SNAP CODE: **030319**

SOURCE ACTIVITY TITLE: **PROCESSES WITH CONTACT**
Bricks And Tiles

NOSE CODE: **104.11.10**

NFR CODE: **1 A 2 f**

1 ACTIVITIES INCLUDED

This chapter covers emissions released from combustion processes within bricks and tiles production. However, in the following if useful for description, also non-combustion emissions are mentioned.

2 CONTRIBUTION TO TOTAL EMISSION

The contribution of fuel use related emissions released from the production of bricks and tiles to total emissions in countries of the CORINAIR90 inventory is given as follows:

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*
Bricks and Tiles	030319	0.3	0.3	0	0	0.3	0.6	0.1	-	-

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 emission of fluorides is also relevant but no information is currently available at the European level.

3 GENERAL

3.1 Description of activities

The manufacture of bricks and related products such as clay pipe, pottery, and some types of refractory brick involves the mining, grinding, screening, and blending of the raw materials, clay with additives such as caoline or limestone, and the forming, cutting or shaping, drying or curing, and firing of the final product. /4/

To start the forming process, clay is mixed with water, usually in a pug mill. The three principal processes for forming bricks are stiff mud, soft mud, and dry press. In the stiff mud process, sufficient water is added to give the clay plasticity, and bricks are formed by forcing the clay through a die. Wire is used in separating bricks. All structural tile and most brick are formed by this process. The soft mud process is usually used with clay too wet for the stiff mud process. The clay is mixed with water to a moisture content of 20 to 30 percent, and the bricks are formed in molds. /4/

Three stages of heating are almost invariably involved /5/:

- The initial drying period, in which appreciable volumes of hot air must be passed through the setting in order to remove moisture until the ware is completely dry.
- The oxidation preheating period, in which chemically combined water is removed and oxidation of any carbonaceous matter in the green product is completed.
- The finishing period, during which the required final temperature of 950 - 1100 °C is attained and soaking time allowed to obtain uniformity of heat treatment and develop the required degree of vitrification and maturity.

3.2 Definitions

3.3 Techniques

Two types of kilns can be distinguished, the intermittent and the continuous kiln:

- Intermittent kilns (discontinuous)
  Intermittent kilns are mainly used to fire special products not amenable to continuous practice and where flexibility is of more importance than high thermal efficiency or large output of any one product. Unavoidable heat loss from the firing of these kilns is considerable /5/.

  Two main types of intermittent kiln are used in the heavy clay industry; the rectangular down-drought and the round down drought. Both muffle and open-flame conditions are used with each type. In muffle firing the gases from the fires are not allowed to make contact with the goods being fired, heat transfer being obtained almost entirely by radiation from the muffle walls. With open-flame firing, which is used to a much larger extent, all gases and flames from the fires pass through setting spaces among the ware before the combustion products are finally exhausted through the flue system. /5/

  Each kiln is usually connected to a separate stack. The draught in the kiln is controlled by means of a damper at the base of the stack. /5/

- Continuous kilns
  Continuous kilns are especially applicable to the firing of standard products where large throughput is desired. Recuperation of heat from cooling goods and from the kiln gases makes this kind of kiln more thermally efficient. The economic advantages of mass production and high thermal efficiency are obtained from the use of continuous kilns. /5/

  Two distinct firing principles are used in continuous practice. In car tunnel kilns the pre-heating, firing and cooling zones are fired and the goods travel through these zones on cars

or bogie carriages operated by an external pusher mechanism. These tunnels may be either straight or annular, a moving hearth being used in the annular kiln instead of cars. /5/
In the second type of continuous kiln the goods are set in the kiln and remain stationary while preheating, firing and cooling zones move round the kiln. With this type, one continuous tunnel may be used or the kiln system may consist of a number of transverse arch chambers connected through suitable chamber openings. /5/

Most commonly natural gas is burned to heat the ovens, but other fuels are possible. Energy consumption is typically around 2 - 2.5 GJ per ton.

3.4 Emissions

Pollutants released are dust, 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), nitrous oxide (N_2O), fluoride ($F_{g)}$, Chlorine (Cl_g) and ammonia (NH_3). According to CORINAIR90 the main relevant pollutants are SO_2, NO_x, CO, and CO_2 (see also table 1).

Pollution from the brick making industry is predominantly confined to stack emissions of kiln exhaust gases. The pollutants in the exhaust gas originate mainly from impurities within the clay, although firing with coal or heavy fuel oil will make a significant contribution to the overall emissions to atmosphere. Such impurities will produce fluoride emissions from the fluorine containing components of the clay minerals; sulphur oxides from iron pyrites or other sulphur bearing minerals (e.g. sulphates); and odorous gases from organic materials occurring naturally within the clay or added to the clay during processing The sulphur content of clay varies widely, with the majority of the clays. Combustion products are emitted from the fuel consumed in the dryer and the kiln. /cf. 5/

However, natural gas is mainly employed for firing and the use of heavy oil and coal has declined. Overall, about 2 % of the sulphur oxides emitted are in the form of sulphur trioxide. Research work in the UK on sulphur dioxide emissions from tunnel kilns gave total sulphur dioxide levels up to 480 mg/m³. /cf. 4, 5/

In the combustion process, oxides of nitrogen will be produced from the oxidation of chemically bound nitrogen in the fuel, the clay and from atmospheric nitrogen. In general, the higher the temperature the greater the production of nitrogen oxides. /5/

3.5 Controls

The following main categories of techniques are available for dealing with these pollutants and may be applicable for this process: dry absorption, condensation, wet scrubbing, flue gas desulphurisation, incineration and wet/dry absorption.

- Dry Absorption :
  Most flue gas cleaning systems currently in operation within the brick industry are dry absorption based processes. Two systems are employed, packed bed filters and cloth filters.

- Packed Bed Filters :
  In the packed bed filter system, fluoride sorption is achieved using a filter bed of granular limestone (calcium carbonate) through which the flue gas passes. Fluorine, and other pollutants are absorbed on the filter media which also allows for dust deposition, thereby avoiding the need for a separate dust filter. The efficiency of these units is generally high, with typical levels in the treated gas quoted as being: e.g. for fluorine < 5 mg/m³ as hydrogen, fluoride, sulphur trioxide 90 % removal, sulphur dioxide 10-15 % removal and particulate matter < 50 mg/m³.
- Cloth Filters :
  Lime or hydrated lime is injected into the gas stream to absorb the gaseous fluorine and sulphur compounds. The resulting fluorspar and gypsum are then removed from the gas stream using cloth filters. The removal efficiencies for such a system are reported to be as follows: Fluorine (99 %), sulphur trioxide (75 %), sulphur dioxide (5 to 10 %) and dust (< 50 mg/m³). The main advantage of the standard cloth filter system its ability to operate in high sulphur environments, possibly up to 2,000 mg/m³ sulphur dioxide since blockage is less likely.

- Condensation :
  The principle behind these systems is to cool the gas down to such a degree that the pollutants are precipitated by condensation. The condensates so produced contain hydrofluoric and sulphuric acids which are highly aggressive. The condensates are then neutralised with castic soda or milk of lime. In practice milk of lime is usually selected because it is cheaper than caustic soda. Reported estimates of the typical removal efficiencies that can be achieved by this technique are for fluorine (90 %), sulphur trioxide (50 %) and sulphur dioxide (15 %).

- Wet scrubbing :
  Wet scrubbing systems aim to produce contact between the scrubbing liquid and the pollutant, in order to promote absorption and/or precipitation processes. Levels of efficiency of removal have been claimed for fluorine 99 %, sulphur dioxide 15 % and particulates 87 %.

- Incineration :
  Incineration of odours may also be undertaken externally to the kiln for successful removal of these odorous compounds.

- Wet/dry absorption :
  A sulphur dioxide absorber (either lime, sodium carbonate or bicarbonate solution or slurry) is injected into the exhaust gas stream upstream of any dust collection equipment. This process removes about 70 % of sulphur in the gas stream.

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 available from national or international statistical publications.

7 POINT SOURCE CRITERIA

The production of bricks and tiles can be considered as an area source. However, production is usually connected to high chimneys that can be regarded as point sources if plant specific data are available.

8 EMISSION FACTORS, QUALITY CODES AND REFERENCES

For the situation in the Netherlands, the following can be proposed:

Emission factors are given for three types of clay:

class A: clay products that after firing are “red” coloured.
class B: clay products that after firing are “yellow” coloured.
class C: clay products that after firing are “white” coloured.

Table 2: Emission factors in kg per ton product:

	class A ‘red’	**class B ‘yellow**	**class C ‘white**
SO_2	0.175	0.040	0.600
SO_3	0.030	0.050	0.055
dust *	0.050	0.050	0.050
F_g	0.170	0.060	0.250
Cl_g	0.040	0.035	0.110

Table 3: Emission factors in kg per m[3] of natural gas used:

	class A 'red'	**class B 'yellow**	**class C 'white**
NO_x	0.0032	0.0032	0.0032
CO	0.0080	0.0100	0.0160
CO_2	2.3000	3.7000	3.0000
C_xH_y	0.0011	0.0011	0.0011

* dust consists of clay particles, the composition may vary widely.

The following Table 4 contains fuel related emission factors for the production of bricks and tiles 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 2 - 100 GJ/Mg product has been reported. Table 5 contains the AP 42 emission factors for particulate matter (US EPA, 1996).

Table 4: Emission factors for the production of bricks and tiles[7)]

Type of fuel				NAPFUE code	Emission factors 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	coking	101	159[1)]	569[1)]		1[1)]		86[1)]		
s	coal	hc	steam	102	407-787[1)]	150-334[1)]	15-21[1)]	0.3-15[1)]	10-120[1)]	79-95[1)]	4-14[1)]	
s	coal	hc	sub-bituminous	103	170[1)]	30[1)]	15[1)]	15[1)]	50[1)]	99[1)]	8[1)]	
s	coal	bc	brown coal/lignite	105	500-2,900[1)]	140-300[1)]	1.5-20[1)]	1.5-100[1)]	14-110[1)]	86-113[1)]	3-14[1)]	
s	coal	bc	briquettes	106	175[1)]	140[1)]	15[1)]	15[1)]	100[1)]	97-98[1)]	3.5[1)]	
s	coke	hc	coke oven	107	400-540[1)]	140-300[1)]	0.5-15[1)]	0.5-15[1)]	15-100[1)]	100-105[1)]	4-14[1)]	
s	coke		petroleum	110	680[1)]	200[1)]	1.5[1)]	1.5[1)]	97[1)]	102[1)]	3[1)]	
s	biomass		wood	111	130[1)]	130-200[1)]	48-50[1)]	30-32[1)]	160[1)]	83-102[1)]	4-14[1)]	
l	oil		residual	203	57-1,470[1)]	57-330[1)]	3-57[1)]	0.1-8[1)]	10-234[1)]	76-78[1)]	2-15[1)]	
l	oil		gas	204	55-1,410[1)]	54-330[1)]	1.5-2.5[1)]	1-8[1)]	10-54[1)]	72-74[1)]	2-14[1)]	
l	kerosene			206	68.6[1)]		2[1)]	1[1)]	12[1)]	71[1)]	14[1)]	
l	gasoline		motor	208	44.7[1)]		2[1)]	1[1)]	12[1)]	71[1)]	14[1)]	
g	gas		natural	301	0.4-8[1)]	50-330[1)]	4-26[1)]	0.4-4[1)]	10-343[1)]	34-66[1)]	1-4[1)]	
g	gas		liquified petroleum gas	303	0.04-2[1)]	20-100[1)]	1-4[1)]	1[1)]	13[1)]	60-65[1)]	1-3[1)]	
g	gas		coke oven	304	9.6[1)]	50[1)]	2.5[1)]	2.5[1)]	10[1)]	44-49[1)]	1.5[1)]	

1) CORINAIR90 data, area sources

2) SO_x:	354	g/Mg	General (1992) /1/
	2,000	g/Mg product	Curing and firing, oil fired tunnel kilns /2/
	3,665	g/Mg product	Curing and firing, coal fired tunnel kilns /2/
	2,950	g/Mg product	Curing and firing, gas fired periodic kilns /2/
	6,065	g/Mg product	Curing and firing, oil fired periodic kilns /2/

3)	NO_x:	500	g/Mg product	General /3/
		120	g/Mg product	General (1992), NAPFUE 301 (94 %) /1/
		90	g/Mg product	Curing and firing, gas fired tunnel kilns /2/
		550	g/Mg product	Curing and firing, oil fired tunnel kilns /2/
		725	g/Mg product	Curing and firing, coal fired tunnel kilns /2/
		250	g/Mg product	Curing and firing, gas fired periodic kilns /2/
		810	g/Mg product	Curing and firing, oil fired periodic kilns /2/
		1,175	g/Mg product	Curing and firing, coal fired periodic kilns /2/
4)	VOC:	10	g/Mg product	Curing and firing, coal fired periodic kilns /2/
		50	g/Mg product	Curing and firing, oil fired periodic kilns /2/
		5	g/Mg product	Curing and firing, gas fired periodic kilns /2/
		5	g/Mg product	Curing and firing, coal fired tunnel kilns /2/
		35	g/Mg product	Curing and firing, coal fired tunnel kilns /2/
		15	g/Mg product	Curing and firing, coal fired tunnel kilns /2/
	NMVOC:	< 500	g/Mg product	General for porous bricks, for FRG, DN and UK, released by waste raw material /3/
5)	CO:	1,600	g/Mg product	EPA-value, ceramic industry /3/
		30	g/Mg product	Curing and firing, gas fired tunnel kilns /2/
		60	g/Mg product	Curing and firing, oil fired tunnel kilns /2/
		715	g/Mg product	Curing and firing, coal fired tunnel kilns /2/
		75	g/Mg product	Curing and firing, gas fired periodic kilns /2/
		95	g/Mg product	Curing and firing, oil fired periodic kilns /2/
		1,195	g/Mg product	Curing and firing, coal fired periodic kilns /2/
		240	g/GJ	General, (1992), NAPFUE 301 (94 %) /1/
6)	CO_2:	61	kg/GJ	General, (1992), NAPFUE 301 (94 %) /1/

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

Table 5: AP 42 Particulate matter emission factors* for Brick and Tiles (g/Mg) /5/

Source	PM (g/Mg)	RATING	PM_{10} (g/Mg)	RATING	$PM_{2.5}$ (g/Mg)	RATING
Primary crusher with fabric filter	ND	NA	0.295	E	ND	NA
Grinding and screening operations						
processing dry material	4250	E	265	E	ND	NA
processing wet material	12.5	E	1.15	E	ND	NA
with fabric filter	3.1	E	1.6	E	ND	NA
Extrusion line with fabric filter	1500	NA	1.8	E	ND	NA
Natural gas-fired kiln	480	D	435	D	ND	NA
Coal-fired kiln						
uncontrolled	900	B	700	C	435	D
with fabric filter	315	E	ND	NA	ND	NA
Sawdust-fired kiln	465	D	425	D	375	D
Sawdust-fired kiln and sawdust dryer	700	E	155	E	ND	NA

* = In the absence of more appropriate data use the AP 42 emission factors
ND = No data
NA = Not applicable

9 SPECIES PROFILES

A profile of the clay used would be useful. This information is not available.

10 UNCERTAINTY ESTIMATES

The quality classification of the emission factors expressed per ton product is estimated to be C.

11 WEAKEST ASPECTS/PRIORITY AREAS FOR IMPROVEMENT IN CURRENT METHODOLOGY

The fuel specific emission factors provided in table 2 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 plant capacity, employment or population statistics.

13 TEMPORAL DISAGGREGATION CRITERIA

The production of bricks and tiles can be considered as a continuous process.

14 ADDITIONAL COMMENTS

15 SUPPLEMENTARY DOCUMENTS

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

Emission factors to be used for the building industry, TNO report 89/091.

Environmental Protection Agency, Compilation of Air Pollutant Emission Factors AP-42

16 VERIFICATION PROCESSES

Verification of the emissions can be done by comparing the results of the calculations with measurements at the individual plant.

17 REFERENCES

/1/ Huizinga, K.; Verburgh, J. J.; Mathijsen, A. J. C. M.: Großkeramische Industrie; RIVM-report 736301112; RIZA-report 92.003/12; 1995

/2/ EPA (ed.): AIRS Facility subsystem; EPA-Doc 450/4-90-003; Research Triangle Park; 1990

/3/ Bouscaren, M. R.: CORINAIR Inventory, Default Emission Factors Handbook; second Edition; Comission of the European Communities; Paris; 1992

/4/ EPA (ed.): AP 42 CD-Rom; 1995

/5/ Her Majesty's Inspectorate of Pollution (HMSO) (ed.): Ceramic Process; Environmental Protection Act 1990; Process Guidance IPR 3/6; London 1992

/6/ US EPA (1996) Compilation of Air Pollutant Emission Factors Vol.1 Report AP-42 (5^{th} 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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20 POINT OF ENQUIRY

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