Vol.1 Report AP-42 (5th ed.)

18 BIBLIOGRAPHY

For a detailed bibliography the primary literature mentioned in AP 42 may be used.

19 RELEASE VERSION, DATE, AND SOURCE

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