AX-Consulting

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

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

Deliverable: DeB2B Results of total emission and indoor air quality measurements in water glass pilot foundry in Sweden

Results of emission and indoor air measurements in Stavanger Steel AB foundry in Norrhult Sweden

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Client	Stavanger Steel AB Industrigatan 4 36071 Norrhult Sweden
Assignment	Measurement of emissions and indoor air concentrations from the casting mold
Measurement date and place	Norrhult, May 10.-11th 2022
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APPENDICES

1 Introduction

Stavanger Steel AB is a steel foundry located in Norrhult, Sweden. The foundry was established in 1995.

Stavanger Steel Ab (previously Norrhults Stålgjuteri Ab) in Norrhult/Sweden is a small steel foundry employing some 30 employers. The production of the foundry has recently been 300 - 500 ton a year, but the technical capacity of the fasility is some 1.000 ton per year. The steel qualities of the foundry are ferritic steel, austenitic and martensite steel, duplex and superduplex steel, in addition to tempered steel. The weights of castings varies from 5 to 1500 kg.

The casting is based on hand forming using silica, chromite and recycled sand. The recycled sand rate is normally some 70 %. The binder agent which is mainly used for mould making is “water glass” natrium silicate Na_2SiO_3 that can be regarded as inorganic binder.

For the core making is used “low free phenol” content type binder which is hardened by CO_2 gas blowing. The trademark of this binder system Ecolotec produced by Foseco.

During the day of the emission and occupational hygiene measurements the production took place in one shift with amounts of melting 2 500 ton and of good castings 1 700 ton. The melting took place in three periods during a day with different samples on each. The melting, pouring and cooling takes place in the melting shop where the emissions were measured as well.

All exhaust air from the foundry is collected on one fiber filter.

Picture 1. Foundry fiber filter

The knock out site and fettling are in separate buildings and each has its own exhaust air filter. The particle cleaning efficiency rate of the Knoc-out filter was measured and fettling shop particle concentration after filter was measured too..

Picture 2. Knock out fiber filter

2 Measurement results

Emission measurement results are presented in APPENDIX1 and the in-door air concentrations in APPENDIX 2. Trends from the measurements are presented in APPENDICES 3-6.

3 Conclusions

The steel cast amount was 2 500 kg/day and the sand amount was about 8 500 kg/day. Since an inorganic resin was used, all gaseous emissions were low. Aldehydes, phenols and cresols were not measured because they do not occur in inorganic resins.

All measurement results are presented in this report.

3.1. Emissions

3.1.1. Particles

Particulate emissions are calculated (APPENDIX 1) from the concentrations measured in front of the filter.

Foundry fibre filter cleaning efficiency was very high 99,8 %.
See appendix 2.

3.1.2. Carbon monoxide (CO)

The carbon monoxide concentration in the exhaust air always increased during casting and varied between 5...30 ppm. See appendix x.

3.1.3. Volatile Organic Compounds (VOC)

VOC concentrations remained low due to the inorganic resin used. The VOC compounds contained a little ethanol, which probably comes from the coating. See appendix 3.

3.1.4. BTEX

BTEX concentrations were very low. See appendix 3.

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

In practice, the SO2 and NOx,concentrations were 0 ppm.

3.1.6. Metals

Of metals, the exhaust air contained the most iron, silicon and magnesium. See appendix 4.

3.2. Indoor air

3.2.1. Particles

Table 1. Measured indoor air particle concentrations

Measuring Point	Measurement			Measured concentration
	date	start *time*	stop *time*	*mg/m³*
Foundry	11.5.2022	8:10	13:49	1,02

Picture 3. Measuring point in foundry

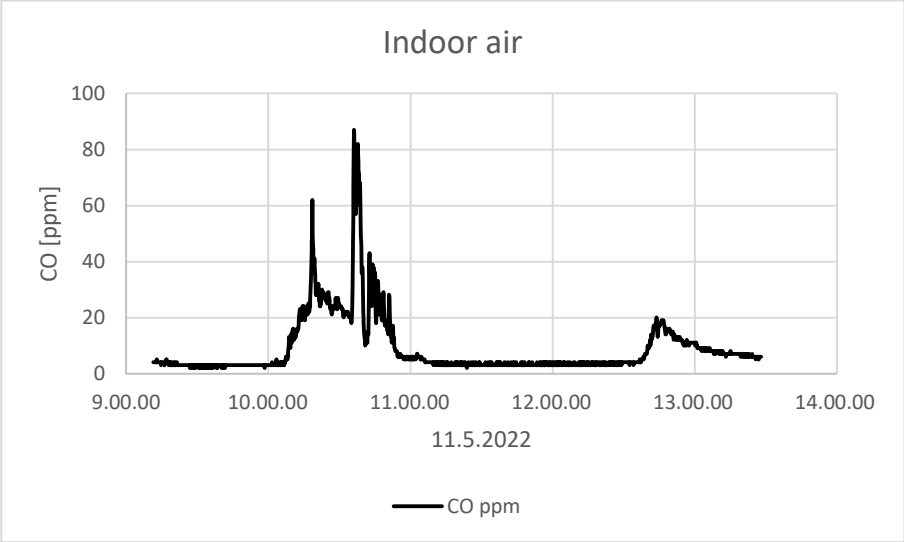
3.2.2. Quarts

Table 2. Measured indoor air quarts concentrations

Measurement Point	Measurement			Measured concentration
	date	start *time*	stop *time*	*mg/m³*
Foundry	11.5.2022	8:16	13:49	0,06

3.2.3. Carbon monoxide

The carbon monoxide concentration during casting were quite high. On average, the concentration was about 30 ppm. During casting, the carbon monoxide concentration rose to around 90 ppm at its worst.



Picture 4. Measured CO concentration in indoor air

4 Procedure

4.1 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

4.2 Metals

The analyses were carried out at a non-accredited laboratory: RZ, Eurofins Environment Testing Finland Oy, Lahti by microwave scattering method, according to standards SFS-EN 16173 and EN 14385.

Uncertainty of concentration depends on the metal in question.

4.3 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 %.

4.4 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 %.

4.5 Quarts

Quart concentration analysis was made by an accredited laboratory: Finnish Institute of Occupational Health (FINAS T013). Concentration was calculated using accredited method AERO-TY-025, where the alveolar dust sample is ashed and the residue is compressed into a KBr tablet and analyzed by FT-IR.

Uncertainty of concentration is ±27 %.

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 1: 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		Before Foundry filter
Binder type		Inorganic
Casting quantity (kg)		1700
Sand quantity (kg)		8500
Binder quantity (kg)		300
Exhaust air flow (Nm^3/s)		6,01
Concentration (mg/Nm^3)	Particles	32,4
	Total VOC	0,79
	BTEX	0,02
	Ethanol	0,35
	2-Propanol	0,32
	Carbon monoxide	25,6
	NO_x	2,05
	SO_2	2,22
Emissions (g/h)	Particles	700
	Total VOC	17,0
	BTEX	0,53
	Ethanol	7,58
	2-Propanol	6,82
	Carbon monoxide	554
	NOx	44,4
	SO2	48,0
Emissions per casting quantity (mg/kg)	Particles	412
	Total VOC	10,0
	BTEX	0,3
	Ethanol	4,5
	2-Propanol	4,0
	Carbon monoxide	326
	NOx	26,1
	SO2	28,2
Emissions per sand quantity (mg/kg)	Particles	82
	Total VOC	2,00
	BTEX	0,06
	Ethanol	0,89
	2-Propanol	0,80
	Carbon monoxide	65
	NOx	5,2
	SO2	5,6
Emissions per binder quantity (mg/kg)	Particles	2335
	Total VOC	57
	BTEX	1,8
	Ethanol	25,3
	2-Propanol	22,7
	Carbon monoxide	1 846
	NOx	148
	SO2	160

Stavange Steel **Dust emissions and** **Appendix 2** 1/1
Norrhult **filters dust cleaning efficiency**
11.5.2022

Measuring point		Start	Stop	Concent-ration	Air flow	Emission
		time	*time*	*mg/Nm³*	Nm^3/s	g/h
Foundry filter	Before	8:24	10:49	38,9		
	After 1	8:22	10:44	0,03	2,96	0,33
	After 2	8:23	10:47	0,08	3,06	0,89
	After	average		0,05	6,01	1,15
Foundry filter	Before	10:50	13:42	25,8		
	After 1	10:45	13:40	0,06	2,96	0,66
	After 2	10:47	13:41	0,09	3,06	1,02
	After	average		0,08	6,01	1,63
Knock-out by joilting filter	Before	13:07	13:28	3 268		
	Before	13:43	13:58	4 289		
	Before	13:29	13:41	3 835		
	Before	average		3 709		
	After	13:07	14:05	0,21	5,29	3,96
Fettling shop	After	9:55	11:28	1,51		
	After	11:29	14:20	1,63		
	After	average		1,59	8,93	51,2

Filter	Concentration		
	Before	After	Cleaning efficiency
	mg/Nm³	*mg/Nm³*	%
Foundry	32,4	0,06	99,80
Knock-out by joilting	3 709	0,21	99,99

Measuring point		Before Foundry filter
Date		11.5.2022
Start		8:39:00
End		13:44:00
VOC-compound	CAS-number	mg/Nm^3
Benzofuran	271-89-6	<0,004
Benzene	71-43-2	0,01
Butans	106-97-8	0,02
Ethylacetate	141-78-6	<0,004
Ethylbenzene	100-41-4	<0,004
2-Ethyl-1-heksanol	104-76-7	<0,004
Ethanol	64-17-5	0,35
Ethyl hexyl asetate	103-09-3	<0,004
3-Caren	498-15-7	0,004
Xylene	1330-20-7	0,004
Methyl acetate	79-20-9	<0,004
2-Butanoni	78-93-3	<0,01
2-Methylfuran	534-22-5	<0,004
Alphapine	7785-70-8	<0,004
2-Propanol	67-63-0	0,32
Styrene	100-42-5	0,01
Toluene	108-88-3	0,004
1,3,5-Trimethylbentsene	108-67-8	<0,004
1,2,3-propanetriol triacetate	102-76-1	<0,004
Other VOCs	-	0,01
Sum		**0,79**
Share of the compound		%
Benzofuran	271-89-6	0,4
Benzene	71-43-2	1,8
Butans	106-97-8	3,1
Ethylacetate	141-78-6	0,4
Ethylbenzene	100-41-4	0,4
2-Ethyl-1-heksanol	104-76-7	0,4
Ethanol	64-17-5	44,6
Ethyl hexyl asetate	103-09-3	0,4
3-Caren	498-15-7	0,4
Xylene	1330-20-7	0,4
Methyl acetate	79-20-9	0,4
2-Butanoni	78-93-3	1,8
2-Methylfuran	534-22-5	0,4
Alphapine	7785-70-8	0,4
2-Propanol	67-63-0	40,2
Styrene	100-42-5	0,9
Toluene	108-88-3	0,4
1,3,5-Trimethylbentsene	108-67-8	0,4
1,2,3-propanetriol triacetate	102-76-1	0,4
Other VOCs	-	1,8
Sum		**100,0**

Metal concentration

Measuring point	Particles	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Li	Mn	Mo	Ni	P	Pb
	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*
Foundry filter	38,90	0,001	5,671	0,005	0,647	0,147	0,001	0,001	0,005	0,805	0,386	0,004	3,403	1,815	0,340	0,125	0,105
Inaccuracy (%)		±26	±31	±36	±41	±31	±41	±31	±21	±31	±26	±26	±16	±26	±21	±41	±26

Metal concentration

Measuring point	Particles	Sb	Se	Sn	Sr	Tl	U	V	Zn	Ca	Fe	K	Mg	Na	S	Si	Hg
	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*
Foundry filter	38,90	0,002	0,017	0,014	0,018	0,001	0,001	0,012	1,112	1,70	9,75	13,61	1,93	43,10	0,23	2,27	0,0001
Inaccuracy (%)		±31	±26	±26	±21	±21	±26	±21	±26	±21	±16	±21	±41	±21	±21	±26	±26

Hourly emissions

Measuring point	Air flow	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Li	Mn	Mo	Ni	P	Pb
	Nm³/s	*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*
Foundry filter	6,0	0,0	122,7	0,1	14,0	3,2	0,02	0,03	0,1	17,4	8,3	0,1	73,6	39,3	7,4	2,7	2,3
Inaccuracy (%)	±5	±31	±36	±41	±46	±36	±46	±36	±26	±36	±31	±31	±21	±31	±26	±46	±31

Hourly emissions

Measuring point	Air flow	Sb	Se	Sn	Sr	Tl	U	V	Zn	Ca	Fe	K	Mg	Na	S	Si	Hg
	Nm³/s	*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*
Foundry filter	6,0	0,04	0,37	0,29	0,39	0,01	0,01	0,27	24,0	36,8	211	294,5	41,7	932,5	4,9	49,1	0,002
Inaccuracy (%)		±36	±31	±31	±26	±26	±31	±26	±31	±26	±21	±26	±46	±26	±26	±31	±31

CO-, NOx-, SO2-concentrations and temperature in exhaust air