



UMC Utrecht



HART LONG CENTRUM UTRECHT

Nederlands Kenniscentrum Arbeid en Longaandoeningen

A cross-sectional study of exposures, lung function and respiratory symptoms among **aluminium cast-house workers**

NKAL

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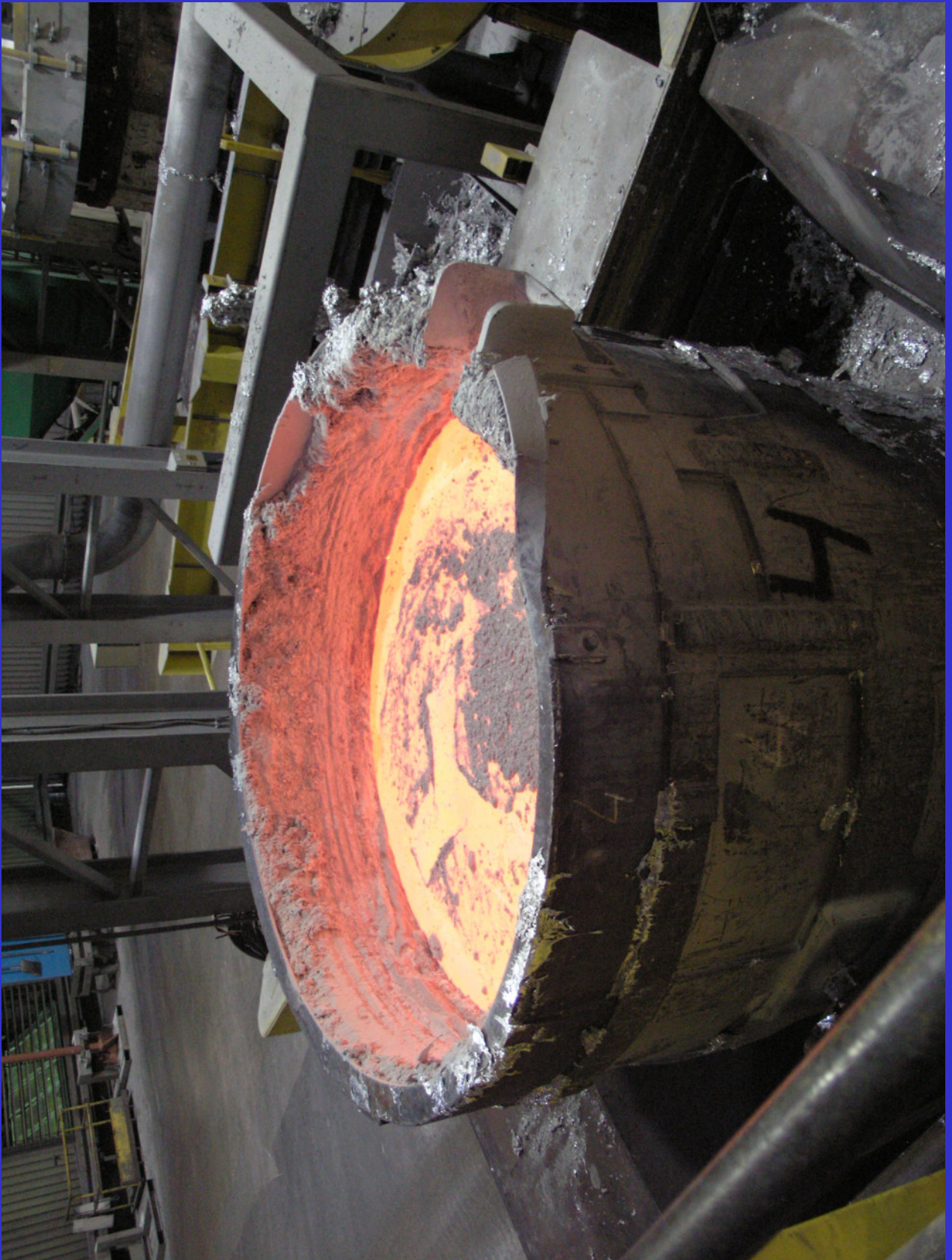
Institute for Risk Assessment Sciences





Aluminium casthouse study

- Respiratory health problems known in aluminum industry in potrooms (potroom asthma), not in casthouse area
- About half of the casthouse workers (N≈150) experienced respiratory symptoms
- Company and/or occupational health service asked 'NKAL' for help
- Pre-study: exploration of all information available including medical files
- Study objectives:
 - Study and objectivate respiratory symptoms
 - Exploration of exposures within the cast-house
 - Relationship between exposures and health outcomes











Production process

Selection of short video images

Adding magnesium

cd-rom

Mixing in oven

Slag scraping and filling oven





Methods

- Exposures:
 - 2nd part presentation
- Health survey among 157 aluminium cast-house workers (response 86%)
 - Questionnaire
 - Spirometry
 - Serology & eosinophil count
 - Non-specific bronchial hyperresponsiveness testing
 - Medical interviews (sub-population)
- Cast-house workers compared to general population sample (EHRCS population)



Lung function (cast-house vs general pop.)

Table 3b Multiple linear regression analysis of pulmonary function variables on age, standing height, smoking in a population of Al workers*

Determinant	FEV ₁ (ml)		FVC (ml)		PEF (ml/s)		FEV ₁ /FVC %	
	β	SE	β	SE	β	SE	β	SE
Intercept	-3329	498	-6223	535	-2849	1578	111	6
Age	-38 [†]	2	-33 [†]	2	-64 [†]	6	-0.26 [†]	0.03
Height	5204 [†]	262	7290 [†]	281	9263 [†]	830	-11 [†]	3
Smoking status (%) [§]								
Current smoker	-236 [†]	48	-124 [†]	51	-424 [†]	151	-2.66 [†]	0.62
Former smoker	-31	50	-42	53	209	158	0.12	0.65
Workers	-195[†]	56	-142[†]	60	-155	178	-1.26 [‡]	0.73
Adjusted R ² (%)	51		54		24		11	

Definition of abbreviation: SE = standard error.

* n = 138, Caucasian males only, age between 30 and 65.

[†] p<0.05; [‡] p<0.10.

[§] Never smoked as reference group.

^{||} General population as reference group, n = 972, Caucasian males only, age between 30 and 65.



Questionnaire (cast-house vs general pop.)

Table 2 Adjusted Prevalence Ratios (PR) with 95% confidence interval (CI) of respiratory symptoms in Al workers and a general Dutch population sample of the European Community Respiratory Health Survey.

	<i>Comparison with external reference population*</i>		
	<i>Aluminium cast-house workers</i>	<i>General population</i>	
	n = 144	n = 1000	
	n (%)	%	PR (95% CI)
<i>Trouble with breathing</i>			
Ever	53 (36.8)	18.9	1.9 (1.5-2.5) [‡]
Continuously	9 (6.3)	2.7	2.5 (1.2-5.3) [‡]
Repeatedly	18 (12.5)	6.9	1.8 (1.1-3.0) [‡]
<i>Cough symptoms</i>			
Daily cough	22/55 (40)	14.7	
Daily cough with phlegm	18/51 (35.3)	11.2	
<i>Shortness of breath (SOB) and wheezing</i>			
Exercise induced SOB	46 (31.9)	19.4	1.7 (1.3-2.3) [‡]
Awakened due to SOB	11 (7.6)	6.1	1.4 (0.7-2.6)
Wheezing	47 (32.6)	24.1	1.4 (1.1-1.8) [‡]
Wheezing with SOB	37 (25.7)	14.6	1.8 (1.3-2.5) [‡]
Awakened due to chest tightness	20 (13.9)	12.4	1.2 (0.8-1.8)
<i>Asthma</i>			
Asthma attack (ever)	20 (13.9)	5.2	2.8 (1.7-4.6) [‡]
Asthma attack, doctor diagnosed	17 (11.8)	4.8	2.6 (1.5-4.4) [‡]

* Caucasian males only, age between 30 and 65.

[‡]p < 0.05; adjusted for age and smoking habits (categorical: never-, ex-, or current smoker)



Work-related symptoms cast-house workers

- 75/151 (50%) work-related upper & lower airway symptoms
 - 93% self report improvement on non-working days (40% of total study population)
- 14 (19%) workers changed jobs due to symptoms
 - 10 (71%) reported having asthma attacks (ever)
 - Detailed physician administered interviews
 - 5/14 report start of symptoms after exposure incident (3x chlorine)
 - 9/14 were treated by pulmonologist (8) or general physician (1) for asthma (others 5/14: COPD or no clear diagnosis)
 - 7/9 told they had no asthma symptoms at starting work in cast-house

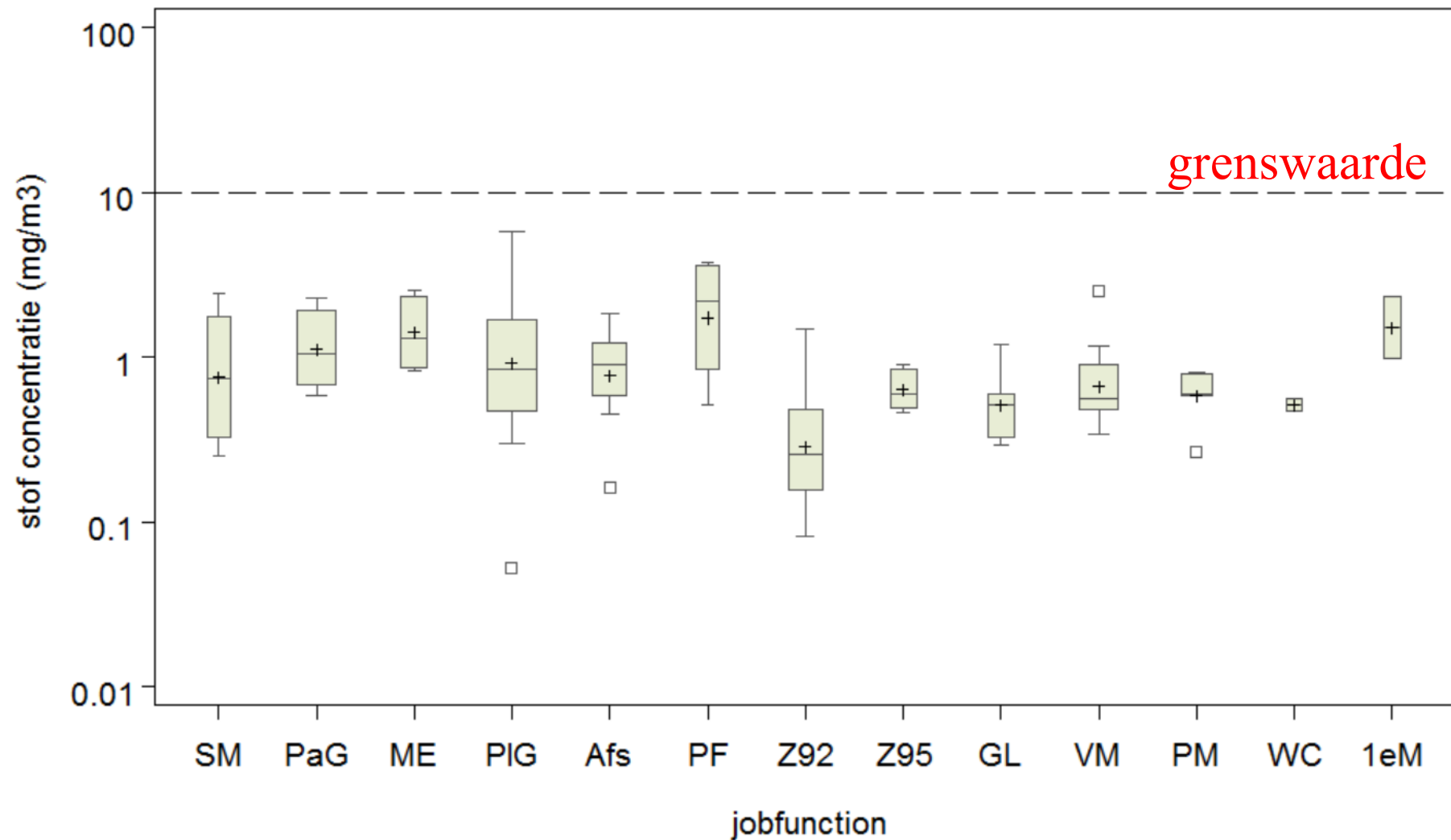


Methods

- **Exposures:**
 - Inhalable dust
 - Metals
 - Fluorides (exposure and urine)
 - Chlorine gas
 - Sulphur dioxide
- **Health survey among 157 aluminium cast-house workers (response 86%)**
 - Questionnaire
 - Spirometry
 - Serology & eosinophil count
 - Non-specific bronchial hyperresponsiveness testing
 - Medical interviews (sub-population)

Inhalable dust exposure (8-hr TWA; N=88)

boxplot stofblootstelling per functie





Metals in dust

Sedimentation dust (N=2) & personal dust sample (N=1)

<u>Metaal</u>	<u>Percentage metal in dust samples</u>
Aluminium	47 - 90 %
Beryllium	< det - < 0,001 %
Boron	< 0,1 – 1,1 %
Chromium	< 0,1 – 0,3 %
Iron	15,2 – 18,3 %
Copper	< 0,1 – 0,4 %
Magnesium	1,7 – 14,4 %
Manganese	0,2 – 2,7 %
Sodium	1,1 – 15,4 %
Selenium	< 0,1 – 0,1 %
Titanium	< det – 0,2 %
Zinc	1,3 %
Zirkonium	< det - < 0,1 %



Exposure

- Real-time monitoring (QRAE with specific sensors):
 - Sulphur dioxide: no relevant signal
 - Chlorine gas:
 - Regular background exposure: 0 – 0.4 ppm
 - During leakage chlorine duct: 30 ppm
 - Taking sample: 3-4 ppm
 - STEL chlorine gas: 1.4 ppm
- Urine samples fluorides on two days (pre- and post shift; N=55)
 - Systematic but small increase over work-shift (including some controls)
 - Low compared to BEI (USA: ACGIH) & BAT (German)

Fluoride exposure (MDHS 35/2)

Datum	Shift	Functie tijdens de meting	Extra functie info	Ademhalingsbescherming gedragen tijdens de metingen	Meetduur (min)	Stofconcentratie (mg/m ³)	Concentratie fluor gasvormig (mg/m ³)	Concentratie fluor deeltjes (mg/m ³)	Concentratie fluor totaal (mg/m ³)	aandeel gasvormig van totaal fluoride
Persoonlijk full-shift										
21-Oct-08	Ochtend	Plakkengieter	put 51, sidafil steken circa 10 min.	Nee	437	0,706	< lod	0,025	0,025	
21-Oct-08	Ochtend	Metaalrijder E-hal	afzuiging defect in electrolysehal	Nee	413	1,076	0,148	0,112	0,261	56,9%
21-Oct-08	Ochtend	Pannenman		Nee	391	0,599	0,097	0,056	0,153	63,3%
22-Oct-08	Ochtend	sectie electrolyse		Ja	334	0,628	0,039	0,034	0,073	52,8%
22-Oct-08	Ochtend	Plakkengieter	put 52	Nee	453	2,176	< lod	0,051	0,051	
22-Oct-08	Ochtend	Plakkengieter	put 51	nee	445	0,808	< lod	0,021	0,021	
Stationair full-shift										
21-Oct-08	Dag	Oven 19			384	0,414	0,049	0,029	0,079	62,7%
21-Oct-08	Dag	Oven 13			390	0,564	0,067	0,024	0,091	73,9%
21-Oct-08	Dag	Oven 17			385	0,404	0,167	0,036	0,203	82,1%
22-Oct-08	Dag	Bovenop de kraan			362	11,772	8,017	3,088	11,105	72,2%
22-Oct-08	Dag	TAC			390	0,534	0,190	0,040	0,230	82,5%
22-Oct-08	Dag	oven 19			390	0,720	0,033	0,030	0,063	53,1%

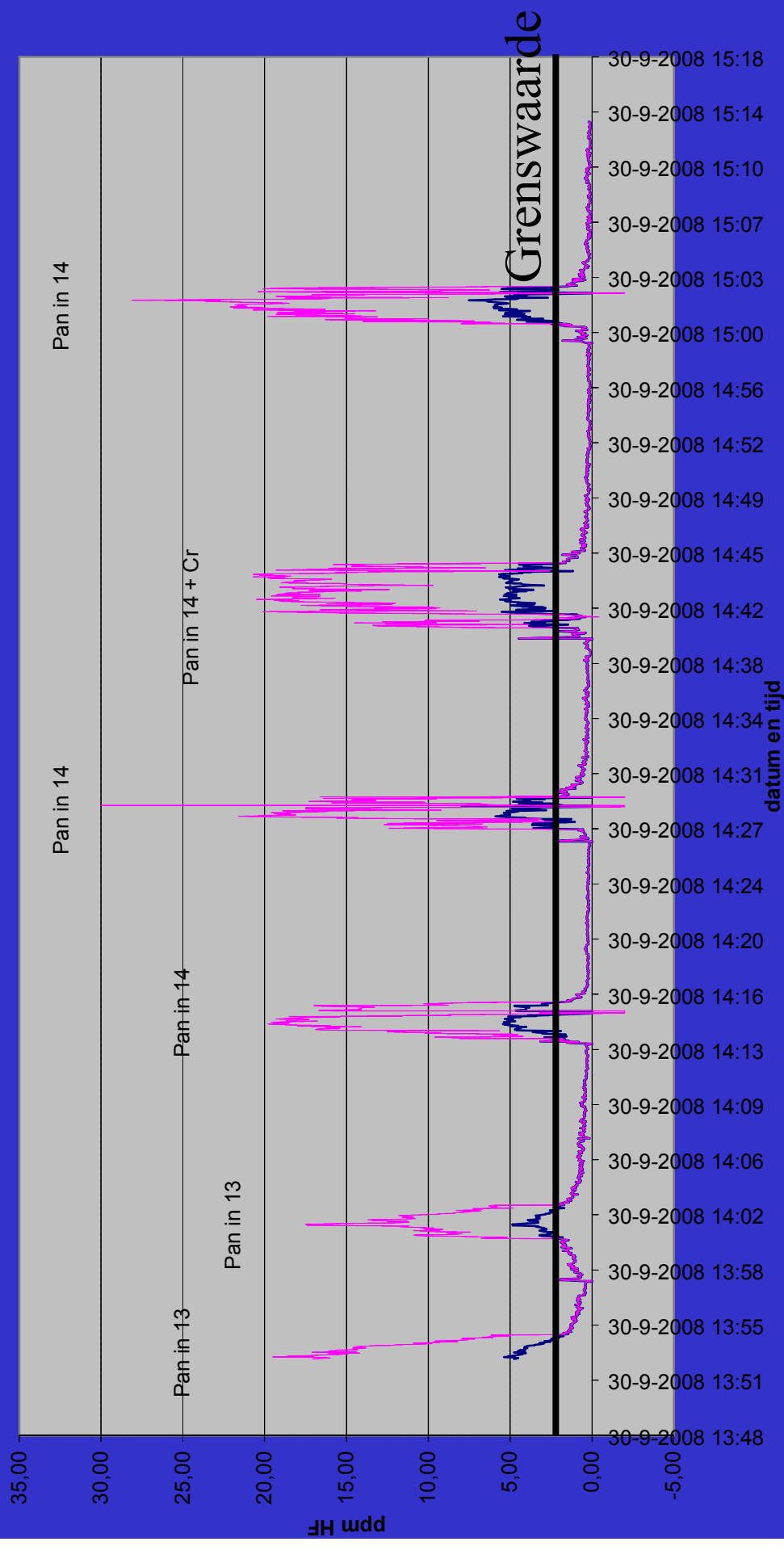
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Grenswaarden: HF: 15-TGG: 1 mg/m³ of 1,5 ppm; 8hr-TGG: 1,5 mg/m³ of 1,8 ppm

Real-time HF monitoring above ovens

(Gasfinder; Tunable Diode Laser technology)

HF-emissie boven mengoven 13 en 14
30 september 2008



N.B. Same peaks if no smoke is seen above the pots



Production process

- Selection of short video images
 - Empty pot in melting oven
 - (cd-rom I; 23.00)



Lung function vs irritant exposure (cast-house workers only)

Table 4a Personal characteristics and lung function test results adjusted for smoking status of cast-house workers* exposed to irritants..

	<i>Exposure high</i>	<i>Exposure moderate</i>	<i>Exposure low</i> <i>(internal reference group)</i>
n	43	43	53
Age - yr (sd)	44 (9.1)	45 (10.2)	48 (7.4)
Smoking status (%)			
Current smoker	58.1	51.2	43.4
Former smoker	30.2	25.6	30.2
Never smoked	11.6	23.3	26.4
FEV ₁ % pred (sd)	104.3 (13.8)	102.2 (14.8)	101.3 (13.8)
FVC % pred (sd)	108.2 (11.6)	108.5 (13.5)	107.3 (12.6)
PEF % pred (sd)	117.5 (21.3)	111.1 (18.7)	115.2 (20.0)
FEV ₁ /FVC % (sd)	78.2 (5.9)	76.6 (8.2)	76.1 (6.7)
[†] Airway obstruction	1 (2.3)	3(7.0)	2(3.8)

*n = 139, Caucasian males only

[†]Airway obstruction¹ (FEV₁/FVC ≤ 70% and FEV₁ <80% pred)



Résumé

Exposur

1. High (s_{mi})p_{rman}nt _{mission} of HF & fluorid_s in cast-hous_□
2. Incid_{nt}(s) with high chlorin_□ p_{ak} _{xposur}_s
3. Low daily av_{rag} _{xposur}_s (inhalabl_□ dust & fluorid_s)

H_□alth _{ff}cts

1. Many cast-hous_□ work_{rs} r_{port} r_{spiratory} symptoms
2. 40% of work_{rs} work-r_{lat}d symptoms with improv_{ment} on non-working days
3. Compar_d with g_nral population significantly
 - a) Mor_rspiratory symptoms
 - b) Low_r spirom_{tric} valu_s
4. Majority of cast-hous_□ work_{rs} with job chang_□ du_□ to symptoms r_{port}d asthma attacks
5. No cl_{ar} _{xposur}_□-r_{spons}_□-r_{lat}ionship



Discussion / Conclusion

- Low daily average exposures: dilution by natural ventilation on most days
- High emissions of HF/fluorides during day
- Many disturbances of optimal airflow: peak exposures likely
- Several (historic) incidents with chlorine
- Regular exposure to respiratory irritants is very likely to happen
- Type of respiratory effects can be explained by irritant exposure
- Study supports respiratory hazards of cast-house workers
- Peak exposures likely explain respiratory health effects
- Preventive measures should be taken
 - Focus on peak-exposures to respiratory irritants
- Health surveillance should be offered to the workers



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