efnagreiningar
KELDNAHOLTI

Nýsköpunarmiðstöð Íslands

6EM12085
Gunnar Kvaran
Hermann Þórðarson

Emission measurement by exhaust duct sampling

Alcoa Fjarðaál,
Reyðarfirði

September 2012

Summary

Results from emission measurements done in September on the exhaust ducts V and A from the primary air emission treatment facilities of Alcoa Fjarðaál, Reyðarfjörður, are reported here.

The following factors were measured: Total particulate content, fluoride content, flow velocity and volume, as well as carbon monoxide content and sulphur dioxide content.

Total average particulate content was found to be on average 1,9 mg/Nm^3 and <0,4 mg/Nm^3 in the exhaust ducts with a sum of less or equal to 3,4 kg/hr emitted. Total fluoride was on average0,45-0,57mg/Nm^3 or total 1,4 kg/hr emitted.

Table 3.1	Exhaust duct V				
	Particulates	F dust	F gas	CO	SO_2
Concentration mg/Nm^3	1,9	0,06	0,39	814	161
Amount kg/klst	3,1	0,10	0,63	1315	259
Exhaust duct V	Velocity m/s	Flow volume dry Nm^3/klst	Temp °C	Humidity %	
Average	18,8	1.615.000	95	0,7	

Table 3.2	Exhaust duct A				
	Particulates	F dust	F gas	CO	SO_2
Concentration mg/Nm^3	< 0,4	0,07	0,50	904	202
Amount kg/klst	0,3	0,10	0,78	1400	313
Exhaust duct A	Velocity m/s	Flow volume dry Nm^3/klst	Temp °C	Humidity %	
Average	17,8	1.550.000	90	0,6	

Keldnaholti, 112 Reykjavík
Sími 522 9000 – Fax 522 9111 – www.nmi.is

Content

Appendices

Air velocity and measurement of particulates

Keldnaholti, 112 Reykjavík
Sími 522 9000 – Fax 522 9111 – www.nmi.is

1. Introduction

Exhaust duct sampling at Alcoa Fjarðaál was carried out on 19-21.9.12. Measured factors were particulates, gaseous and particulate fluorides (F_{gas} and F_{dust}). Additionally carbon monoxide (CO) and sulfur dioxide (SO_2) were measured.

2. Measurement and sampling

2.1 Method and execution

Particulates: Determination of dust or particulate material in air or gasstream, flowing at an air velocity to be determined, in a closed conduit or channel. The particulate content is determined by weighing and the amount of air is measured by volume measurement. The sample is withdrawn from the conduit using isokinetic sampling and filtered through a glass wool filter, that has been previously dried and weighed. After sampling the filter is dried again and weighed. The air volume is corrected to NTP (0°C, 1013 hPa) and the particulate content is calculated in mg/Nm^3. The detection limit for a 1 m^3 sample is about 1 mg/Nm^3 and is proportionally smaller the larger the sample volume.

Air velocity: Isokinetic sampling means that the speed of the air stream through the sampler orifice is the same as the speed of the air in the conduit. The air velocity head is determined using a pitot tube and differential manometer and the air velocity calculated, taking account also of temperature, pressure, humidity and composition of the air or density. The number and position of traverse points are dependent on the dimensions of the conduit. From the air velocity and the cross sectional area of the conduit, the flow volume is determined and the conditions for isokinetic sampling. The method applies to air velocity streams of 4-40 m/s.

Fluoride: Samples are drawn through a 37 mm cellulose acetate membrane filter (0,8 µm) and then through an impinger train of three bottles containing 0.1 M NaOH solution. The gas volume is measured by gas meter. The particulate fluoride is determined from the dust collected on the filter. The gaseous fluoride is determined from the total collected fluoride in the impinger train solution. The concentration of fluoride is determined by ion-specific electrode measurement.

Equipment: Strohlein STE4 sampling heads, filters and filter compartment, water trap, drying filter, gas volume meter, flow meter, pump. The range of the equipment assumes 1-4 m^3/hr sampling. Pitot tube, differential manometer (corresp. to 40 ±1 mm water), pressure meter, thermometer. Impinger train, heated inlet for gaseous fluoride sampling.

References: VDI 2066, Bl.1 og 2, Vejledning nr.7, 1974, Miljöstyrelsen, Denmark.

Keldnaholti, 112 Reykjavík
Sími 522 9000 – Fax 522 9111 – www.nmi.is

2.2 Air velocity of exhaust stream

There are two exhaust ducts from the aluminum smelter, duct V (west) and duct A (east). Measurements with pitot tube were done in the 4 sampling access openings on the horizontal exhaust duct V. 6 traverse points were measured in each access opening and the measurement was carried out three times during the sampling period. The average results are below:

Table 2.1		Exhaust duct V			
		Air velocity m/s	Flow volume m^3/klst	Flow volume Nm^3/klst	Flow vol dry Nm^3/klst
N 20.9.12		19,7			
S 21.9.12		18,4			
T 21.9.12		18,4			
B 20.9.12		18,6			
Exhaust duct V	Average	18,8	2.170.000	1.625.000	1.615.000

Only three of the four sampling openings could be accessed on exhaust duct A. The execution of the measurement was in other respects the same.

Table 2.2		Exhaust duct A			
		Air velocity m/s	Flow volume m^3/klst	Flow volume Nm^3/klst	Flow vol dry Nm^3/klst
N 19.9.12		17,4			
S 20.9.12		18,2			
B 20.9.12		17,8			
Exhaust duct A	Average	17,8	2.060.000	1.560.000	1.550.000

2.3 Total particulate, particulate fluoride and gaseous fluoride

The sample collector is introduced through the access openings and a partial airstream is withdrawn. The exhaust sample is taken isokinetically using average air velocity, thus aiming for a kinetic ratio of 1.1-1.3. The total sampled volume is measured by gas volume meter. One sample from each opening is drawn using a 8 mm orifice Strohlein STE4 sampler containing glass wool filters. The particulates are measured in the collected filters along with 2-3 blank filters.

Total fluoride as separated particulate and gaseous fluoride is collected simultaneously by a separate collection channel. The samples are drawn through a 37 mm cellulose acetate membrane (0.8 µm) and then through an impinger train of three bottles containing 0.1 M NaOH solution. The gas volume is measured by gas meter. The concentration of fluoride collected on the particulate filters and in the solution is then determined by ion-specific electrode measurement. The results can be seen in tables 2.3 and 2.4.

Keldnaholti, 112 Reykjavík
Sími 522 9000 – Fax 522 9111 – www.nmi.is

Table 2.3	Exhaust duct V			
North N	Particulates mg/Nm^3	F dust mg/Nm^3	F gas mg/Nm^3	F total mg/Nm^3
20.9.12	3,14	0,05	0,31	0,35
Top T				
21.9.12	3,04	0,07	0,42	0,49
South S				
21.9.12	0,32	0,06	0,29	0,35
Bottom B				
20.9.12	1,23	0,07	0,55	0,62
Exhaust duct V				
20.-21.9.12				
Average [1]	1,9	0,06	0,39	0,45
St. dev. [2]	1,4	0,01	0,12	0,13

[1] Averages based on total amount and volume sampled, not arithmetic mean of individual results
[2] St.dev. based on individual results

Table 2.4	Exhaust duct A			
North N	Particulates mg/Nm^3	F dust mg/Nm^3	F gas mg/Nm^3	F total mg/Nm^3
19.9.12	0,33 (<0,4)	0,06	0,60	0,66
Top T				
South S				
20.9.12	0,18 (<0,4)	0,06	0,42	0,48
Bottom B				
20.9.12	0,00 (<0,4)	0,08	0,49	0,57
Exhaust duct A				
19.-20.9.12				
Average [1]	0,16 (< 0,4)	0,07	0,50	0,57
St. dev. [2]	0,2	0,01	0,09	0,09

[1] Averages based on total amount and volume sampled, not arithmetic mean of individual results
[2] St.dev. based on individual results

The detection limit for particulates is 0,4 mg/Nm^3 for the approximately 2,7 cubic normal meter samples.

The result is then that particulates are 1,1 mg/Nm^3 on average in the emission from the common exhaust chimney. This corresponds to 3,4 kg/hr total particulate emission.

Total fluorides are 0,51 mg/Nm^3 on average in the emission from the common exhaust chimney. This corresponds to a 1,6 kg/hr emission of total fluorides.

2.4 Other factors measured

Carbon monoxide and sulfur dioxide in the exhaust were also measured, using a Testo 350/454 flue gas analyzer. The results are averages from a 1 hr measurement or more in each sample access opening, using a recording interval of 20 sec.

Table 2.5 Exhaust duct V

	CO mg/Nm^3	SO_2 mg/Nm^3
North N 20.9.2012	796	168
Top T 20.9.2012	839	171
South S 21.9.2012	808	143
Exhaust duct V		
Average 20-21.9.2012	814	161

Table 2.6 Exhaust duct A

	CO mg/Nm^3	SO_2 mg/Nm^3
North N 20.9.2012	913	193
South S 19.9.2012	895	210
Exhaust duct A		
Average 19-20.9.2012	904	202

The values in each sampling point are usually fairly stable, with RSD% typically 2-10% in the measurement interval.

Keldnaholti, 112 Reykjavík
Sími 522 9000 – Fax 522 9111 – www.nmi.is

3. Summary

Average results are reported below.

Table 3.1	Exhaust duct V				
	Particulates	F dust	F gas	CO	SO_2
Concentration mg/Nm^3	1,9	0,06	0,39	814	161
Amount kg/klst	3,1	0,10	0,63	1315	259

Exhaust duct V	Velocity m/s	Flow volume dry Nm^3/klst	Temp °C	Humidity %
Average	18,8	1.615.000	95	0,7

Table 3.2	Exhaust duct A				
	Particulates	F dust	F gas	CO	SO_2
Concentration mg/Nm^3	< 0,4	0,07	0,50	904	202
Amount kg/klst	0,3	0,10	0,78	1400	313

Exhaust duct A	Velocity m/s	Flow volume dry Nm^3/klst	Temp °C	Humidity %
Average	17,8	1.550.000	90	0,6

October 2012,
Hermann Þórðarson
Efnagreiningum, Nýsköpunarmiðstöð.

Keldnaholti, 112 Reykjavík
Sími 522 9000 – Fax 522 9111 – www.nmi.is

Alcoa-Fjarðaál				20.-21.9.2012		Vestari útblástursleggur V		
Lofthraða- og rykmæling								
				Þvermál rás	Staðs.í rás	Straumþrýstingur		Lofthraði
Þrýst.umhv.	1017	mbör	30,9	cm	cm	mm vatn	mbör	m/s
Þrýst.í rás	1022	mbör		640	13	18,0	1,77	19,11
					45	17,5	1,72	18,85
Hitast.umhv.	300	°K			77	20,0	1,96	20,15
Hitast.í rás	368	°K	95		115	21,0	2,06	20,65
					160	21,0	2,06	20,65
Þverm. rás	6,4	m			230	20,0	1,96	20,15
Lofthraði rás	18,76	m/s			0	16,0	1,57	18,02
Straummassi	2172710	m3/klst						
í rás	1626140	Nm3/klst			Meðaltal A	19,07	1,87	19,65
þurrt	1615378	Nm3/klst						
Æskil.straummassi					Staðs.í rás	Straumþrýstingur		Lofthraði
í mælibún.	2,54	Nm3/klst	Hlutf.flæðim.			mm vatn	mbör	m/s
	2,64	m3/klst	101		13	16,5	1,62	18,30
þurrt	2,52	m3/klst	98		45	16,5	1,62	18,30
Þverm.dísu	8	mm			77	18,0	1,77	19,11
Hitast.mælib.	286	°K	13		115	18,0	1,77	19,11
					160	17,5	1,72	18,85
			Bl.vigt	Kvst.gasm.	230	17,0	1,67	18,58
				0,97	0	13,0	1,28	16,24
Mæling B:	7							
Loftmagn	2,90806	m3	3432,98	3435,978	Meðaltal B	16,64	1,63	18,36
	2,775	Nm3						
Tími	64	mín	Hittni		Staðs.í rás	Straumþrýstingur		Lofthraði
Flæði	2,60	Nm3/klst	1,03			mm vatn	mbör	m/s
Ryk í síu	0,0034	g			13	13,0	1,28	16,24
Ryk í lofti	1,23	mg/Nm3			45	15,5	1,52	17,74
Ryk í útbl.	1,99	kg/klst			77	16,0	1,57	18,02
					115	17,0	1,67	18,58
Mæling N:	8				160	18,0	1,77	19,11
Loftmagn	2,83434	m3	3435,978	3438,9	230	20,0	1,96	20,15
	2,705	Nm3			0	18,0	1,77	19,11
Tími	66	mín	Hittni					
Flæði	2,46	Nm3/klst	0,97		Meðaltal C	16,79	1,65	18,42
Ryk í síu	0,0085	g						
Ryk í lofti	3,14	mg/Nm3			Staðs.í rás	Straumþrýstingur		Lofthraði
Ryk í útbl.	5,11	kg/klst				mm vatn	mbör	m/s
					13	15,5	1,52	17,74
Mæling T:	9				45	16,0	1,57	18,02
Loftmagn	2,79069	m3	3438,9	3441,777	77	17,5	1,72	18,85
	2,663	Nm3			115	18,5	1,81	19,38
Tími	65	mín	Hittni		160	18,0	1,77	19,11
Flæði	2,46	Nm3/klst	0,97		230	17,0	1,67	18,58
Ryk í síu	0,0081	g						
Ryk í lofti	3,04	mg/Nm3						
Ryk í útbl.	4,95	kg/klst			Meðaltal D	17,08	1,68	18,61
Mæling S:	10				Vatnsinnih.	Loftmagn	Rúmmáls%	g/kg, g/Nm
Loftmagn	2,91776	m3	3441,777	3444,785	57,9	10,93	0,66	4,11
	2,784	Nm3						5,30
Tími	64	mín	Hittni					
Flæði	2,61	Nm3/klst	1,03					
Ryk í síu	0,0009	g						
Ryk í lofti	0,32	mg/Nm3						
Ryk í útbl.	0,53	kg/klst						
Meðaltal	1,91	mg/Nm3						
	3,11	kg/klst						

Keldnaholti, 112 Reykjavík
Sími 522 9000 – Fax 522 9111 – www.nmi.is

Alcoa-Fjarðaál				**19.-20.9.12**		**Austari útblástursleggur A**		
Lofthraða- og rykmæling								
				Þvermál rás	**Staðs.í rás**	**Straumþrýstingur**		**Lofthraði**
Þrýst.umhv.	1015	mbör	30,9	cm	cm	mm vatn	mbör	m/s
Þrýst.í rás	1020	mbör		640	13	12,5	1,23	15,84
					45	14,5	1,42	17,06
Hitast.umhv.	290	°K			77	16,5	1,62	18,19
Hitast.í rás	363	°K	90		115	18,0	1,77	19,00
					160	18,0	1,77	19,00
Þverm. rás	6,4	m			230	19,0	1,86	19,52
Lofthraði rás	17,80	m/s			0	18,0	1,77	19,00
Straummassi	2061949	m3/klst						
í rás	1561438	Nm3/klst			**Meðaltal A**	16,64	1,63	18,23
þurrt	1552370	Nm3/klst						
Æskil.straummassi					**Staðs.í rás**	**Straumþrýstingur**		**Lofthraði**
í mælibún.	2,44	Nm3/klst	**Hlutf.flæðim.**			mm vatn	mbör	m/s
	2,53	m3/klst	97		13	11,5	1,13	15,19
þurrt	2,43	m3/klst	94		45	13,5	1,32	16,46
Þverm.dísu	8	mm			77	16,5	1,62	18,19
Hitast.mælib.	285	°K	12		115	17,5	1,72	18,74
					160	17,5	1,72	18,74
			Bl.vigt	**Kvst.gasm.**	230	18,5	1,81	19,26
				0,97	0	14,0	1,37	16,76
Mæling N:	1				0	13,0	1,28	16,15
Loftmagn	2,87993	m3	3424,129	3427,098	**Meðaltal B**	15,25	1,50	17,44
	2,758	Nm3						
Tími	65	mín	**Hittni**		**Staðs.í rás**	**Straumþrýstingur**		**Lofthraði**
Flæði	2,55	Nm3/klst	1,05			mm vatn	mbör	m/s
Ryk í síu	0,0009	g			13	13,0	1,28	16,15
Ryk í lofti	0,33	mg/Nm3			45	13,0	1,28	16,15
Ryk í útbl.	0,51	kg/klst			77	15,5	1,52	17,63
					115	18,0	1,77	19,00
Mæling S:	2				160	17,0	1,67	18,47
Loftmagn	2,83822	m3	3427,098	3430,024	230	16,5	1,62	18,19
	2,718	Nm3			0	17,0	1,67	18,47
Tími	64	mín	**Hittni**		0	16,0	1,57	17,92
Flæði	2,55	Nm3/klst	1,04		**Meðaltal C**	15,75	1,55	17,75
Ryk í síu	0,0005	g						
Ryk í lofti	0,18	mg/Nm3			**Staðs.í rás**	**Straumþrýstingur**		**Lofthraði**
Ryk í útbl.	0,29	kg/klst				mm vatn	mbör	m/s
Mæling T:								
Loftmagn	0	m3						
	0,000	Nm3						
Tími		mín	**Hittni**					
Flæði	#DIV/0!	Nm3/klst	#DIV/0!					
Ryk í síu		g						
Ryk í lofti	#DIV/0!	mg/Nm3						
Ryk í útbl.	#DIV/0!	kg/klst			**Meðaltal D**	#DIV/0!	#DIV/0!	
Mæling B:	3				**Vatnsinnih.**	**Loftmagn**	**Rúmmáls%**	**g/kg, g/Nm3**
Loftmagn	2,83822	m3	3430,024	3432,95	38,1	8,19	0,58	3,60
	2,718	Nm3						4,65
Tími	63	mín	**Hittni**					
Flæði	2,59	Nm3/klst	1,06					
Ryk í síu	0,0000	g						
Ryk í lofti	0,00	mg/Nm3						
Ryk í útbl.	0,00	kg/klst						
Meðaltal	0,17	mg/Nm3						
	0,27	kg/klst						

Keldnaholti, 112 Reykjavík
Sími 522 9000 – Fax 522 9111 – www.nmi.is