AX-Consulting

Green Foundry LIFE project (LIFE17 ENV/FI/173)

Action B2 Total emissions and indoor air quality measurements of pilot foundries

Deliverable DeB2A: Results of total emission and indoor air quality measurements in an inorganic binder system pilot foundry in Germany

Results of emission and indoor air measurements in KSM Castings Group foundry in Hildesheim, Germany

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Client	KSM Castings Group GmbH Cheruskerring 38 31137 Hildesheim Germany
Assignment	Measurement of emissions and indoor air concentrations from the casting mold
Measurement date and place	Hildesheim, March 09-10th 2022
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APPENDICES

1 Introduction

The KSM Castings Group is part of international CITIC Dicastal Corporation and it manufactures components and systems made of aluminum and magnesium for the automotive industry in modern casting and manufacturing processes and under the observance and being conscious of the strictest environmental standards. The KSM Castings Group consists of eight production units in Germany, Czech Republic, USA and China. Total number of employees is ca. 3700.

The KSM apply consistently efficient manufacturing technologies and support them by cutting-edge IT technologies.

The KSM produce sophisticated products by using most modern, state-of-the-art casting and machining technologies. Integrated, certified quality control loops ensure process stability and specification capability. KSM Castings Group foundries apply different casting methods, high pressure die casting, gravity die casting and counter pressure casting (CPC).

The emission measurements of this action were made in **Hildesheim, Germany**, where KSM Castings Group has a gravity die casting foundry using sand moulds and cores. The foundry products in Hildesheim are aluminium castings for automotive. Castings are parts for chassis, transmission and engine.

The sand binder system is inorganic: Cordis + Anorgit, produced by Hüttenes & Albertus. Cordis is a binder system based on a silicate solution and is used in conjunction with the inorganic Anorgit additive (two-component system). Hardening takes place by heating to a temperature of 150...200 °C either by hot gas blowing or by using ovens.

KSM Hildesheim's casting line consists of an automatic 8-seater carousel. The cores are installed into the mould halves by robots and the moulds are assembled before casting. Robots dispense the required amount of melt for each mould into the pouring ladle and pour the melt into the moulds. After solidification, the moulds are broken and the castings are moved to the finishing area.

The need for personnel in casting area is minimal, and the exposure to possible emissions is very low. Therefore, the exposure measurements for individual workers were not made.

2 Measurement arrangements and results

The total emissions were measured from the roofs, Picture 1.

Picture 1. Measurements in progress with the sunroof

Indoor air measurements were not made at ground level, because the large outer doors of the foundry were mostly open, Picture 2. In this case, the measurement result would have reflected the concentration of the outdoor air. In addition to emissions, the concentration measured from the roof hatches describes also the worst possible indoor air concentrations.

Picture 2. Open outer door

In addition to the emission measurements, also the cleaning efficiency of the filter system in use was measured.

Emission measurement results are presented in APPENDICES 1-10 and indoor air concentrations in Table 1. Trends from the measurements are presented in APPENDICES 3-6.

3 Conclusions

The individual emission measurement results are presented in the appendices. As a conclusion, it can be stated all gaseous emissions were low. Main reason for low gaseous emissions is the inorganic binder system used in KSM, Hildesheim.

3.1. Emissions

3.1.1. Particles

The majority of emissions are released into the outside air through sunroofs. Particulate emissions are calculated from the concentrations measured in front of the filter and in order to find out the degree of filtration, also after the filter.

The cleaning efficiency of the Donaldson fiber filter installed in the exhaust air of the discharge site was found to be excellent 99.97%.

Picture 3. Donaldson fiber filter installed in the exhaust air of the discharge site

3.1.2. Carbon monoxide (CO)

Carbon monoxide concentration was very low. See appendix 7.

3.1.3. Volatile Organic Compounds (VOC)

VOC-concentration was very low. See appendix 3.

3.1.4. BTEX

BTEX-concentration was very low. See appendix 3.

3.1.5. Sulphur dioxide (SO_2) and nitrogen oxides (NO_X)

SO2- and NOx-concentration was very low. See appendix 7.

3.1.6. Formaldehyde and other aldehydes

All aldehyde concentration was very low. See appendix 4.

3.1.7. Phenols and cresols

Phenols- and cresols concentration was very low. See appendix 5.

3.1.8. Metals

Metal concentration was very low. See appendix 6.

3.2. Indoor air

3.2.1. Particles (oil mist)

Table 1. Measured indoor air concentrations

Oil mist

Measuring Point	Measurement			Measured concentration
	date	start	stop	
		time	*time*	*mg/m³*
Post-processing, indoor air	9.3.2022	10:41	18:18	0,47
	10.3.2022	9:29	16:28	0,66

4 Procedures

4.1 Particles

Particle concentrations from the exhaust air were measured from samples taken with sond and pump in accordance with SFS-EN 13284-1 and SFS 3866 standards. Size of the sond and absorption rate were set so that the speed of the sample rate was as isokinetic with the speed of the exhaust air as possible.

Uncertainty of concentration is ±15 %.

4.2 O_2, CO_2, CO, NO_x and SO_2

Sample from the exhaust air for the measurement of O_2, CO_2, CO, NO_x and SO_2 were taken with to the analyzers.

Uncertainty of the concentration is ±15 %.

4.3 Volatile Organic Compounds (VOC)

VOC measurement was made with the adsorption samples. Quantitative analysis from the hydrocarbon compounds was done one by one. Measurement was carried out in accordance with the SFS 3861 standard.

Tenax tube samples were analyzed by an accredited laboratory: Finnish Department of Occupational Health (FINAS T013)

Uncertainty of concentration is ±17 %.

4.4 Aldehydes

The aldehyde samples were taken from the exhaust air with a sample pump to SepPAK-DNPH tubes. The analyses were carried out at an accredited laboratory: Finnish Department of Occupational Health (FINAS T013) by liquid chromatography.

Uncertainty of concentration is ±21 %.

4.5 Phenols and cresols

Phenols and cresols in the gas phase were collected from the exhaust air with the pump into the XAD-2-Supelco adsorption tubes. The analyses were carried out at an accredited laboratory: Finnish Department of Occupational Health (FINAS T013). Samples collected were extracted and phenols and cresols were determined using liquid chromatography.

4.6 Metals

The analyses were carried out at a laboratory: Eurofins Labtium Oy, Espoo. Metals were determined according to standards ISO 11885 and ISO 17294-2 using spectrometry method.

Uncertainty of concentration depends on the metal in question.

4.7 Flow rate

The flow rate of the exhaust air was measured continuously with the pitot tube and the micromanometer. The result was calibrated with measuring the flow rate randomly from the exhaust air, using multi-point method with the micromanometer and the pitot tube, according to the SFS 5512 standard. The dry and wet temperatures were measured with the instant thermometer. Uncertainty of concentration is ±5 %.

The temperature was measured continuously with the thermoelement and the datalogger. Uncertainty of temperature is approximately ±1 °C.

5 Measurement equipment

The analyzer equipment and used standards and guidance, according to the measurements of the different components that were carried out, are presented in table 2.

Table 2. The measurement equipment, standards and guidance that were followed in the measurements.

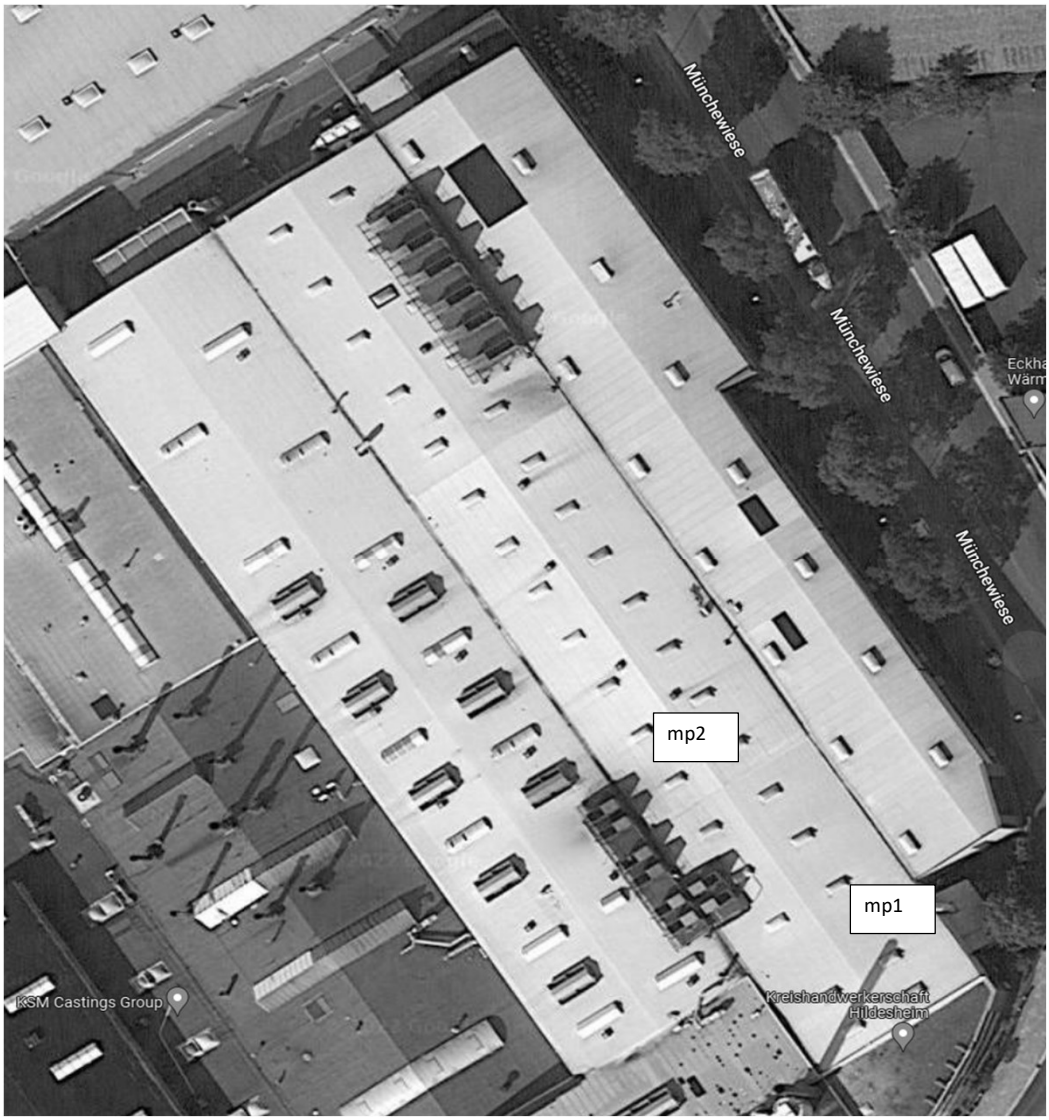
Measurement method	Device mark	Measurement	Standard
CO SO2	Testo 300	Chemical cell	SFS 3869 SFS 5412 ISO 12039:2001
NOx	Testo 300	Chemical cell	SFS 3869 SFS 5425 SFS EN 14792:2005
SO2	Testo 300	Chemical cell	SFS 3869 ISO 7935:1992
Flow rate	Micromanometer and pitot-tube	Pressure difference	SFS 3866 SFS 3869 SFS EN 132844:2001
Temperature	Thermoelement	Voltage difference	SFS 3866 SFS 3869 SFS EN 132844:2002
VOC	Adsorption equipment	Adsorption	SFS EN 1948 SFS 3869
Phenols Aldehydes	Adsorption equipment	Adsorption	SFS EN 1948 SFS 3870
Particles	Particle measurem	Gravimetric	SFS EN 13284 SFS 3866 (adjusted)
H2O	Dry/wet temperature	Voltage difference	SFS 3866 SFS 3869 SFS EN 132844:2002

Measuring point		Vibration	Roof openings
Binder type		Inorganic	Inorcanic
Casting quantity (kg)		5502	5502
Sand quantity (kg)		28196	28196
Binder quantity (kg)		975,0	975,0
Exhaust air flow (Nm^3/s)		1,13	26,6
Concentration (mg/Nm^3)	Particles	78,6	0,42
	Total VOC	0,33	0,19
	BTEX	0,01	0,02
	Ethanol	0,01	0,01
	2-Propanol	0,01	0,01
	Phenols	<0,01	<0,004
	Cresols	<0,01	<0,004
	Asetaldehyde	0,001	0,01
	Formaldehyde	0,002	0,02
	Carbon monoxide		4,2
	NO_x		1,04
	SO_2		0,35
Emissions (g/h)	Particles	319,9	40,1
	Total VOC	1,3	18,6
	BTEX	0,04	2,06
	Ethanol	0,02	1,03
	2-Propanol	0,02	0,78
	Phenols	0,05	0,39
	Cresols	0,05	0,39
	Asetaldehyde	0,00	0,69
	Formaldehyde	0,01	1,98
	Carbon monoxide		401
	NOx		99,3
	SO2		33,5
Emissions per casting quantity (mg/kg)	Particles	58,1	7,3
	Total VOC	0,2	3,4
	BTEX	0,01	0,4
	Ethanol	0,00	0,2
	2-Propanol	0,00	0,1
	Phenols	0,01	0,1
	Cresols	0,01	0,1
	Asetaldehyde	0,001	0,1
	Formaldehyde	0,001	0,4
	Carbon monoxide		73
	NOx		18,0
	SO2		6,1
Emissions per sand quantity (mg/kg)	Particles	11,3	1,4
	Total VOC	0,05	0,66
	BTEX	0,002	0,07
	Ethanol	0,001	0,04
	2-Propanol	0,001	0,03
	Phenols	0,002	0,01
	Cresols	0,002	0,01
	Asetaldehyde	0,0001	0,02
	Formaldehyde	0,0003	0,07
	Carbon monoxide		14,2
	NOx		3,5
	SO2		1,2
Emissions per binder quantity (mg/kg)	Particles	328	41
	Total VOC	1,4	19
	BTEX	0,0	2,1
	Ethanol	0,0	1,1
	2-Propanol	0,0	0,8
	Phenols	0,1	0,4
	Cresols	0,1	0,4
	Asetaldehyde	0,0	0,7
	Formaldehyde	0,0	2,0
	Carbon monoxide		412
	NOx		102
	SO2		34,3

Measuring point	Start	Stop	Concent-ration	Air flow	Emission
	time	*time*	*mg/Nm³*	Nm^3/s	g/h
Roof opening, South-East (mp1)	8:44	11:45	0,36	12,5	16,0
Roof opening, North-West (mp2)	8:52	11:47	0,48	12,5	21,5
Cooling line	9:09	11:59	0,07	0,07	0,02
Vibration	9:18	12:10	78,6	1,13	319
After Donaldson-filter	9:21	12:20	0,02		
	12:26	16:18	0,02		
	Average		0,02	1,17	0,10

Donaldson filter

Concentration		Cleaning efficiency
Before	After	
mg/Nm³	*mg/Nm³*	%
74,1	0,02	99,97



Measuring point		Roof opening South-East	Roof opening North-West	Cooling	Vibration
Date		10.3.2022	10.3.2022	10.3.2022	10.3.2022
Start		8:44:00	8:52:00	9:08:00	9:18:00
End		15:37:00	15:41:00	16:06:00	16:12:00
VOC-compound	CAS-number	mg/Nm^3	mg/Nm^3	mg/Nm^3	mg/Nm^3
Acetone	67-64-1	<0,02	<0,01	<0,00	<0,00
Benzofuran	271-89-6	<0,01	<0,01	<0,00	<0,00
Benzene	71-43-2	<0,01	<0,01	<0,00	<0,00
Butans	106-97-8	0,01	0,02	0,01	0,02
Dichloromethane	75-09-2	<0,02	<0,02	<0,01	0,16
Ethylacetate	141-78-6	<0,01	<0,01	<0,00	<0,00
Ethylbenzene	100-41-4	<0,01	<0,01	<0,00	<0,00
2-Ethyl-1-heksanol	104-76-7	<0,01	<0,01	<0,00	<0,00
Ethanol	64-17-5	<0,01	<0,01	<0,01	<0,01
Ethyl hexyl asetate	103-09-3	<0,01	<0,01	<0,00	<0,00
Glycyeryl triasetate	102-76-1	<0,01	<0,01	<0,00	<0,00
3-Caren	498-15-7	<0,01	<0,01	<0,00	<0,00
Xylene	1330-20-7	<0,01	<0,01	<0,00	<0,00
Solvent naphtha, group 1	-	<0,01	0,03	0,01	0,05
Methyl acetate	79-20-9	<0,01	<0,01	<0,01	<0,01
2-Butanoni	78-93-3	<0,01	<0,01	<0,00	<0,01
Methanol	67-56-1	<0,01	<0,01	<0,01	0,01
Alphapine	7785-70-8	<0,01	<0,01	<0,00	<0,00
2-Propanol	67-63-0	<0,01	0,01	0,01	0,01
Styrene	100-42-5	<0,01	<0,01	<0,00	<0,00
Toluene	108-88-3	<0,01	<0,01	<0,00	<0,00
1,3,5-Trimethylbentsene	108-67-8	<0,01	<0,01	<0,00	<0,00
Other VOCs	-	<0,01	<0,01	<0,00	0,01
Sum		**0,18**	**0,21**	**0,09**	**0,33**
Share of the compound		%	%	%	%
Acetone	67-64-1	11,8	2,6	3,0	0,8
Benzofuran	271-89-6	2,9	2,6	3,0	0,8
Benzene	71-43-2	2,9	2,6	3,0	0,8
Butans	106-97-8	5,9	10,5	6,1	7,4
Dichloromethane	75-09-2	11,8	10,5	12,1	49,6
Ethylacetate	141-78-6	2,9	2,6	3,0	0,8
Ethylbenzene	100-41-4	2,9	2,6	3,0	0,8
2-Ethyl-1-heksanol	104-76-7	2,9	2,6	3,0	0,8
Ethanol	64-17-5	5,9	5,3	6,1	1,7
Ethyl hexyl asetate	103-09-3	2,9	2,6	3,0	0,8
Glycyeryl triasetate	102-76-1	2,9	2,6	3,0	0,8
3-Caren	498-15-7	2,9	2,6	3,0	0,8
Xylene	1330-20-7	2,9	2,6	3,0	0,8
Solvent naphtha, group 1	-	2,9	13,2	9,1	16,5
Methyl acetate	79-20-9	5,9	5,3	6,1	1,7
2-Butanoni	78-93-3	5,9	5,3	3,0	1,7
Methanol	67-56-1	5,9	5,3	6,1	4,1
Alphapine	7785-70-8	2,9	2,6	3,0	0,8
2-Propanol	67-63-0	2,9	5,3	6,1	1,7
Styrene	100-42-5	2,9	2,6	3,0	0,8
Toluene	108-88-3	2,9	2,6	3,0	0,8
1,3,5-Trimethylbentsene	108-67-8	2,9	2,6	3,0	0,8
Other VOCs	-	2,9	2,6	3,0	4,1
Sum		**100,0**	**100,0**	**100,0**	**100,0**

Measuring point	Roof opening South-East	Roof opening North-West	Cooling Line	Vibration
Date	10.3.2022	10.3.2022	10.3.2022	10.3.2022
Time started	8:44:00	8:52:00	9:08:00	9:18:00
Time finished	15:37:00	15:41:00	16:06:00	16:12:00
Concentration	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*
Acetaldehyde	0,005	0,010	0,002	0,0008
Bentsaldehyde	0,001	0,001	0,0000	0,0001
Formaldehyde	0,007	0,035	0,003	0,002
Heksanale	0,001	0,002	0,0004	0,0002
2-Butanone	0,004	0,007	0,002	0,001
Acrolein	0,0000	0,0006	0,0000	0,0000
Butyraldehyde	0,001	0,002	0,0003	0,0001
Pentanal	0,001	0,002	0,0000	0,0001
Propionaldehyde	0,000	0,002	0,0003	0,0001
sum	**0,02**	**0,06**	**0,008**	**0,005**
Part of compound	%	%	%	%
Acetaldehyde	23,1	16,1	27,0	17,8
Bentsaldehyde	4,1	1,7	0,0	2,0
Formaldehyde	32,6	57,9	40,5	39,5
Heksanale	3,8	2,8	5,4	4,6
2-Butanone	22,0	11,7	20,3	28,5
Acrolein	0,0	1,0	0,0	0,0
Butyraldehyde	5,4	3,4	3,4	2,6
Pentanal	6,5	2,6	0,0	2,4
Propionaldehyde	2,4	2,8	3,4	2,6
sum	**100,0**	**100,0**	**100,0**	**100,0**

Measuring point	Roof opening South-West	Roof opening North-West	Cooling	Vibration
Date	10.3.2022	10.3.2022	10.3.2022	10.3.2022
start	8:44:00	8:52:00	9:08:00	9:18:00
Stop	15:37:00	15:41:00	16:06:00	16:12:00
Concentration	*mg/Nm³*	*mg/Nm³*	*mg/Nm132*	*mg/Nm³*
Phenols	<0,00	<0,01	<0,00	<0,01
Cresols	<0,01	<0,01	<0,00	<0,01
sum	**<0,01**	**<0,01**	**<0,01**	**<0,02**
Inaccyracy (%)	±19	±19	±24	±18

Metal concentration

Measuring point	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Li	Mn	Mo	Ni	P	Pb	Rb
	mg/Nm³	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*
Roof opening, South-East (mp1)	0,0000	0,0015	0,0000	0,0001	0,0002	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0009	0,0000	0,0000	0,0010	0,0000	0,0000
Roof opening, North-West (mp2)	0,0000	0,0064	0,0000	0,0001	0,0001	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0001	0,0000	0,0000	0,0008	0,0000	0,0000
Cooling line	0,0000	0,0004	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0002	0,0000	0,0000
Vibration	0,000	17,09	0,004	0,021	0,085	0,000	0,004	0,002	0,021	0,105	5,585	0,089	0,006	0,019	0,267	0,014	0,002
Inaccuracy (%)	±26	±31	±36	±41	±31	±41	±31	±21	±31	±26	±26	±16	±26	±21	±41	±26	±26

Metal concentration

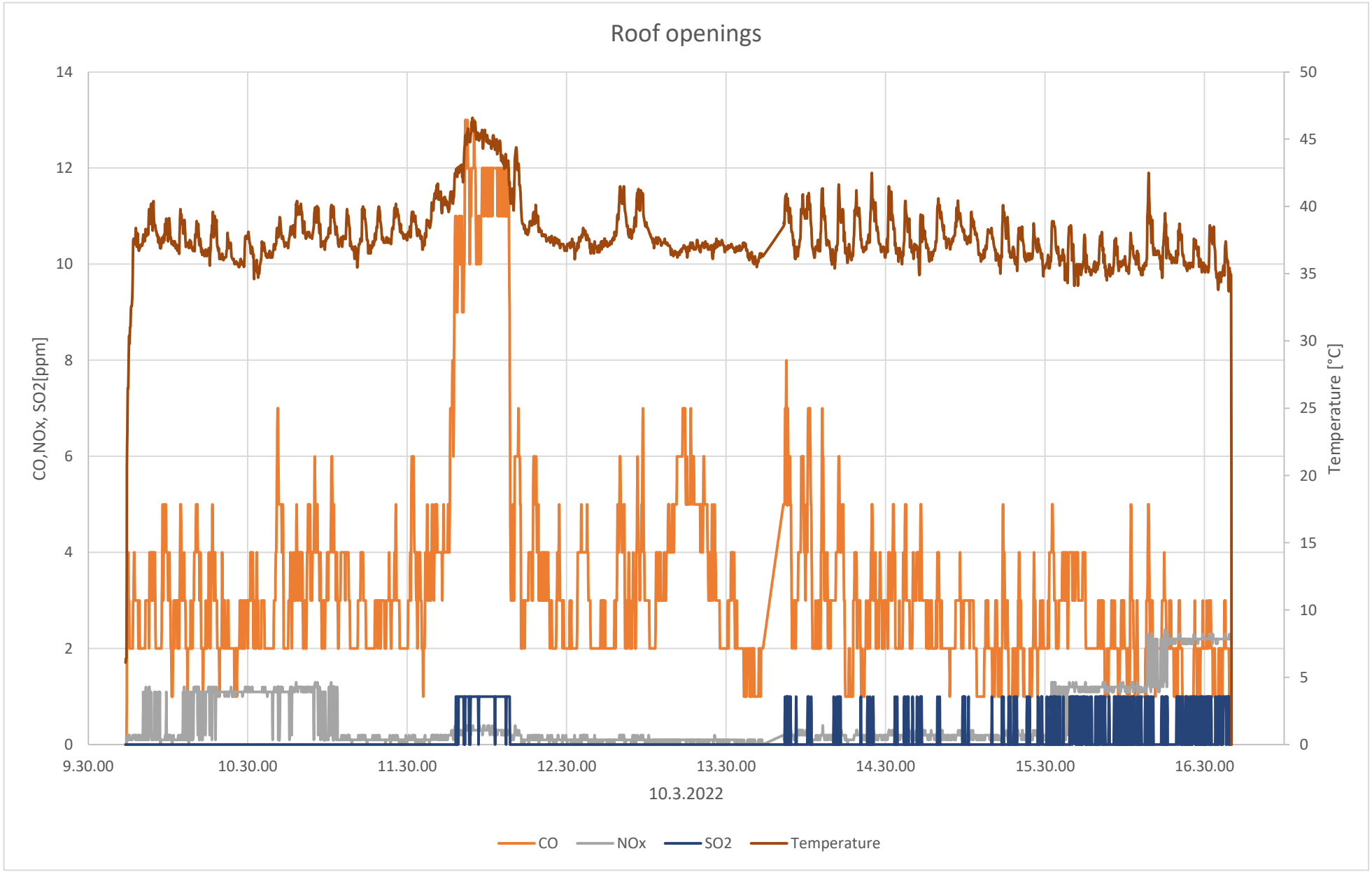
Measuring point	Sb	Se	Sn	Sr	Th	Tl	U	V	Zn	Ca	Fe	K	Mg	Na	S	Si
	mg/Nm³	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*
Roof opening, South-East (mp1)	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0001	0,0021	0,0021	0,0010	0,0010	0,0031	0,0021	0,0105
Roof opening, North-West (mp2)	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0002	0,0028	0,0028	0,0014	0,0014	0,0042	0,0028	0,0140
Cooling line	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0004	0,0004	0,0002	0,0002	0,0006	0,0004	0,0020
Vibration	0,005	0,005	0,000	0,007	0,000	0,000	0,000	0,001	0,03	0,46	0,46	0,23	0,23	0,69	0,46	2,29
Inaccuracy (%)	±31	±26	±26	±21	±26	±21	±26	±21	±26	±21	±16	±21	±41	±21	±21	±26

Hourly emissions

Measuring point	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Li	Mn	Mo	Ni	P	Pb	Rb
	g/h	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*
Roof opening, South-East (mp1)	0,00	0,07	0,00	0,00	0,01	0,00	0,00	0,00	0,00	0,00	0,00	0,04	0,00	0,00	0,05	0,00	0,00
Roof opening, North-West (mp2)	0,00	0,29	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,04	0,00	0,00
Cooling line	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Vibration	0,0	69,3	0,0	0,1	0,3	0,0	0,0	0,0	0,1	0,4	22,6	0,4	0,0	0,1	1,1	0,1	0,0
Inaccuracy (%)	±31	±36	±41	±46	±36	±46	±36	±26	±36	±31	±31	±21	±31	±26	±46	±31	±31

Hourly emissions

Measuring point	Sb	Se	Sn	Sr	Th	Tl	U	V	Zn	Ca	Fe	K	Mg	Na	S	Si	Sum
	g/h	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*
Roof opening, South-East (mp1)	0,0009	0,0009	0,0000	0,001	0,0000	0,0000	0,0000	0,0001	0,01	0,09	0,09	0,05	0,05	0,14	0,09	0,47	1,2
Roof opening, North-West (mp2)	0,0013	0,0013	0,0001	0,002	0,0001	0,0001	0,0001	0,0002	0,01	0,13	0,13	0,06	0,06	0,19	0,13	0,63	1,7
Cooling line	0,0000	0,0000	0,0000	0,000	0,0000	0,0000	0,0000	0,0000	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,0
Vibration	0,0186	0,0186	0,0009	0,028	0,0009	0,0009	0,0009	0,0028	0,10	1,86	1,86	0,93	0,93	2,79	1,86	9,29	114,2
Inaccuracy (%)	±36	±31	±31	±26	±31	±26	±31	±26	±31	±26	±21	±26	±46	±26	±26	±31	


Roof openings
CO,NOx, SO2[ppm]
Temperature [°C]
0
2
4
6
8
10
12
14
0
5
10
15
20
25
30
35
40
45
50
9.30.00
10.30.00
11.30.00
12.30.00
13.30.00
14.30.00
15.30.00
16.30.00
10.3.2022
CO
NOx
SO2
Temperature