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

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

DeB2D Results of total emission measurements in organic binder system pilot foundry in URV foundry in Finland

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1 Introduction

Uudenkaupungin Rautavalimo Oy (URV) is a ferrous foundry that produces cast components for diesel and electric motors and for process, pump, mining and elevator industries. The production began at Uusikaupunki in 1950 and at the present location in 1980.

The melting capacity consists of two 2 tons and one 4 tons induction furnaces and the total production capacity is 6 tons per hour.

URV produces ductile and gray cast iron, ADI iron (Austempered Ductile Iron) and SiMo ductile iron. The weight range is between 2 to 5000 kg, but typical product weight is between 20 to 500 kg.

The moulding is made by hand moulding. The binder systems for moulds is phenolic-formaldehyde (Alphaset) resin. The cores are made by using Alphaset or Cold-Box binder systems. Both these core making methods are based on phenolic resin binders.

The sand used for moulds and cores is high quality silica sand. About 70...75 % recycled sand is used for moulds but only new silicate sand is used for cores. The painting of the moulds and cores is made by Mg- or Ti-oxide based coatings.

Cooled moulds are shaken out by the vibration. The feeders are removed by pressure air or hand hammering. The surfaces of the castings are refined by steel shot blasting. URV has invested into machining and delivers now most of the castings as machined.

Annual production capacity is 10000 tons. but the production in recent years has been about 5000 tons URV foundry has about 100 employees.

The total emission measurement was made at URV Ltd on 30.-31.1.2019 and results are utilised in the Green Foundry LIFE project (LIFE17 ENV/FI/173). This measurement represents the total emission measurement in the iron foundry using organic binder system (Alphaset) and are part of the activities in the Action B2 Total emissions and indoor air quality measurements of pilot foundries.

In this measurement the emission limit values set in the environmental permit are followed.

2 Limit values and conclusions

2.1 Limit values

In the environmental permit it is given limit values for the exhaust gas of the punctual emission targets (melting, casting, vibration removal, finishing of castings and aftertreatment):

Particles	20 mg/Nm³
Particles	10 mg/Nm³ (sand reclamation)
Nitrogen oxides (NO_x)	50 mg/Nm³ (local exhaust ventilation of induction furnace)
Carbon monoxide (CO)	200 mg/Nm³ (local exhaust ventilation of induction furnace)
Amines	5 mg/Nm³ (core cannon)
Dioxines and furans	0,1 ngTEQ/Nm³ (local exhaust ventilation of induction furnace)

Limit values has been followed, when each of the measurement serie average is not going to exceed the limit value taking into account total uncertainty.

2.2 Conclusions

The result conclusions have been made in accordance with ILAC-guide (ILAC-G8:03/2009 Guidelines on the Reporting of Compliance with Specification):

1) measured concentration is under the limit value from the environmental permit taking into account the measurement uncertainty (measurement result + uncertainty < limit value)

2) measured concentration exceeds the limit value taking into account the measurement uncertainty (measurement result – uncertainty > limit value)

3) measured concentration is in the limit value, but fulfilment comparing to the limit value is not going to take a stand (measurement result < limit value, but measurement result + uncertainty > limit value or measurement result > limit value, but measurement result – uncertainty < limit value).

3 Results

Measurement results are presented in APPENDICES 1-6 and measurement points in APPENDIX 7.

3.1 Particles

Average particle concentration from exhaust air of induction furnaces (nr 7) (20,1 mg/Nm^3) is on the limit value.

Average particle concentration from removal place hood and sand reglamation Wiser-filter (nr 21) (117 mg/Nm^3) exceeds clearly the limit value of the environmental permit. Most probably reason for that is leakages from the filter structure or leakages in the filter bags.

Particle concentrations from other places are under the limit value.

Annual particle emission has been calculated with two ways: based on production time and production volume of measuring day. Emission calculated from production times has been calculated with multiplying measured hourly emission with yearly production time. Emission calculated from production volume has been calculated with multiplying specific emission (g/produced ton) with yearly production time. Calculated with both ways, results are in a same level.

3.2 Nitrogen oxides

Average NO_x-concentration from exhaust air of induction furnaces (nr 7) is clearly below the limit of the environmental permit.

3.3 Carbon monoxide

Average CO-concentration from exhaust air of induction furnaces (nr 7) is clearly below the limit of the environmental permit.

3.4 Amines

Average amine concentration from amine scrubber of core cannon (nr 5) is clearly below the limit of the environmental permit.

3.5 Dioxines and furans

PCDD/F-concentration from exhaust air of induction furnaces (nr 7) exceeds the limit of the environmental permit.

4 Measuring points

Measuring point are presented in the APPENDIX 7.

Most of measuring points are roof fans, whose measuring places are not fulfilling requirements of the standard SFS-EN 15259 regarding trouble-free flow distances. Anyhow for this kind of industry, this measuring points are typical and best.

Other remarks from measuring points:

- measuring points 23 ja 24 are not existed anymore
- measuring points 3 ja 10 are not in use anymore
- measuring points 10, 11, 12, 26 are not in the production hall.

5 Process during the measurements

Measurements were carried out on 30.-31.1.2019 during production at the foundry was normal.

During measuring emissions from exhaust air of induction furnaces, ball graphite handling was going on. So emissions from this process are also included to the results of particle- and metal emissions.

Hoods on top of induction furnaces (nr 8 and 9) are on only during adding magnesium (ball graphite handling) around 5-15 minutes. There are around 700 ball graphite handlings in a year. Measurement from hoods was going to carry out on 31.1.2018, but there were no ball graphite handlings going on that day. In calculations it has been used results from measurement in a year 2001.

To the painting hall it was arranged one big piece for painting, so that measurement was able to carry out.

6 Measurement staff

Laboratory of AX-Consulting Ltd's measurement of emissions is FINAS-accredited test laboratory T232. Qualification area of the accreditation is presented on FINAS webpage (www.finas.fi). Organisation fulfills requirements of the standard SFS-EN ISO/IEC 17025:2005.

7 Measurement methods

7.1 Particles

Measurement of particles was carried out with gravimetric method in accordance with the SFS-EN 13284-1 standard. Sample was collected with out-stack method to quartz- or glass fiber filter diameter 37 mm.

Sample filters were weighted before and after measurement in the laboratory of AX-Consulting Ltd. Before weighing filters were dried in desiccator (>24 h).

7.2 Metals

From particle sample of induction furnace was analyzed metal concentration with ICP-MS and ICP-OES-techniques.

The analysis was carried out by the Labtium Oy, laboratory in Espoo. Laboratory is accredited test laboratory T025.

7.3 Nitrogen oxides and carbon monoxide

NO_x- and CO-concentrations were measured continuously with electrochemical measurement cell. Before the measurements it was made leaking test and to make sure that the sample line is tight.

7.4 Amines

The concentrations of amines were measured from sample taken with Anasorb 747-sample tubes from exhaust air. The amine concentration was analyzed with liquid chromatograph analysis. The measurement was carried out in accordance with the SFS-EN 13649 standard.

The analysis was carried out by the Finnish Institute of Occupational Health, laboratory in Helsinki. Laboratory is FINAS-accredited test laboratory T013. Analyze method is under the accreditation.

7.5 Dioxines and furans

PCDD/F-concentration was measured according to standard SFS-EN 1948 by taking at least 6 hours sample. In the method, particles are separated to quarzfilter, water is condensated and compounds of vapor phase are absorbed to XAD-resin. During the analysis, fractions from three samples are combined.

The analysis was carried out by Eurofins GFA Lab Service Gmbh (Hamburg, Germany). Laboratory is accredited test laboratory D-PL-14629-01-00. Analyze method is under the accreditation.

7.6 Flow rate and condition of the gas

The flow rates of the exhaust air were measured with a pitot tube and a micromanometer according to the ISO 10780 standard or with impeller anemometer.

Temperature of the exhaust air was measured with K-type thermocouple and thermometer.

The humidity of the exhaust air was calculated with dry/wet temperature measurements.

8 Uncertainty of measurements

To find out the uncertainty of the measurements, results have been calculated with the calculation program from the publication "ISO/IEC Guide 98-3:2008 Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)".

Total uncertainties with the confidence level 95 % (k=2) have been presented with the results. Measurement conditions (trouble-free flow distance, etc.) can substantially add uncertainty.

Nr	Measuring point	Date	Starting	Ending	Concen-tration	Flowrate	Emission	Production time	Annual emission	Specific emission	Annual emission
			time	*time*	*mg/Nm³*	*Nm³/s*	*g/h*	*h/a*	*kg/a*	*g/t*	*kg/a*
Molding shop											
1	Roof fan 99TK01 PF02	30.1	9:50	12:01	0,69						
		30.1	12:03	14:08	0,87						
		average			**0,78**	2 (1	5,6	2 200	12,3	6,4	14,1
		Total uncertainty from the measured value (%)			±20						
2	Fire hood	30.1	9:53	12:06	1,2						
		30.1	12:07	14:10	1,3						
		average			**1,3**	5 (1	22,8	2 200	50,1	26,0	57,2
		Total uncertainty from the measured value (%)			±15						
Melting shop											
7	Exhaust air from the induction furnace	30.1	9:42	12:09	23,1						
		30.1	12:10	14:04	22,9						
		30.1	14:05	15:32	14,5						
		average			**20,2**	1,1	79,1	3 600	285	90,4	325
		Total uncertainty from the measured value (%)			±10	±7	±25				
8and9	Hoods on top of the induction furnace 2 pcs (used during ball graphite handling) (2				**4,9**	9,7	171	175	29,9	196	34,2
Casting hall											
14	General exhaust air from the casting hall	30.1	10:01	12:12	0,05						
		30.1	12:13	14:32	0,04						
		average			**0,05**						
		Total uncertainty from the measured value (%)			±100						
17	General exhaust air from the casting hall	30.1	10:07	12:14	2,0						
		30.1	12:15	14:33	1,8						
		average			**1,9**						
		Total uncertainty from the measured value (%)			±15						
18	General exhaust air from the casting hall	30.1	10:13	12:17	1,6						
		30.1	12:18	14:34	1,5						
		average			**1,6**						
		Total uncertainty from the measured value (%)			±15						
13-20	General exhaust air from the casting hall, total 8 pcs				**1,2**	37,4	156	3 600	560	178	640
Finishing											
25	Ionblast-filter	31.1	8:37	10:23	0,04						
		31.1	10:24	13:25	0,04						
		average			**0,04**	1,5	0,20	3 600	0,74	0,23	0,84
		Total uncertainty from the measured value (%)			±100	±20	±46				
30	Filter from finishing and sandblasting	31.1	7:54	9:30	0,16						
		31.1	9:39	12:24	0,12						
		average			**0,14**	11,9	5,9	3 600	21,1	6,7	24,1
		Total uncertainty from the measured value (%)			±100	±13	±33				
Vibration removal and sand handling											
21	Vibration removal hood and sand regeneration Wiser-filter	30.1	10:29	12:19	181						
		30.1	12:20	13:36	52						
		average			**117**	10,4	4 356	3 600	15 683	4 979	17 923
		Total uncertainty from the measured value (%)			±10	±5	±24				
6	Sand silos Gietart-filter	31.1	9:19	10:37	0,09						
		31.1	10:47	13:10	0,05						
		average			**0,07**	1,4	0,35	3 600	1,2	0,40	1,4
		Total uncertainty from the measured value (%)			±100	±40	±82				
Painting hall											
27	Exhaust ventilation fan 1PK2	31.1	11:59	13:24	**0,93**	3,3	11,2	1 800	20,1	12,7	22,9
		Total uncertainty from the measured value (%)			±20	±5	±14				
28-29	Painting hall roof fans, 2 pcs (3				**0,04**	2,7	0,40	1 800	0,72	0,46	0,83
								Total	**16 664**		**19 044**
								Total without measuring point 21	**981**		**1 121**

Annual melting	3 500	t/a
Production time of melting	3 600	h/a
Production 30.-31.1	14	t/d
Production time 30.-31.1	16	h/d
Hourly production 30.-31.1	0,88	t/h
Hourly production average	1,0	t/h

(1 Shield value, flow rate is not possible to measure.

(2 31.1.2019, when it was suppose to make measurement from hoods on top of the induction furnaces, it was not any ball graphite handling.

In the calculation it has been used measuring results from the year 2001. During ball graphite handling fan 8 or 9 is on around 15 minutes. Handlings are made around 700 pieces per year.

(3 Bigger roof fan in the painting hall was not on. In the calculation it has been used measuring results from the year 2013.

URV Oy
Uusikaupunki

Metal emissions from local exhaust ventilation in the induction furnace

APPENDIX 2 1/1

Concentration of metals

Nr	Measuring point	Al	As	Cd	Co	Cu	Ni	Pb	Sn	Mg
		mg/Nm³	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*	*mg/Nm³*
7	Local exhaust ventilation from the induction furnaces	0,04	0,002	0,0001	0,0002	0,02	0,002	0,04	0,03	0,78
Total uncertainty from the measured value (%)		±30	±35	±30	±20	±25	±20	±25	±25	±40

There is no limit values for the metals in the environmental permit.

Hourly emissions from metals

Nr	Measuring point	Al	As	Cd	Co	Cu	Ni	Pb	Sn	Mg
		g/h	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*	*g/h*
7	Local exhaust ventilation from the induction furnaces	0,15	0,01	0,001	0,001	0,09	0,01	0,14	0,10	3,1
Total uncertainty from the measured value (%)		±37	±42	±37	±27	±32	±27	±32	±32	±47

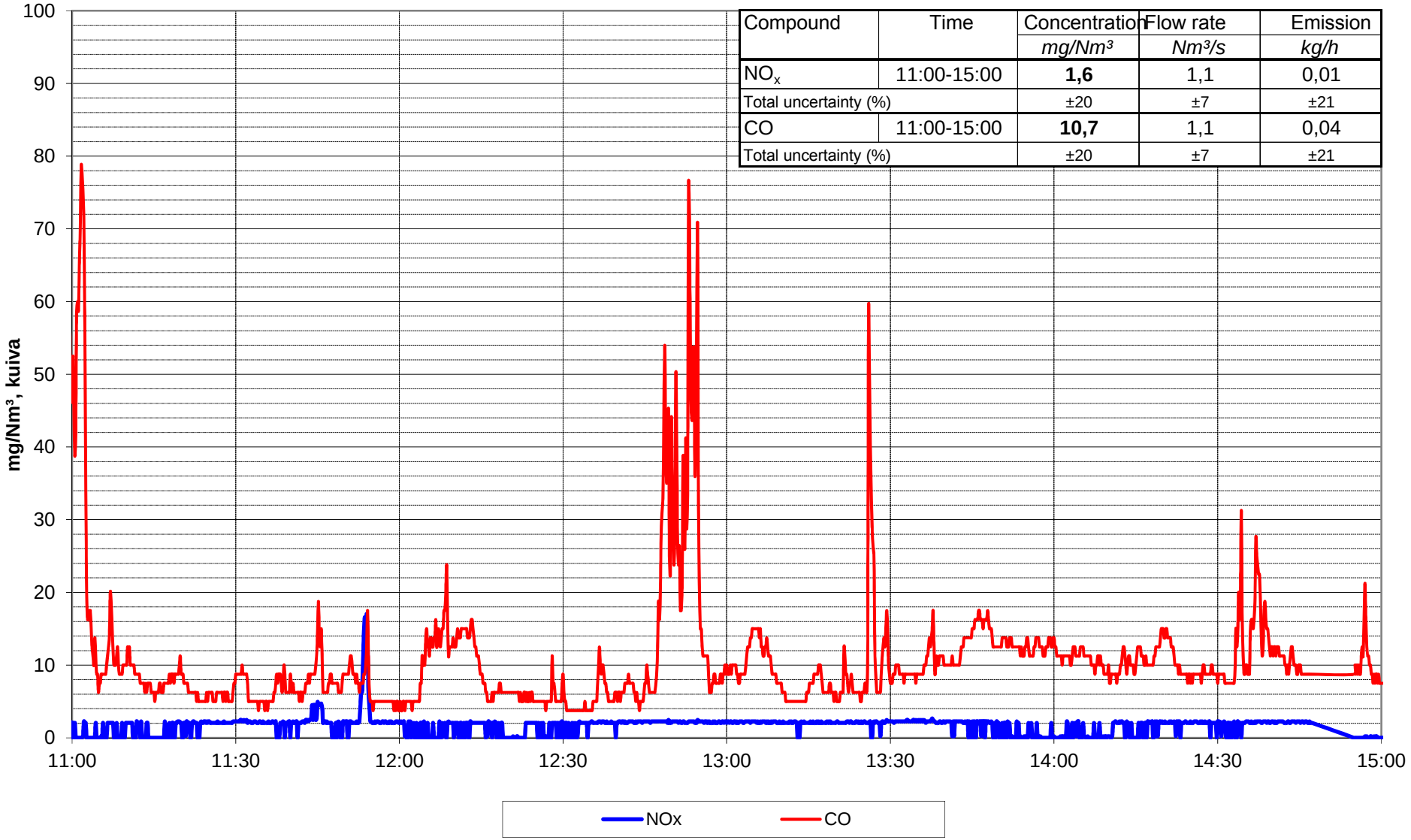
Annual emission of metals

Nr	Measuring point	Al	As	Cd	Co	Cu	Ni	Pb	Sn	Mg
		kg/a	*kg/a*	*kg/a*	*kg/a*	*kg/a*	*kg/a*	*kg/a*	*kg/a*	*kg/a*
7	Local exhaust ventilation from the induction furnaces	0,55	0,02	0,002	0,002	0,31	0,02	0,50	0,35	11,1

Annual emission of metals has been counted based on the production time.

NO_x- and CO-emissions from the induction furnaces local exhaust ventilation

Compound	Time	Concentration	Flow rate	Emission
		mg/Nm³	*Nm³/s*	*kg/h*
NO_x	11:00-15:00	**1,6**	1,1	0,01
Total uncertainty (%)		±20	±7	±21
CO	11:00-15:00	**10,7**	1,1	0,04
Total uncertainty (%)		±20	±7	±21



PCDD/F-emission from the induction furnaces local exhaust ventilation

Measuring point	Induktiouunien kohdepoisto
Date	30.1.2019
Time started	9:42
Time finished	15:42

Compound	Concentration	Toxicity equivalent factor	Highlighted concentration	Uncertainty
	ng/Nm³		*ngTEQ/Nm³*	%
2,3,7,8-TetraCDD	<0,003	1	<0,003	±55
1,2,3,7,8-PentaCDD	<0,003	0,5	<0,002	±53
1,2,3,4,7,8-HeksaCDD	<0,01	0,1	<0,001	±47
1,2,3,6,7,8-HeksaCDD	<0,01	0,1	<0,001	±47
1,2,3,7,8,9-HeksaCDD	<0,01	0,1	<0,001	±47
1,2,3,4,6,7,8-HeptaCDD	0,06	0,01	0,001	±31
OktaCDD	0,16	0,001	0,0002	±30
2,3,7,8-TetraCDF	0,42	0,1	0,04	±30
1,2,3,7,8-PentaCDF	0,11	0,05	0,01	±31
2,3,4,7,8-PentaCDF	0,47	0,5	0,23	±30
1,2,3,4,7,8-HeksaCDF	0,13	0,1	0,01	±31
1,2,3,6,7,8-HeksaCDF	0,07	0,1	0,01	±31
1,2,3,7,8,9-HeksaCDF	<0,01	0,1	<0,001	±47
2,3,4,6,7,8-HeksaCDF	0,09	0,1	0,01	±31
1,2,3,4,6,7,8-HeptaCDF	0,31	0,01	0,003	±30
1,2,3,4,7,8,9-HeptaCDF	0,04	0,01	0,0004	±32
OktaCDF	0,27	0,001	0,0003	±30
Total	2,2		**0,32**	±31

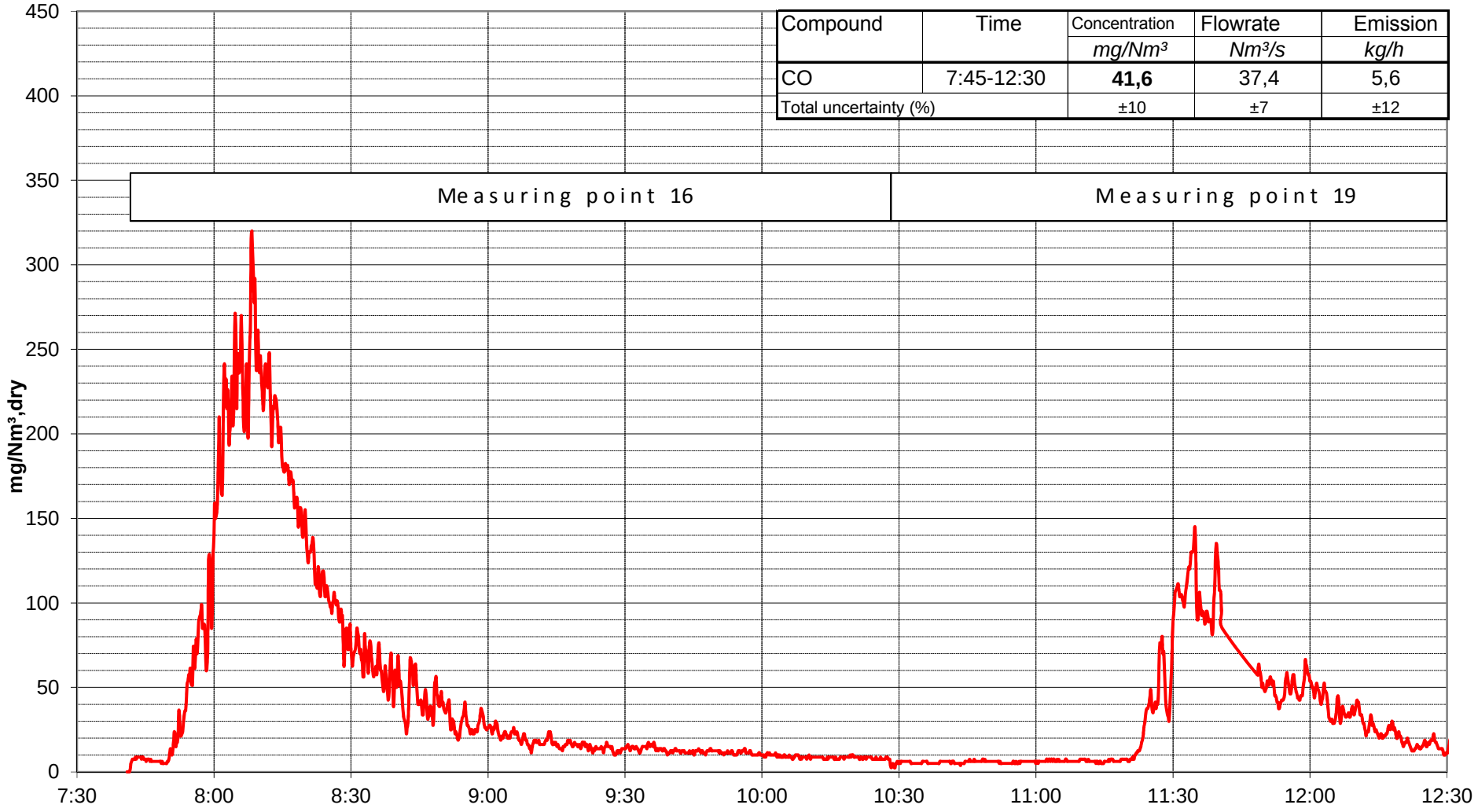
Flow rate	*Nm³/s*	1,1	±7
Emission mass flow	*µg/h*	1,3	±31

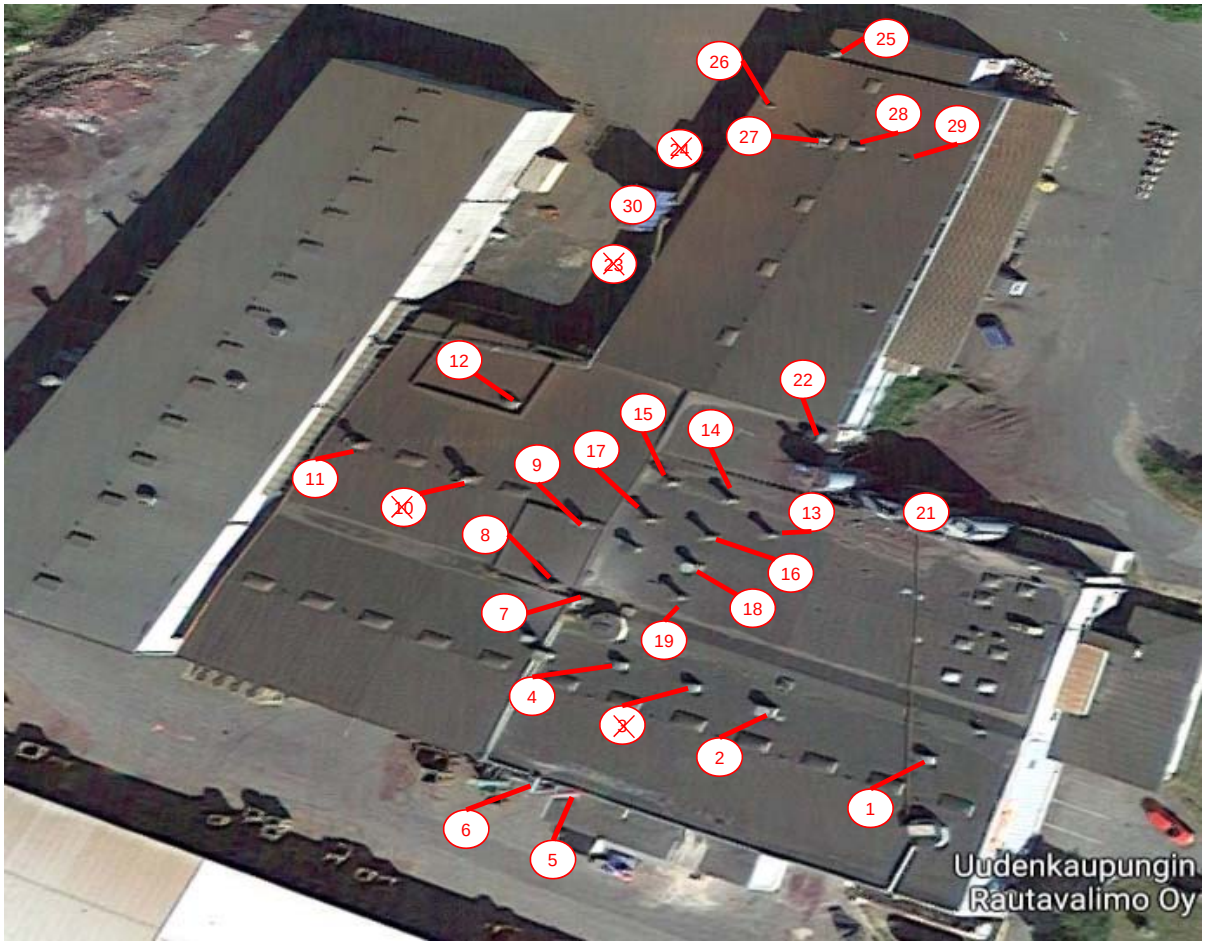
Dimethylethyleamine

Nr	Measuring point	Date	Starting time	Ending time	Concen-tration	Flowrate	Emission
			klo	*klo*	*mg/Nm³*	*Nm³/s*	*g/h*
5	Core cannon	30.1	12:04	13:08	1,4		
		30.1	13:10	14:11	1,4		
		average			**1,4**	0,61	3,0
		Total uncertainty from measured value (%)			±17	±9	±19

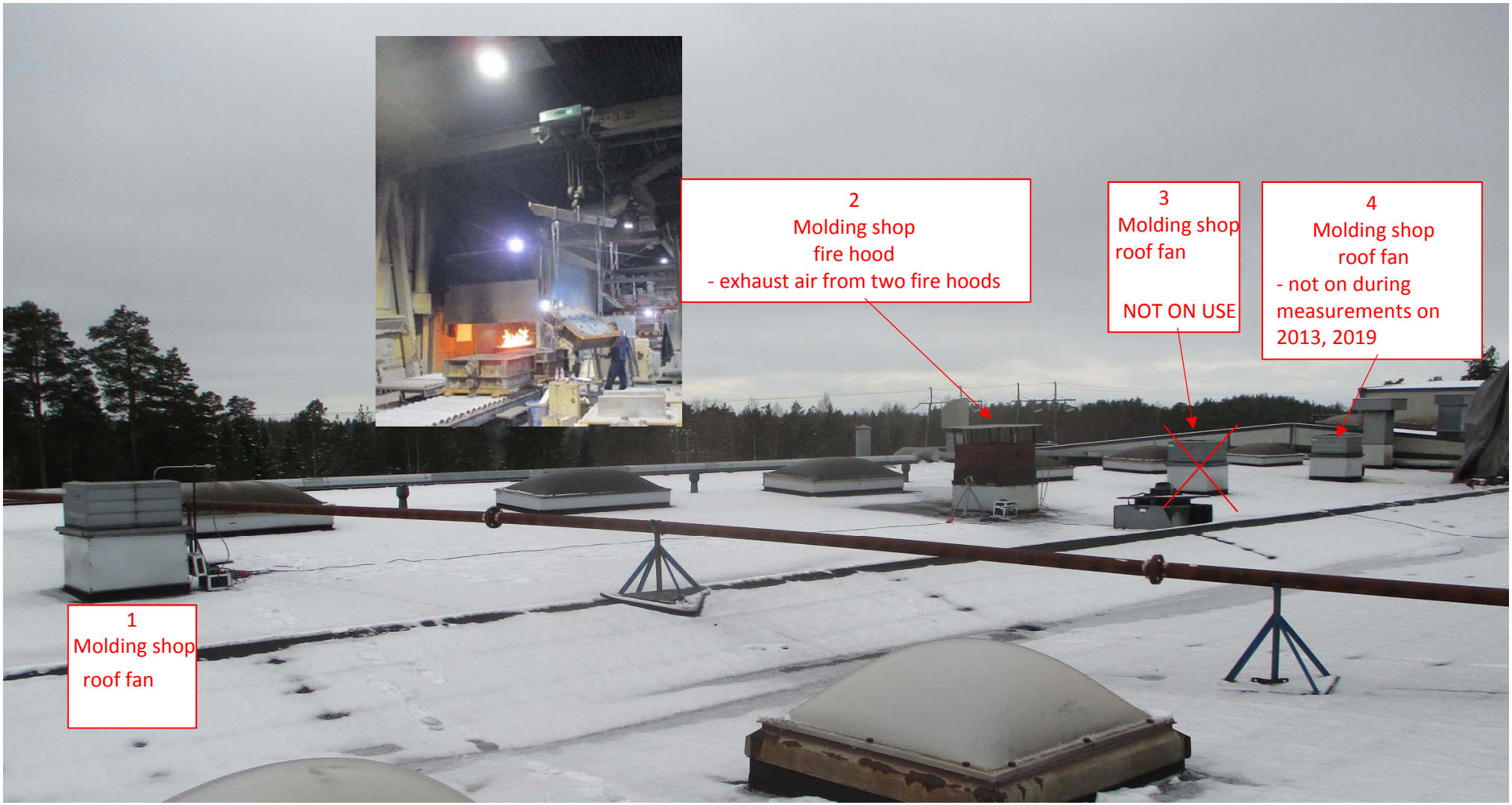
CO-emission from general exhaust air in the casting hall

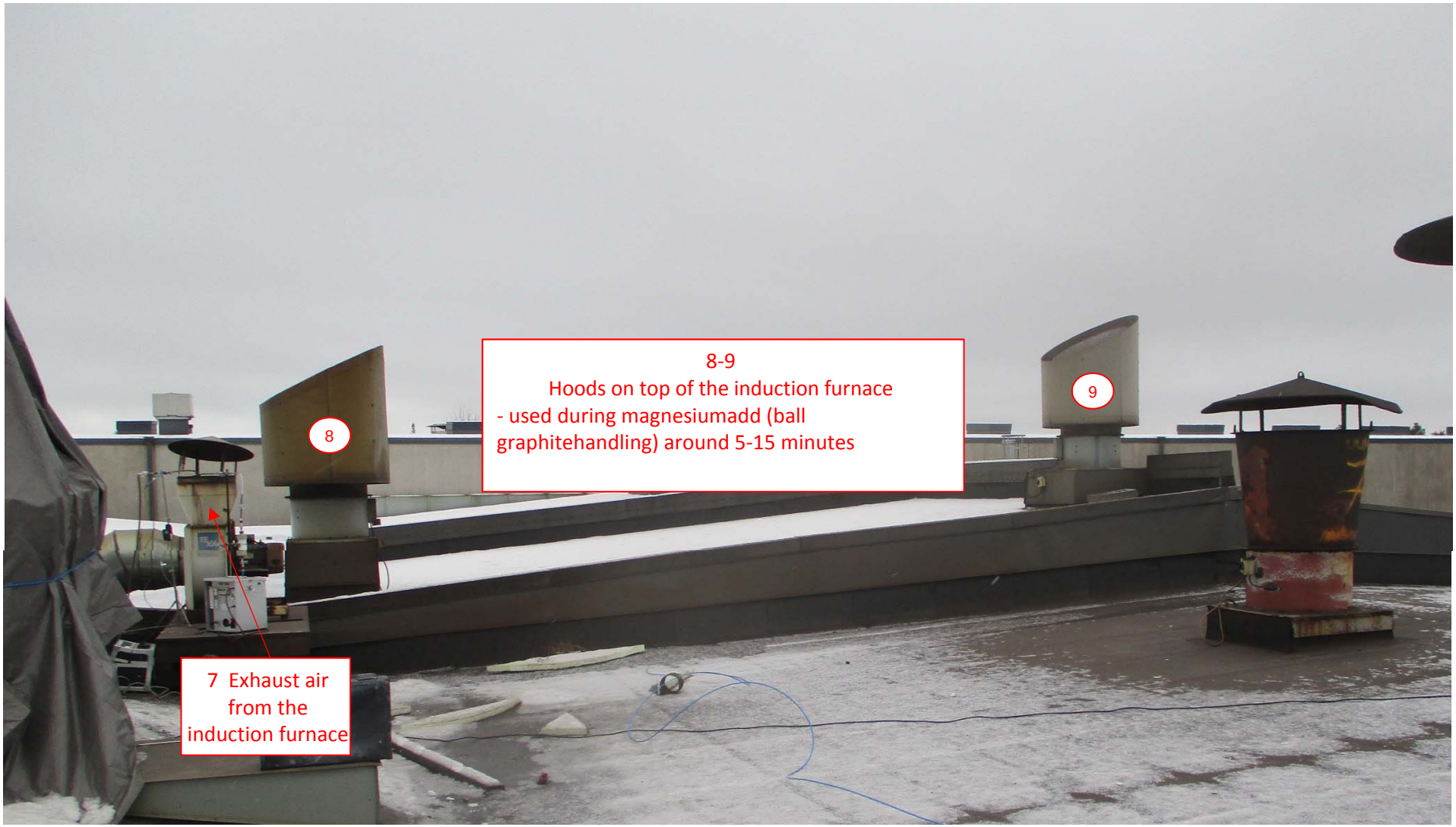
Compound	Time	Concentration	Flowrate	Emission
		mg/Nm³	*Nm³/s*	*kg/h*
CO	7:45-12:30	**41,6**	37,4	5,6
Total uncertainty (%)		±10	±7	±12

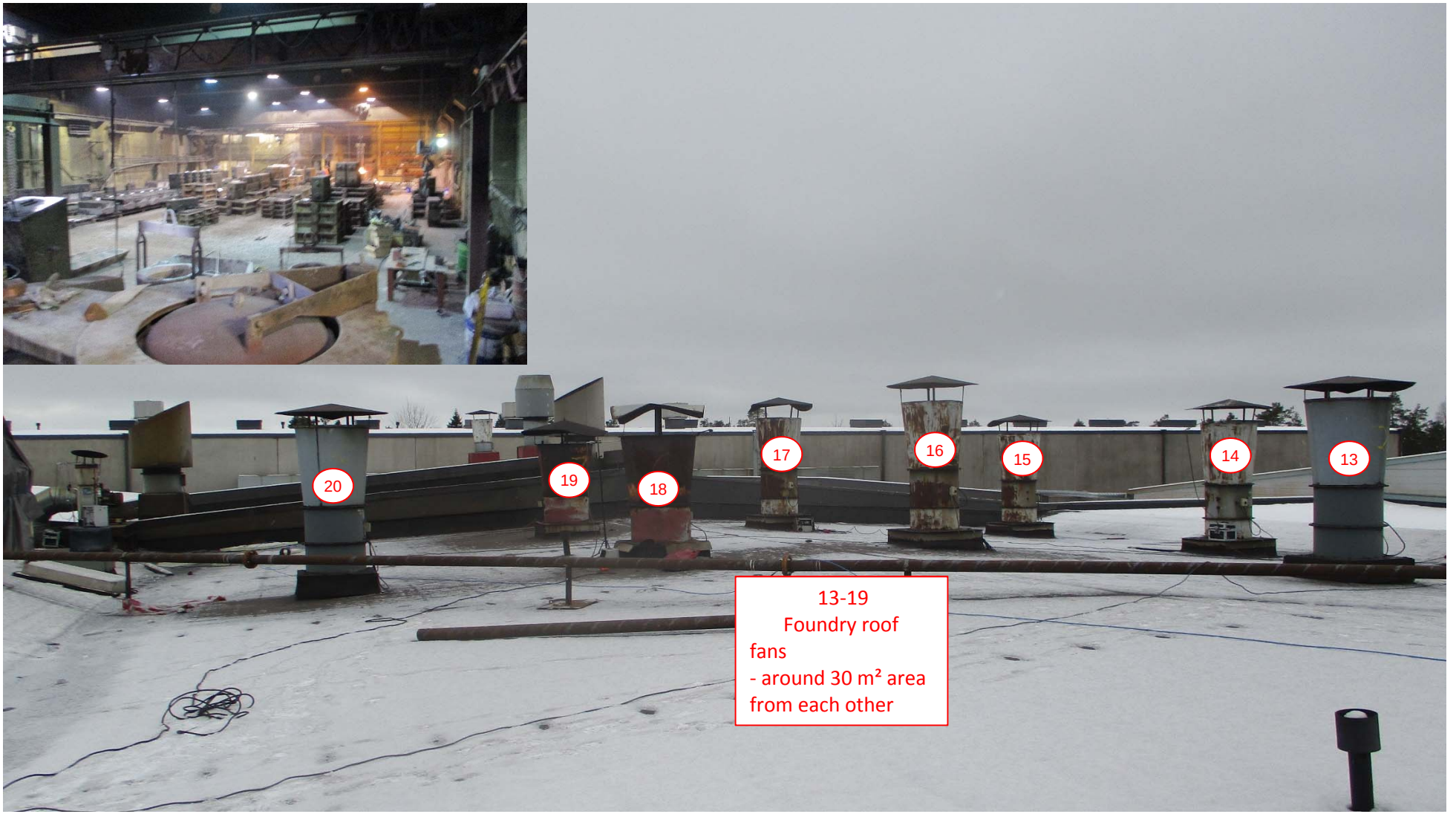




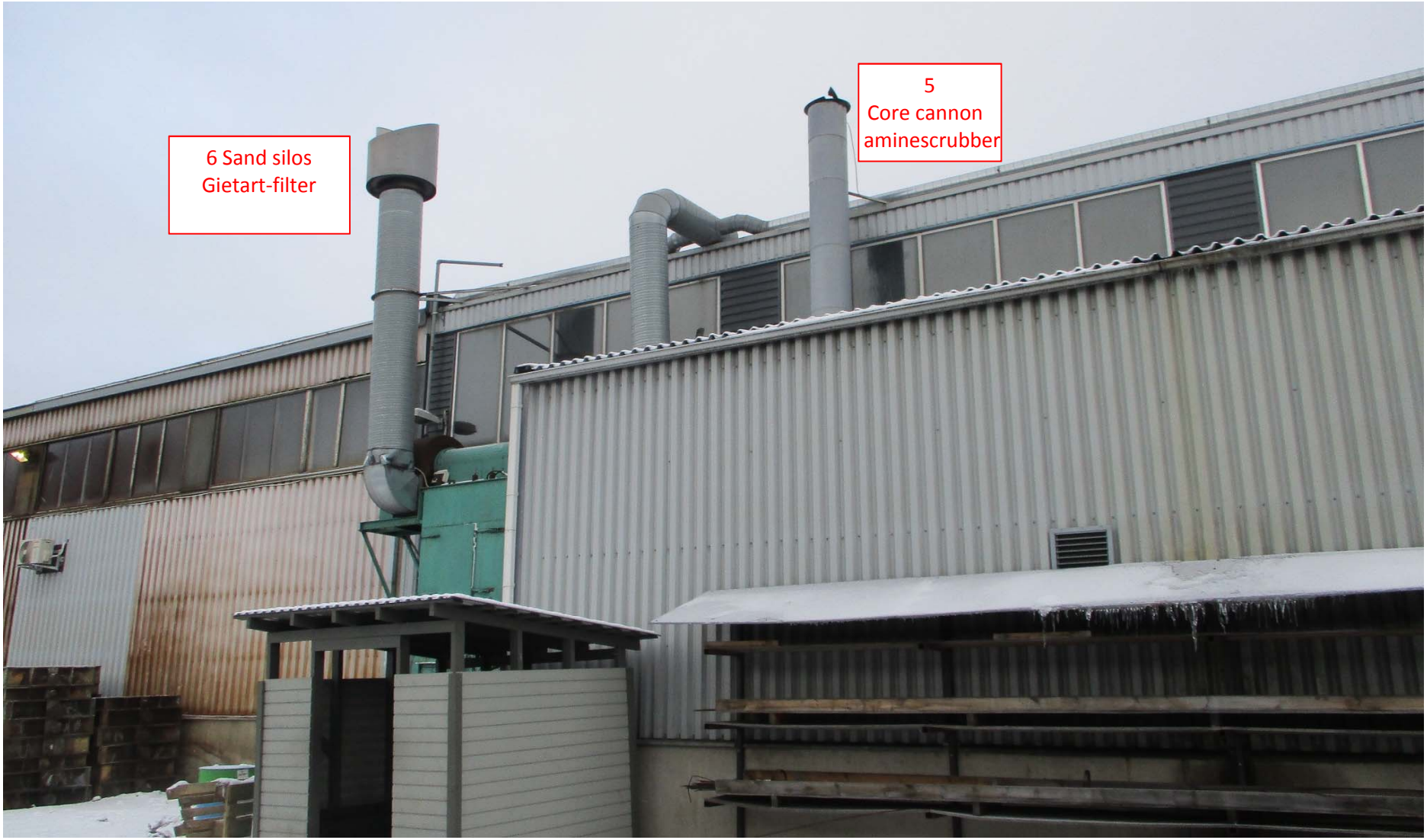
Nr	Measuring point	Use	Measurements 2018
1	Molding shop, roof fan 99TK01 PF02	on use	measured
2	Molding shop, fire hood	on use	measured
3	Molding shop, roof fan 99TK01 PF03	not on use	
4	Molding shop, roof fan99TK01 PF03	not on	
5	Core cannon, amine scrubber	on use	measured
6	Sand silos Gietart-filter	on use	measured
7	Exhaust air from the induction furnace	on use	measured
8	Exhaust air from the induction furnace	on use	taking into account in calculation
9	Hood on top of the induction furnace	on use	taking into account in calculation
10	General exhaust air	not on use	no production
11	General exhaust air	not on	no production
12	Roof fan	not on	no production
13	General exhaust air from the casting hall	on use	taking into account in calculation
14	General exhaust air from the casting hall	on use	measured
15	General exhaust air from the casting hall	on use	taking into account in calculation
16	General exhaust air from the casting hall	on use	taking into account in calculation
17	General exhaust air from the casting hall	on use	measured
18	General exhaust air from the casting hall	on use	measured
19	General exhaust air from the casting hall	on use	taking into account in calculation
20	General exhaust air from the casting hall	on use	taking into account in calculation
21	Removal place hood and sand regeneration Wiser-filter	on use	measured
22	General exhaust air from the removal place	not on	
~~23~~	~~Sinkopuhdistin, suodatin~~	not exist	
~~24~~	~~Puhdistamo, suodatin~~	not exist	
25	Finishing, Ionblast-filter	on use	measured
26	Paint storage, roof fan 5 PK	on use	no production
27	Exhaust air from the paint storage 1PK2	on use	measured
28	Painting hall, roof fan 1PK3	not on	
29	Painting hall, roof fan 1PK4	on use	
30	Filter from finishing and sandblasting	on use	measured


2
Molding shop
fire hood
- exhaust air from two fire hoods
3
Molding shop
roof fan
NOT ON USE
4
Molding shop
roof fan
- not on during
measurements on
2013, 2019
1
Molding shop
roof fan


8-9
Hoods on top of the induction furnace
- used during magnesiumadd (ball graphitehandling) around 5-15 minutes
8
9
7 Exhaust air from the induction furnace


20
19
18
17
16
15
14
13
13-19
Foundry roof fans
- around 30 m² area from each other


21
Removal place hood and sand regeneration Wiser-filter
22
General exhaust air from removal place - not on during measu-rements 2013, 2019


6 Sand silos
Gietart-filter
5
Core cannon
aminescrubber


10
"Hallway"
general exhaust air
- no production, no emission
NOT ON USE
11
"Hallway"
general exhaust air
- not on during measurements 2013, 2019 - no production, no emission
12
General exhaust air
- not on during measurements 2013, 2019 - no production, no emission


30 Filter from finishing and sandblasting


27
Painting hall exhaust air
25
Finishing Ionblast-filter
26
Paint storage roof fan
- no production, no emission
28
Painting hall general exhaust air
- not on during measu-rements 2013, 2019
29
Painting hall general exhaust air

Component	Measuring principle	Device mark	Device	Measuring area	The method of instruction	Standard
Particles	Gravimetric	Out-stack-sond Quartz/glass fiber filter Sample pump	TTL-2 TTL-3 A011-4 A011-6 A011-8 A011-9 A011-10 A011-11		MEN 011	SFS-EN 13284
Metals	Gravimetric	Out-stack-teflon-sond Quartzfilter Sample pump	A011-8		MEN 112	SFS-EN 14385
NO_x CO	Electrochemical cell	Testo 350 -flue gas analyzator	A120-3	0-4000 ppm 0-10000 ppm		SFS-EN 14792 SFS-EN 15058
Amine	Adsorption	SKC-222 pump Anasorb 747-pipes	pckc-1			SFS-EN 13649
PCDD/F	Absorption	Quartz level filter Resin shell Sample pump	A011-4		MEN 111	SFS-EN 1948
Flowrate and condition of the gas		DP Measurement-micromanometer	A021-7	0-100 m/s	MEN 011	ISO 10780
		L-pitot-pipe, I-pitot-pipe	L081-3, L080-8		MEN 021	SFS-EN 14790
		Testo 511-air pressure indicator	L121-4		MEN 023	
		Fluke 52-2-thermometer	L025-15			
		K-type thermoelement	L095-15			