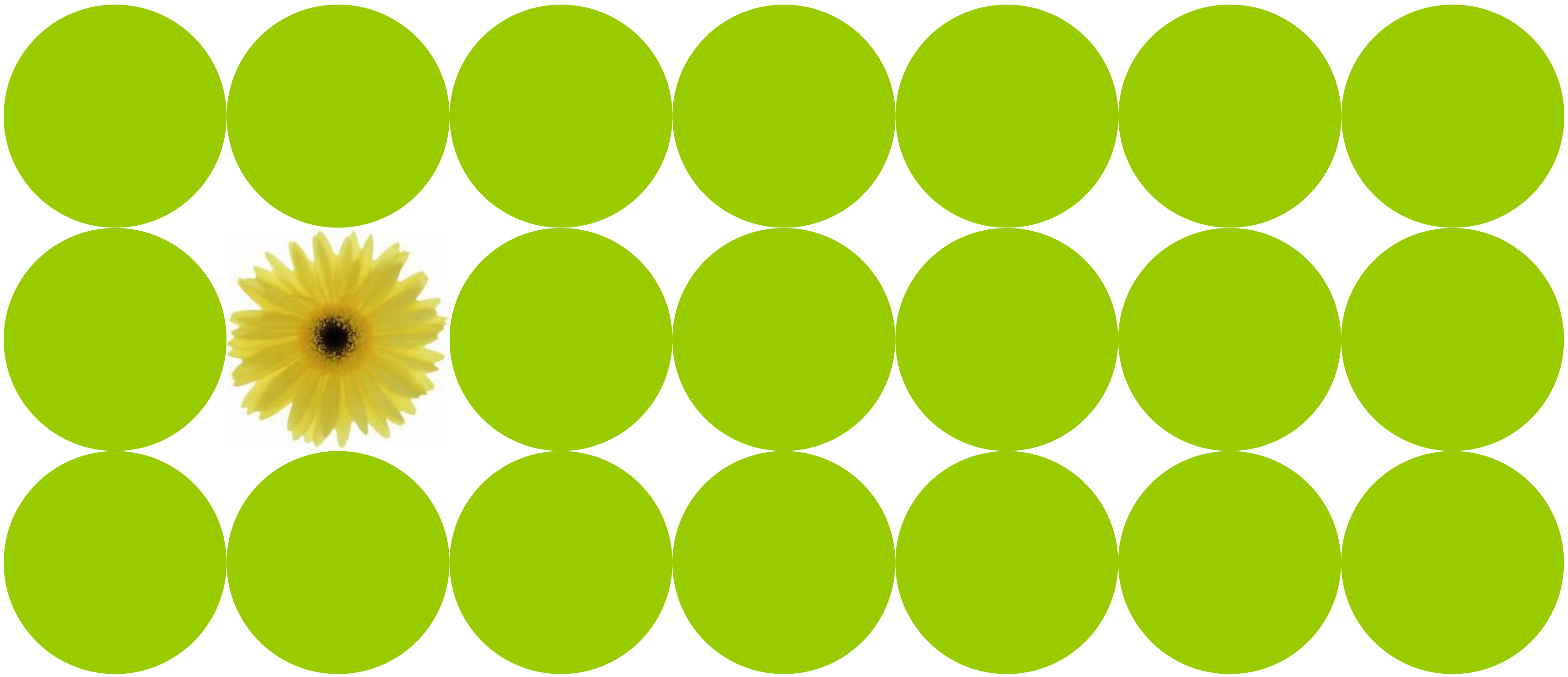
Emissions from Su3 and Su4 at Hydro Sunndal



Bjørn Moxnes, Linda Aaram, Knut Solbu and Halvor Kvande

February 2009

Potlines at Hydro Sunndalsøra Norway

Søderberg line

- Started in 1954-1959, 264+36 cells operating at 86 kA
- Shut down in 2002

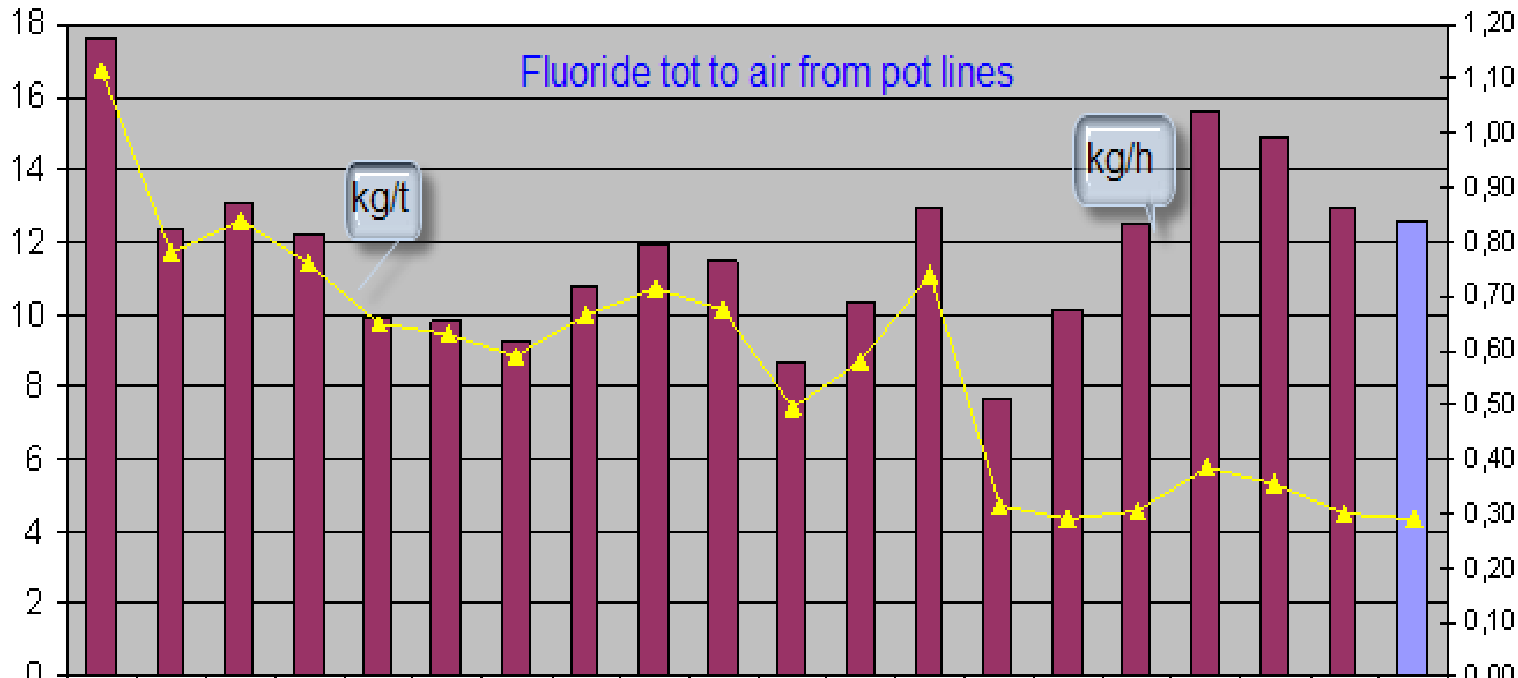
Su3

- Started in 1969, Alcan Technology, end-to-end cells
- Started at 135 kA and currently operating with point feeders at 202 kA

Su4

- Built in 2002, Hydro technology, side-by-side cells
- Started at 252 kA and currently operating at 302 kA
  - An upgraded version of this cell will be installed in Qatar

Total Fluoride Emission to Air 1990 - 2008



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Siste 12
Tot. ASU	17,6	12,4	13	12,2	9,87	9,81	9,21	10,8	11,9	11,5	8,73	10,4	12,9	7,68	10,2	12,6	15,6	14,9	12,9	
Siste 12																				12,6
F- utslipp pr tonn Al	1,12	0,78	0,84	0,76	0,65	0,63	0,59	0,67	0,71	0,67	0,49	0,58	0,74	0,31	0,29	0,3	0,38	0,35	0,3	0,29

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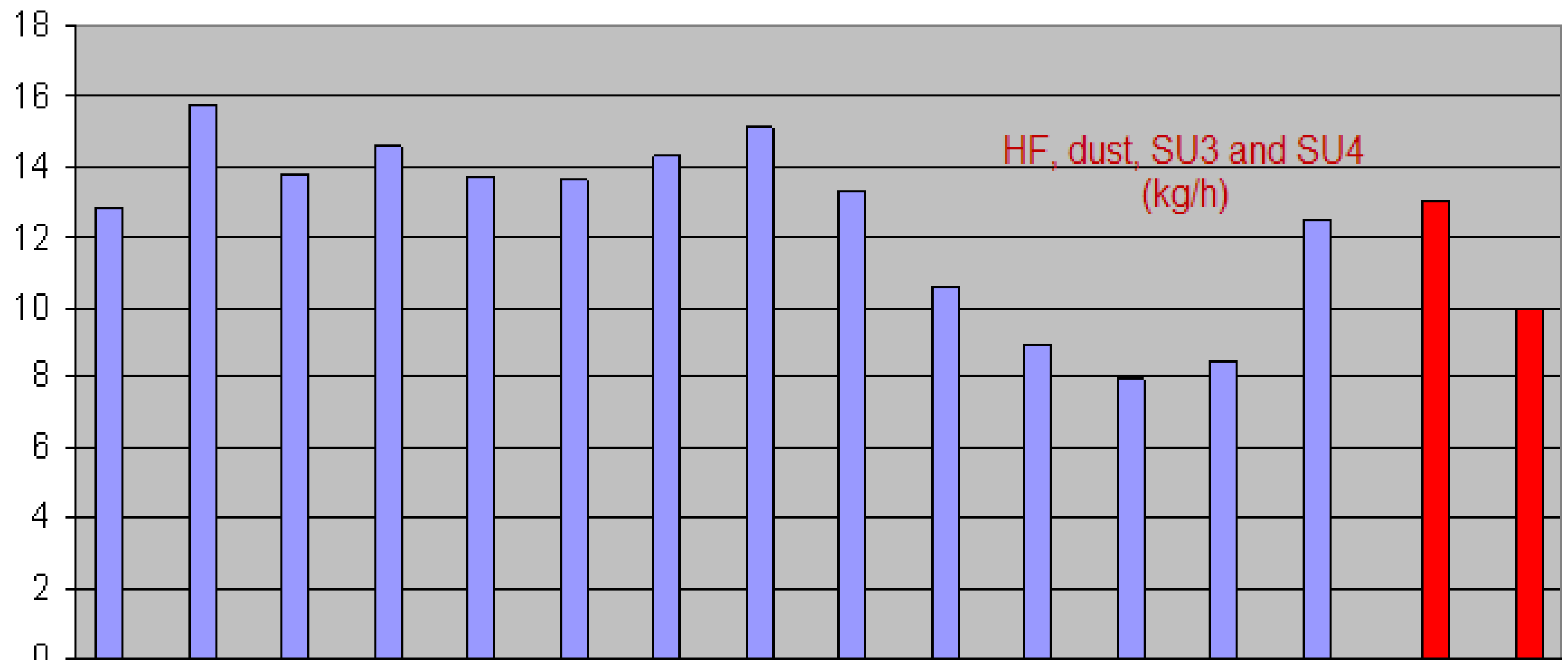
Total Fluoride Emission SU3 and SU4 2008 – 2009 (kg/h)



	Jan	Feb	Mar	Apr	Mai	Juni	Juli	Aug	Sep	Okt	Nov	Des	Jan	siste 12	SFT-krav mnd	SFT-krav år
El.lyse	12,765	15,79	13,735	14,597	13,685	13,611	14,247	15,103	13,319	10,582	8,916	7,961	8,506	12,504		
SFT-krav elektrolyse															13	10

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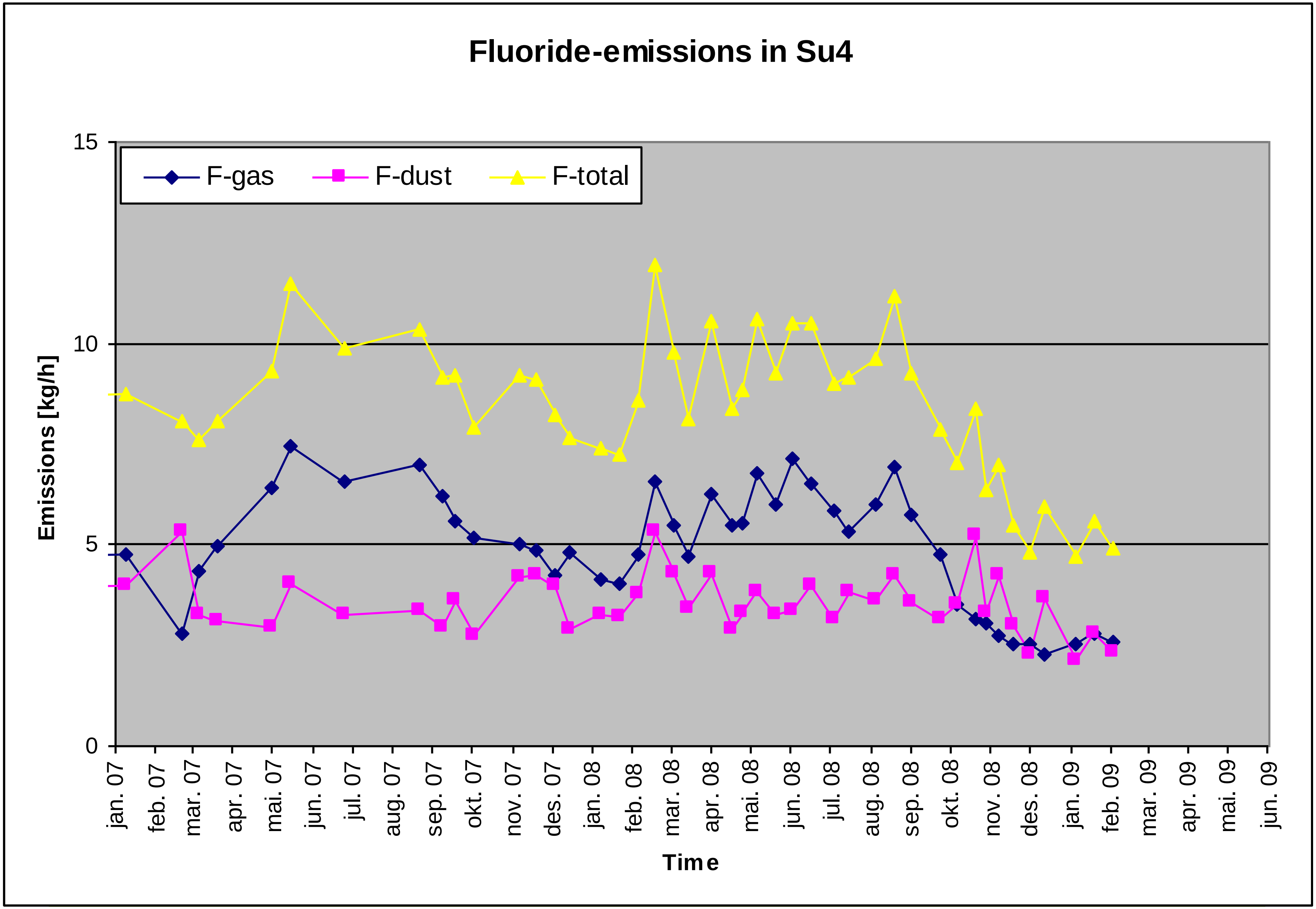
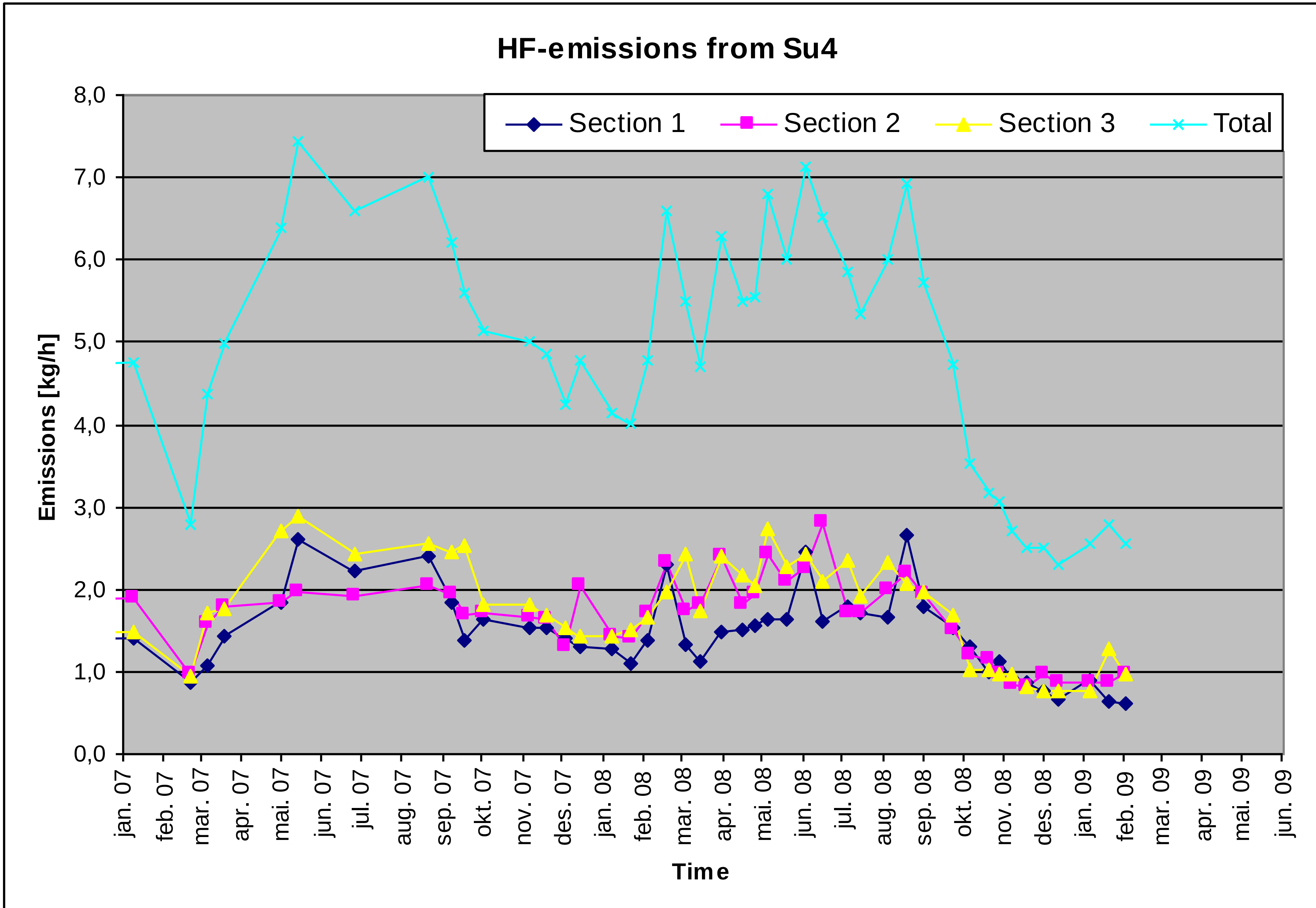


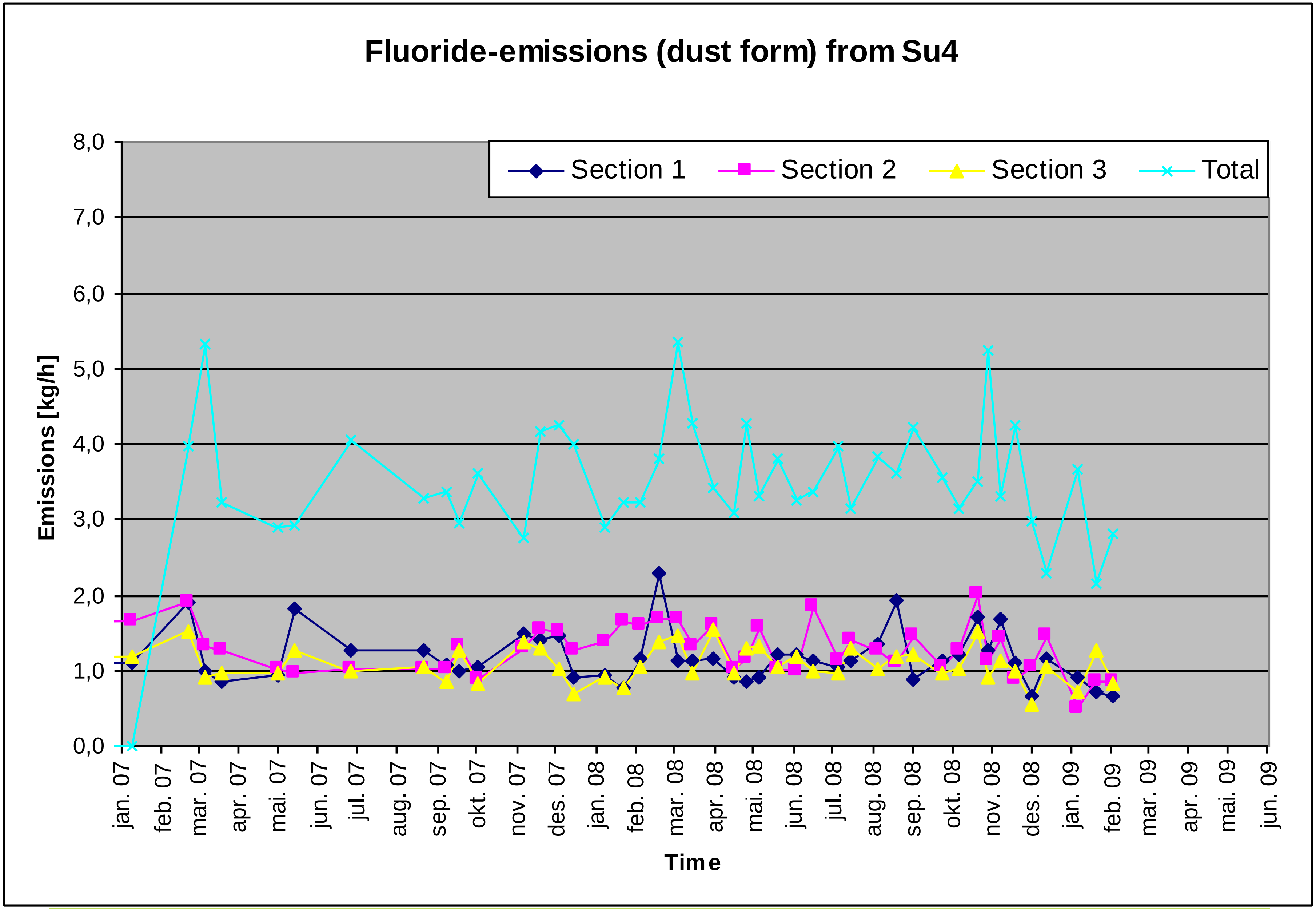
Fluoride-emissions in Su4
F-gas
F-dust
F-total
Emissions [kg/h]
15
10
5
0
jan. 07
feb. 07
mar. 07
apr. 07
mai. 07
jun. 07
jul. 07
aug. 07
sep. 07
okt. 07
nov. 07
des. 07
jan. 08
feb. 08
mar. 08
apr. 08
mai. 08
jun. 08
jul. 08
aug. 08
sep. 08
okt. 08
nov. 08
des. 08
jan. 09
feb. 09
mar. 09
apr. 09
mai. 09
jun. 09
Time

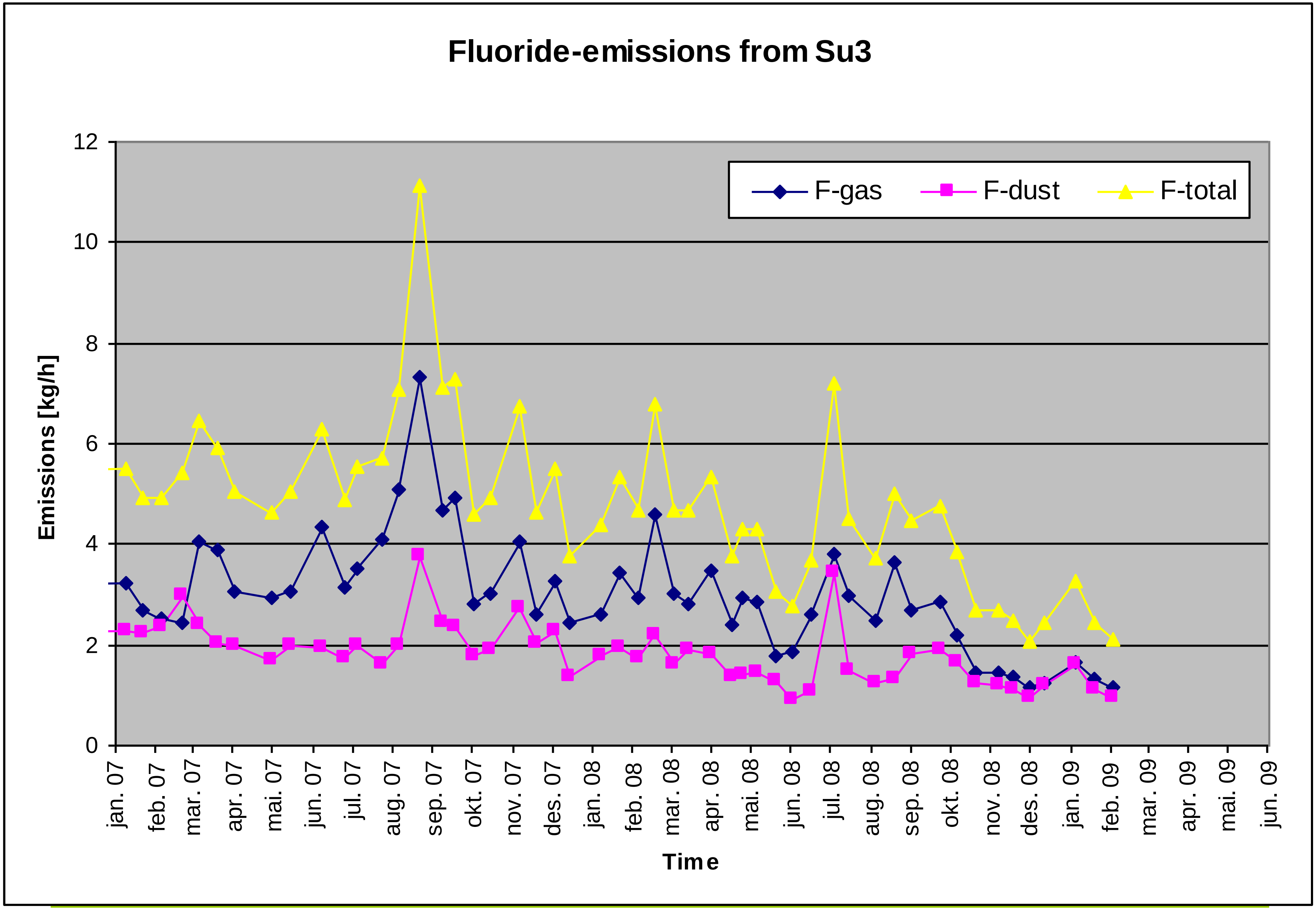
HYDRO



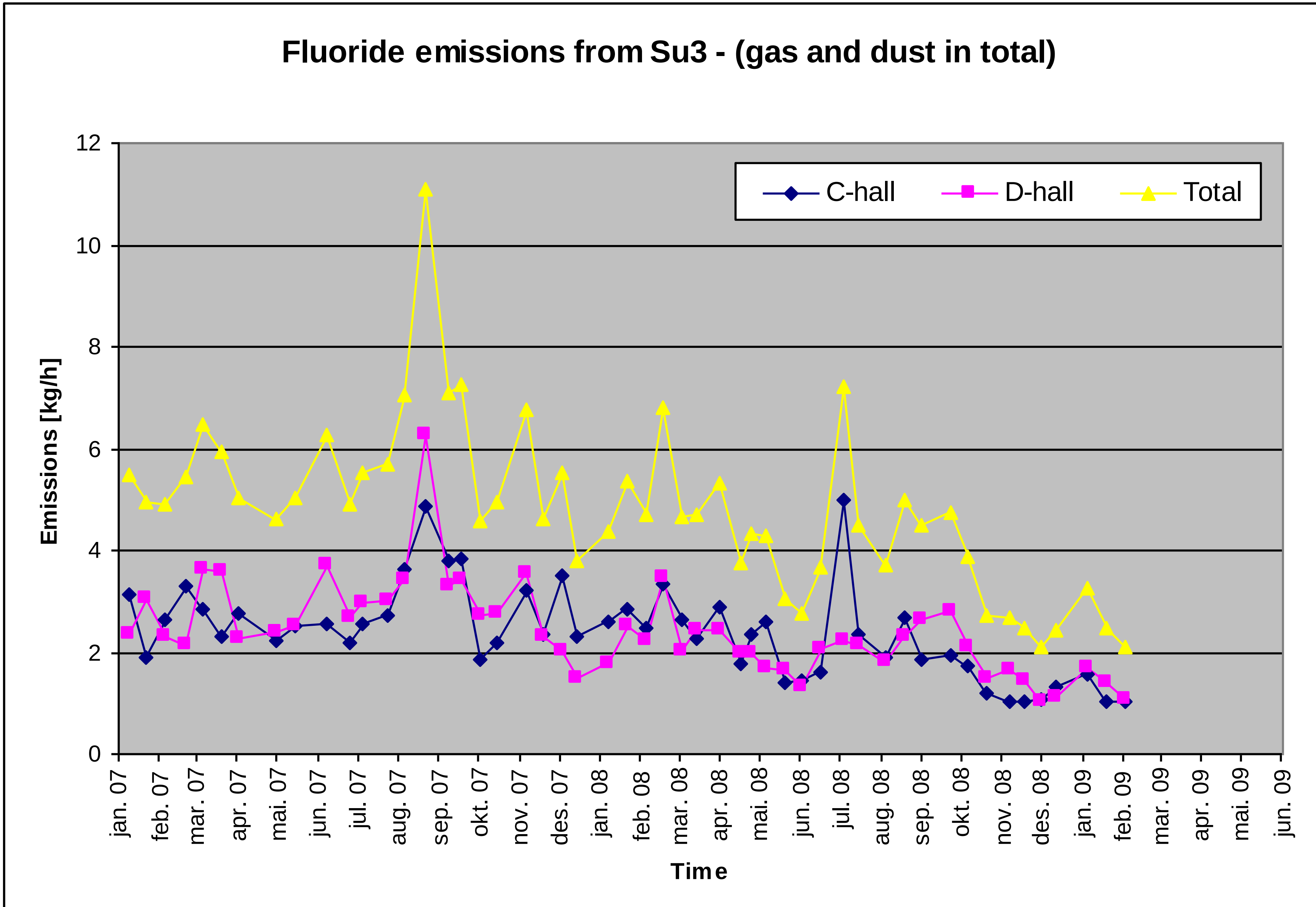
HF-emissions from Su4
Section 1
Section 2
Section 3
Total
Emissions [kg/h]
8,0
7,0
6,0
5,0
4,0
3,0
2,0
1,0
0,0
jan. 07
feb. 07
mar. 07
apr. 07
mai. 07
jun. 07
jul. 07
aug. 07
sep. 07
okt. 07
nov. 07
des. 07
jan. 08
feb. 08
mar. 08
apr. 08
mai. 08
jun. 08
jul. 08
aug. 08
sep. 08
okt. 08
nov. 08
des. 08
jan. 09
feb. 09
mar. 09
apr. 09
mai. 09
jun. 09
Time

HYDRO


Fluoride-emissions (dust form) from Su4
Section 1
Section 2
Section 3
Total
Emissions [kg/h]
8,0
7,0
6,0
5,0
4,0
3,0
2,0
1,0
0,0
jan. 07
feb. 07
mar. 07
apr. 07
mai. 07
jun. 07
jul. 07
aug. 07
sep. 07
okt. 07
nov. 07
des. 07
jan. 08
feb. 08
mar. 08
apr. 08
mai. 08
jun. 08
jul. 08
aug. 08
sep. 08
okt. 08
nov. 08
des. 08
jan. 09
feb. 09
mar. 09
apr. 09
mai. 09
jun. 09
Time



Fluoride-emissions from Su3
Emissions [kg/h]
12
10
8
6
4
2
0
F-gas
F-dust
F-total
jan. 07
feb. 07
mar. 07
apr. 07
mai. 07
jun. 07
jul. 07
aug. 07
sep. 07
okt. 07
nov. 07
des. 07
jan. 08
feb. 08
mar. 08
apr. 08
mai. 08
jun. 08
jul. 08
aug. 08
sep. 08
okt. 08
nov. 08
des. 08
jan. 09
feb. 09
mar. 09
apr. 09
mai. 09
jun. 09
Time


Fluoride emissions from Su3 - (gas and dust in total)
C-hall
D-hall
Total
Emissions [kg/h]
0
2
4
6
8
10
12
jan. 07
feb. 07
mar. 07
apr. 07
mai. 07
jun. 07
jul. 07
aug. 07
sep. 07
okt. 07
nov. 07
des. 07
jan. 08
feb. 08
mar. 08
apr. 08
mai. 08
jun. 08
jul. 08
aug. 08
sep. 08
okt. 08
nov. 08
des. 08
jan. 09
feb. 09
mar. 09
apr. 09
mai. 09
jun. 09
Time

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Main Actions to Lower Fluoride Emissions Autumn-Winter 2008 (1)

Upgrading of scrubbers to increase suction capacity.

- From 5500 to 6500 Nm3/h per cell in Su4
- From 5000 Nm3 to 7000 Nm3/h per cell in SUIII
- Forced suction in Su4 increased from 15000 to 18000 Nm3/h
  - Maximum two cells per 15 cell at forced suction at the same time
- Suction rate on environmental boxes is increased

Systematic mapping of status on suction canals, from the scrubbers to each cell, by measuring under pressure and air flow.

- Focus on high hooding efficiency on the cells.

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Main Actions to Lower Fluoride Emissions Autumn-Winter 2008 (2)

Balancing suction rate, to secure right amount of suction from each cell.

Cleaning and improving old suction channels in SU3.

Focus on operational routines giving fluoride emissions.

New preheat and start up procedures in Su4

- Coke preheat with no skimming of carbon dust

How to reduce Green House Gas Emissions?

How to Reduce Greenhouse Gas Emissions

1. **CO_2 - Reduce net anode consumption**
2. **PFC - Reduce the number of anode effect minutes per cell-day by:**
- **Reduce anode effect frequency**
- **Reduce anode effect duration**

Green House Gas Emissions

Greenhouse gas emissions from aluminium electrolysis cells:

CO_2 from electrolysis:

$$2\ Al_2O_3\,(dissolved) + 3\ C\ (s) = 4\ Al\ (l) + 3\ CO_2\,(g)$$

(Global Warming Potential, GWP = 1)

PFCs:

CF_4 from anode effects (GWP = 6500)

C_2F_6 from anode effects (GWP = 9200)

(C_2F_6 is typically 5 to 12 % of the amount of CF_4)

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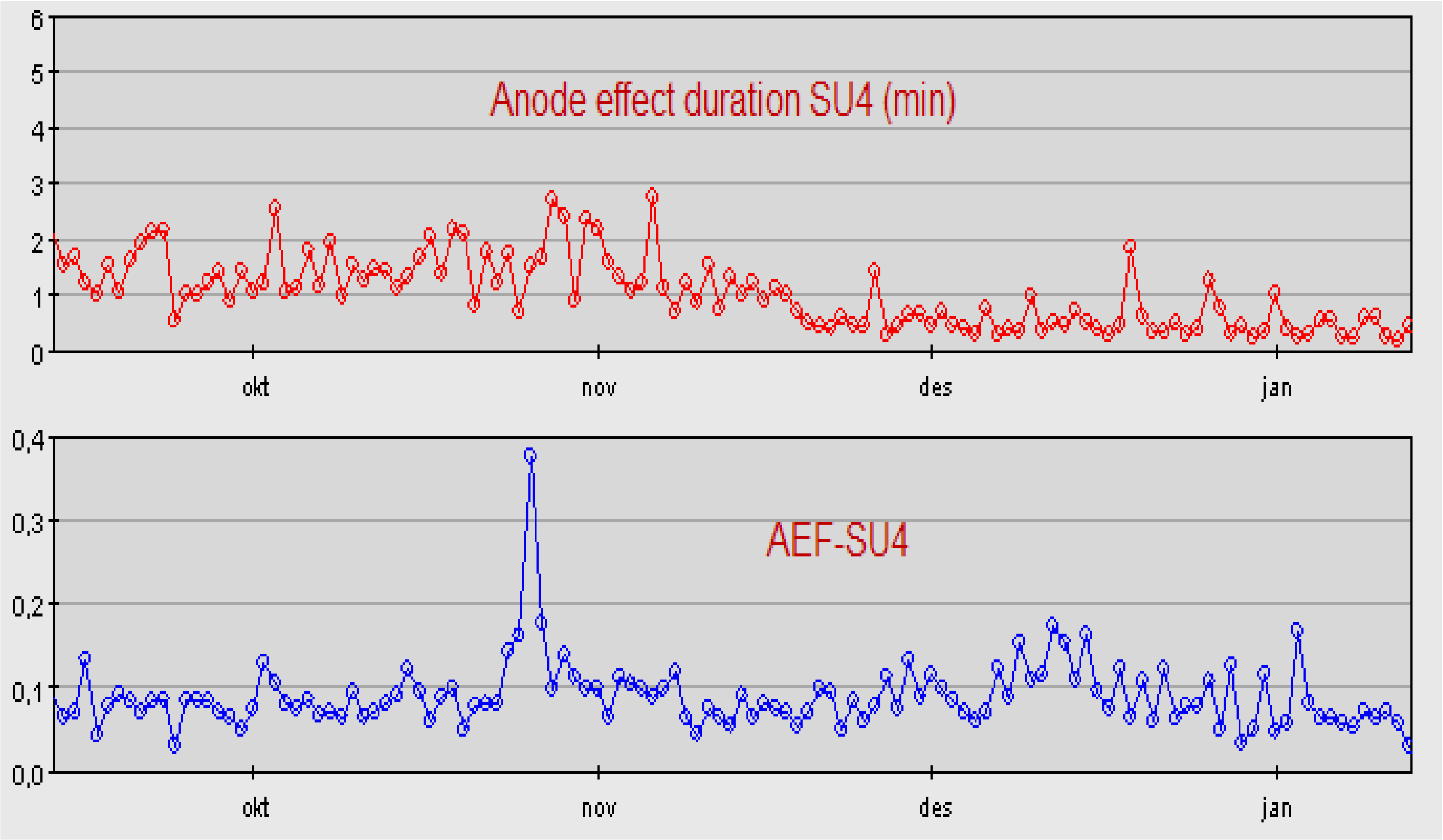
CF4 and C2F6 Emissions From Su4 (daily average figures)



Automatic Anode effect Quenching

An effective strategy has the following objectives:

a. Minimize the energy input to the cell.

b. Avoid extensive anode movement.

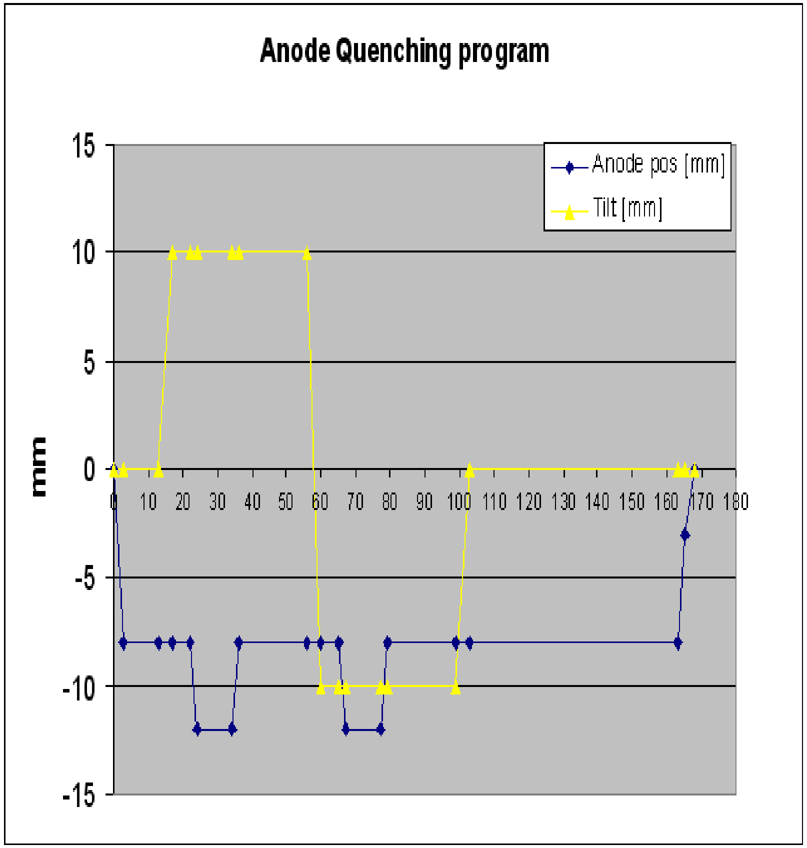
c. Optimize alumina addition.

The results from a successful strategy are:

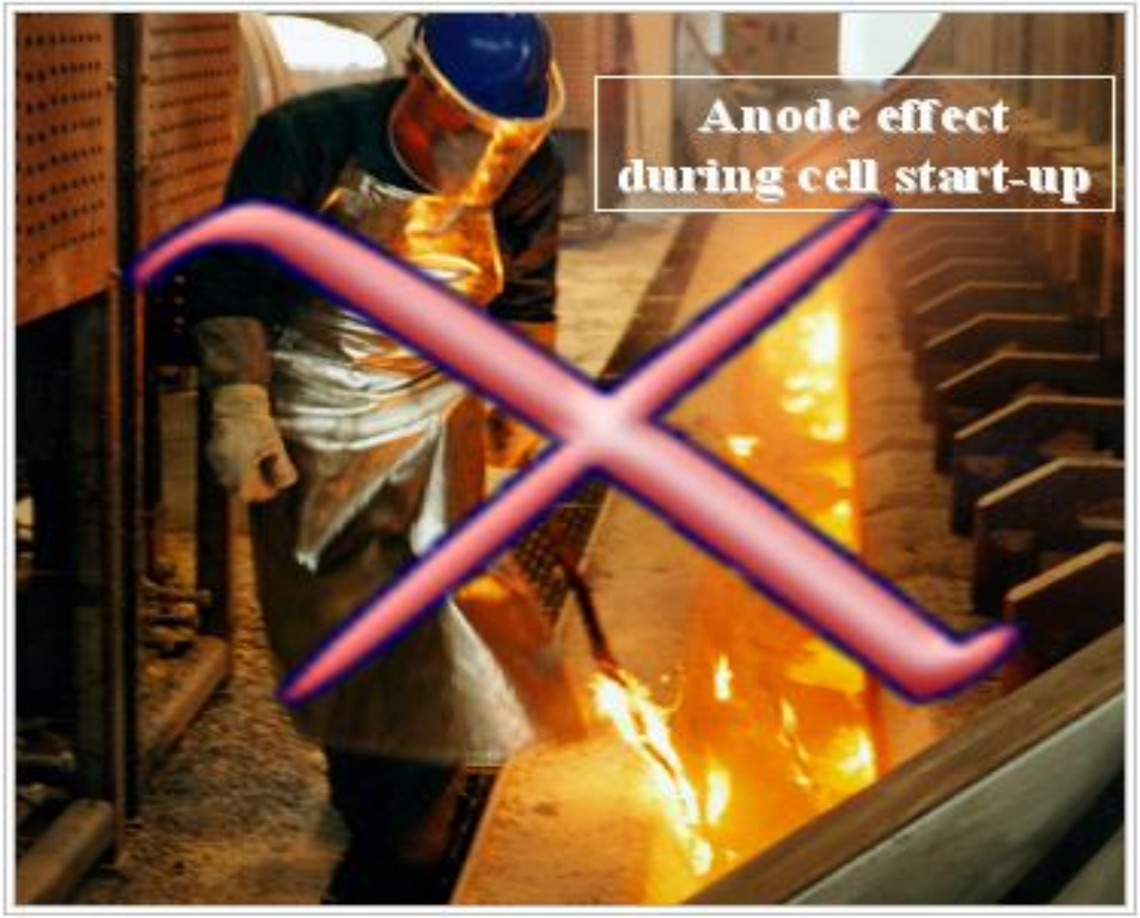
High percentage of successful quenching. (70-90%)

Short recovery time after anode effect. (0-1h)

Low anode effect duration. (<45 s)



Anode Effect During Start Up



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Anode Effect During Start Up

Net Anode Consumption

Net Anode Consumption

- **What is the theoretical (electrolytic) anode consumption?**
  The reaction: $2\ Al_2O_3 + 3C = 4\ Al + 3\ CO_2$ gives 333 kg C/t Al

- **What is the extra contribution from current efficiency (CE)?**
  The back reaction is: $2\ Al + 3\ CO_2 = Al_2O_3 + 3CO$
  The net anode consumption then is: 333/(100/%CE) (kg/t Al)
  Thus, 95% CE gives 351 kg C/t Al, while 90% CE gives 370 kg C/t Al

- **What is the excess (non-electrolytic) anode consumption?**

1. **Reaction of carbon with O_2 at the exposed anode top surface (airburn)**
   This gives a loss of 30 – 70 kg C/t Al
2. **Reaction of carbon with CO_2 in the exposed burn area at the bottom (carboxy attack: $CO_2 + C = 2\ CO$)**
   This gives a loss of 20 – 30 kg C/t Al

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Calculating CO2 emission from Net Anode Consumption

Calculation of Carbon Dioxide Emissions from Prebake Anode Consumption During Electrolysis

$$E_{CO_2} = \left[MP \times NAC \times \left(\frac{100 - S_a - Ash_a}{100} \right) \right] \times 44/12$$

E_{CO_2} = CO_2 emissions in tonnes per year

MP = Total metal production, tonnes aluminium per year
NAC = Net anode consumption, tonnes per tonne aluminium
S_a = Sulphur content in baked anodes, wt%
Ash_a = Ash content in baked anodes, wt%
44/12 = CO_2 **Molecular Mass : Carbon Atomic Mass Ratio, dimensionless**

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Physical Spesification on Anode Quality

Physical properties:

Function	Unit	Lot average	Accepted deviation in lot	Method
Equivalent temperature		≥1230		ISO 17499
Dust by CO_2 oxidation		≤3.0		TOS Årdal
Baked bulk density		≥1.59		ISO 12985-1
Specific electric resistance		≤53.0		ISO 11713
Air oxidation reactivity		≤30.0		TOS Årdal
Permeability		≤0.5		- - - - - - - -
Thermal conductivity		<3.0, 4.2>		ISO 12987
Thermal expansion coefficient		≤4.2		ISO 14420
Flexural strength		≥12.0		ISO 12986-1
Compressive strength		≥35		ISO 18515

(Functions/properties are "ranked", i.e. those at the top are considered more important with respect to operational performance in the electrolysis than those close to the bottom.)

Conclusion

Over the last year for the Hydro Sunndalsøra plant:

The total fluoride emission from the two lines has been reduced significantly by increasing the dry scrubber capacity and improving the operational routines

- Targeting 0.2 kg Ftot per tonne aluminium in 2009

The PFC emissions has been reduced by approximately 70 - 80 % by implementing an effective automatic anode effect quenching program and start-ups without anode effects

The net anode consumption has been improved by implementing anode quality with reduced carboxy and air reactivity

Thank you for your attention