Excess AlF_3 Concentration in Bath Control Logic

Dr Marc Dupuis

GENISIM

Plan of the Presentation

- AlF_3 mass balance
- AlF_3 deposit
- Control logic based on bath sampling
- Control logic based on bath temperature measurement
- Control logic based on both bath sampling and bath temperature measurement
- Conclusions

AlF_3 Mass Balance

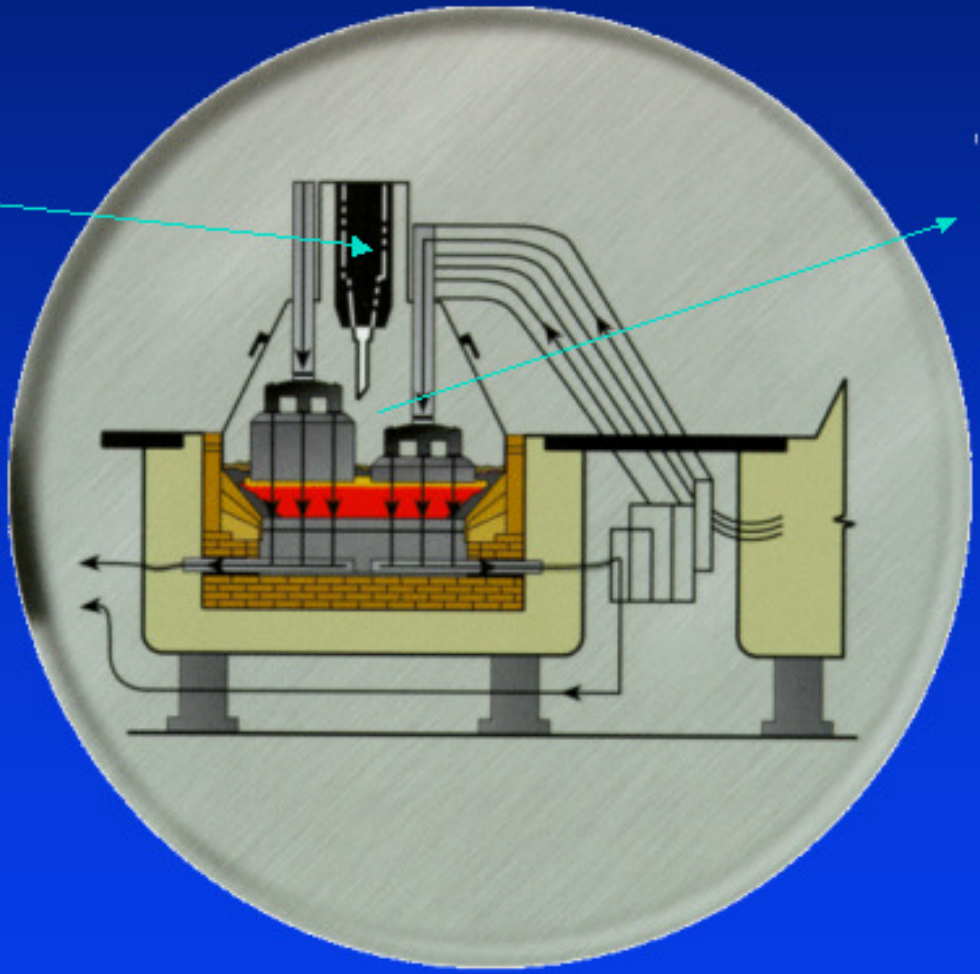
In:

Alumina

$$\frac{2}{102} \times 175.9 = 3.45 \frac{kg}{hr} AlF_3$$

Direct feeding

$$1.19 \frac{kg}{hr} AlF_3$$



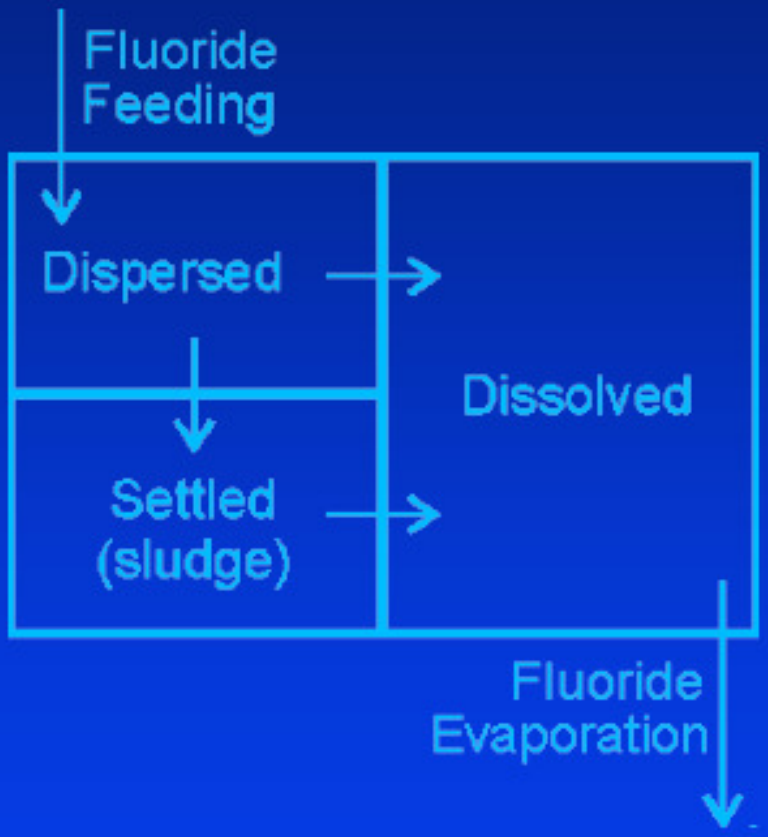
Out:

AlF_3 evolution

$$33.8 \times \frac{93.13}{1000} \times \frac{84}{57} = 4.64 \frac{kg}{hr} AlF_3$$

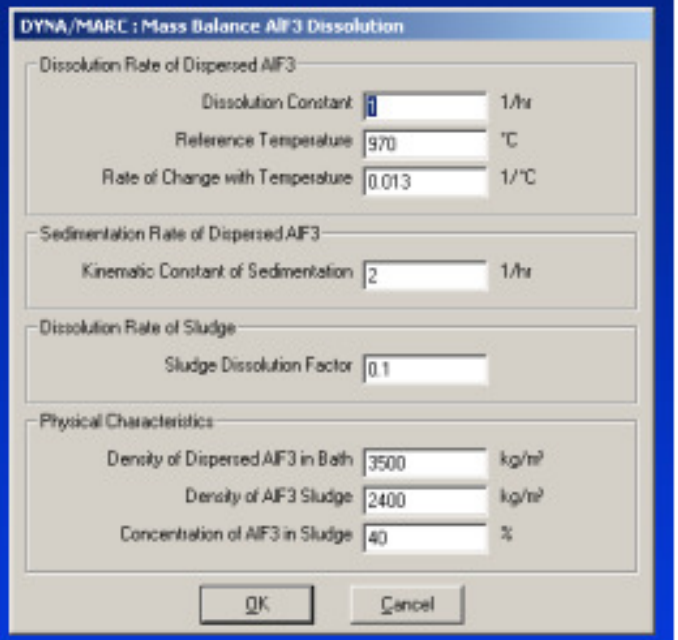
GENISIM

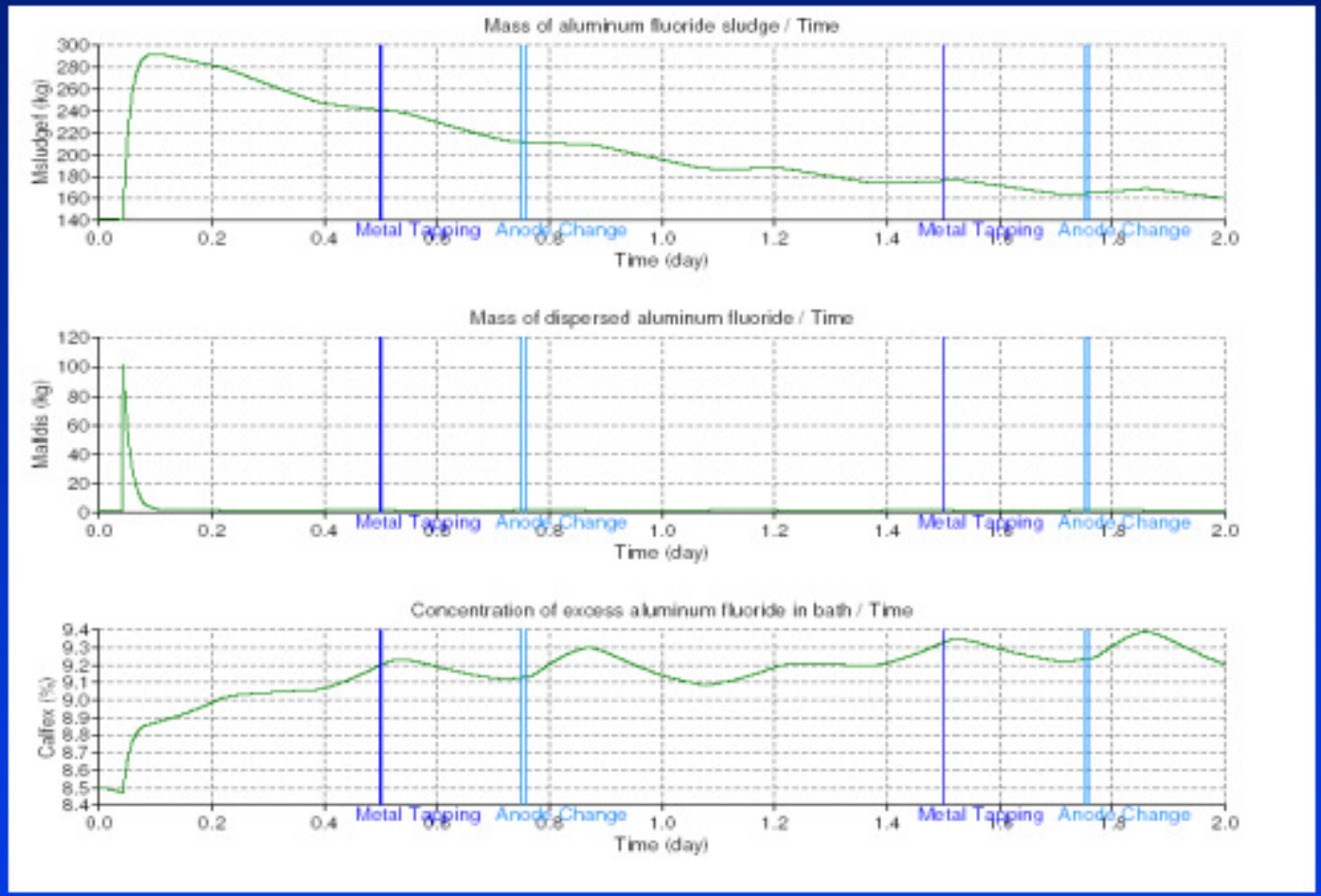
AlF_3 Deposit



The observed time lag between the time of the direct AlF3 addition and its impact on the excess AlF3 concentration in the bath is explained by a form of AlF3 "deposit". If we assume that AlF3, like alumina, when added to the cell forms first a dispersed phase in the bath before dissolving, it is also normal to assume that that dispersed phase can also, like alumina, settle down as sludge on the cathode surface.

AlF_3 Deposit

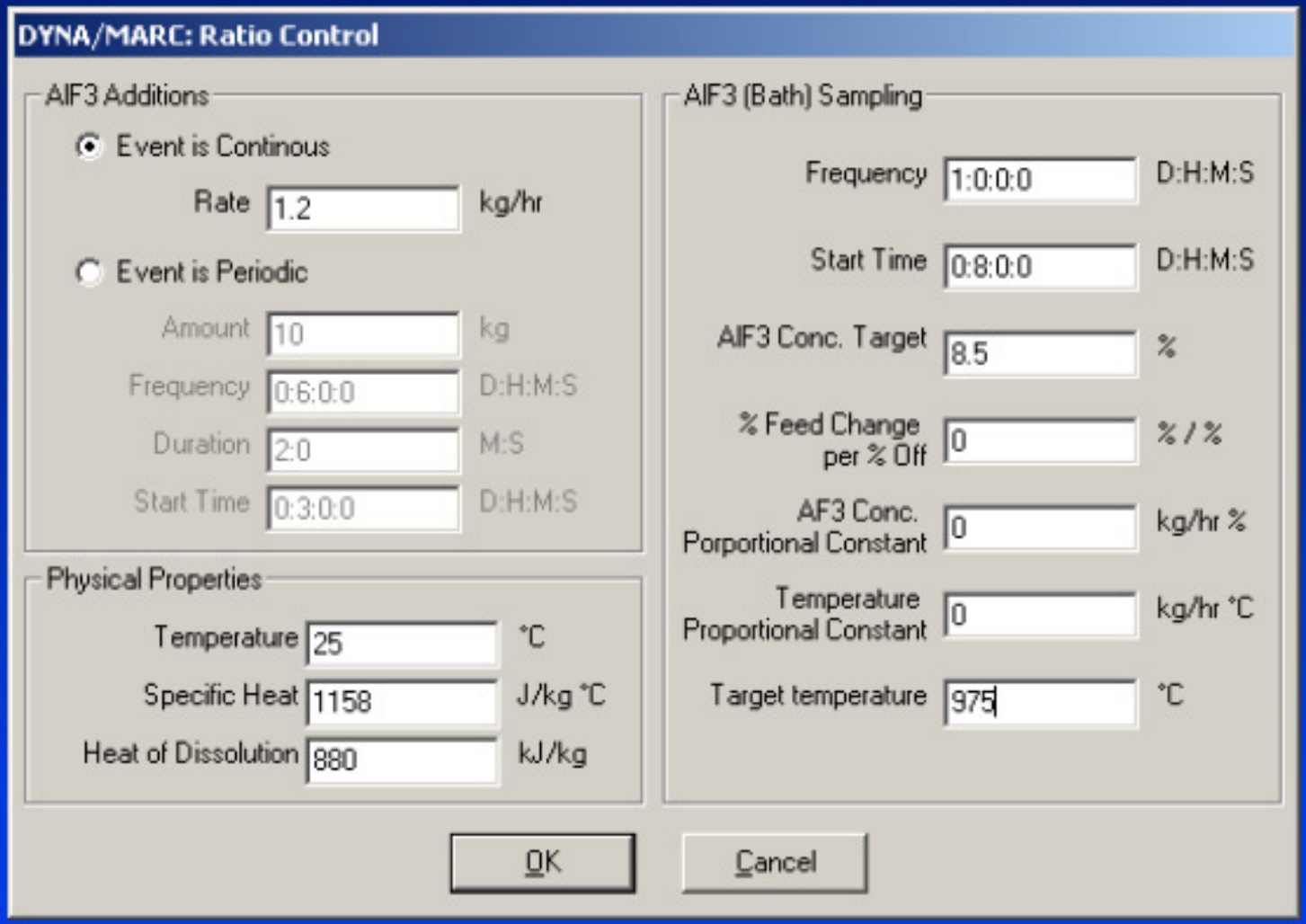




Cell response to an instantaneous 100 kg AlF3 addition

GENISIM

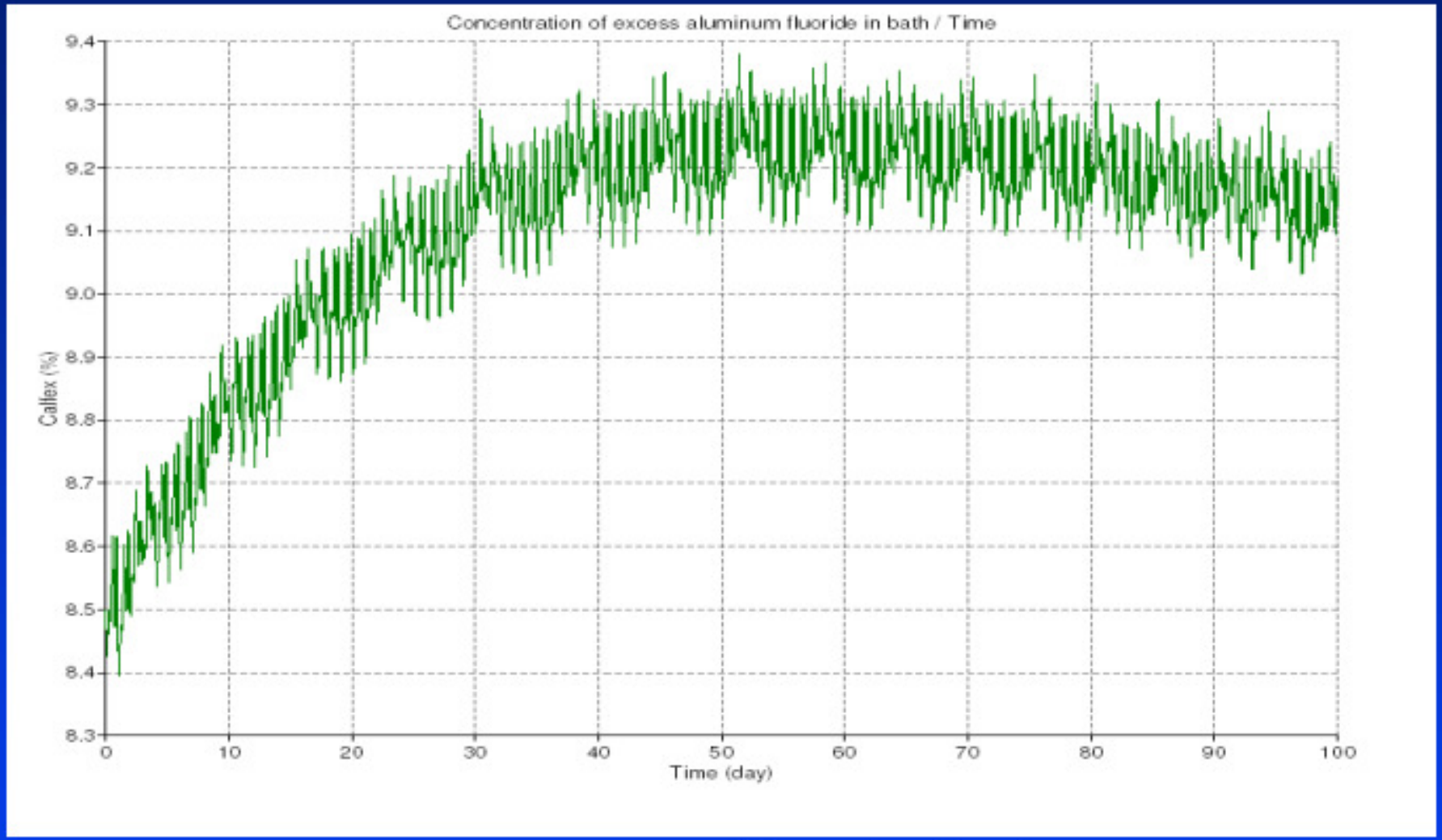
Control logic based on bath sampling



Starting with a constant 1.2 kg per hour direct AlF3 feeding rate

GENISIM

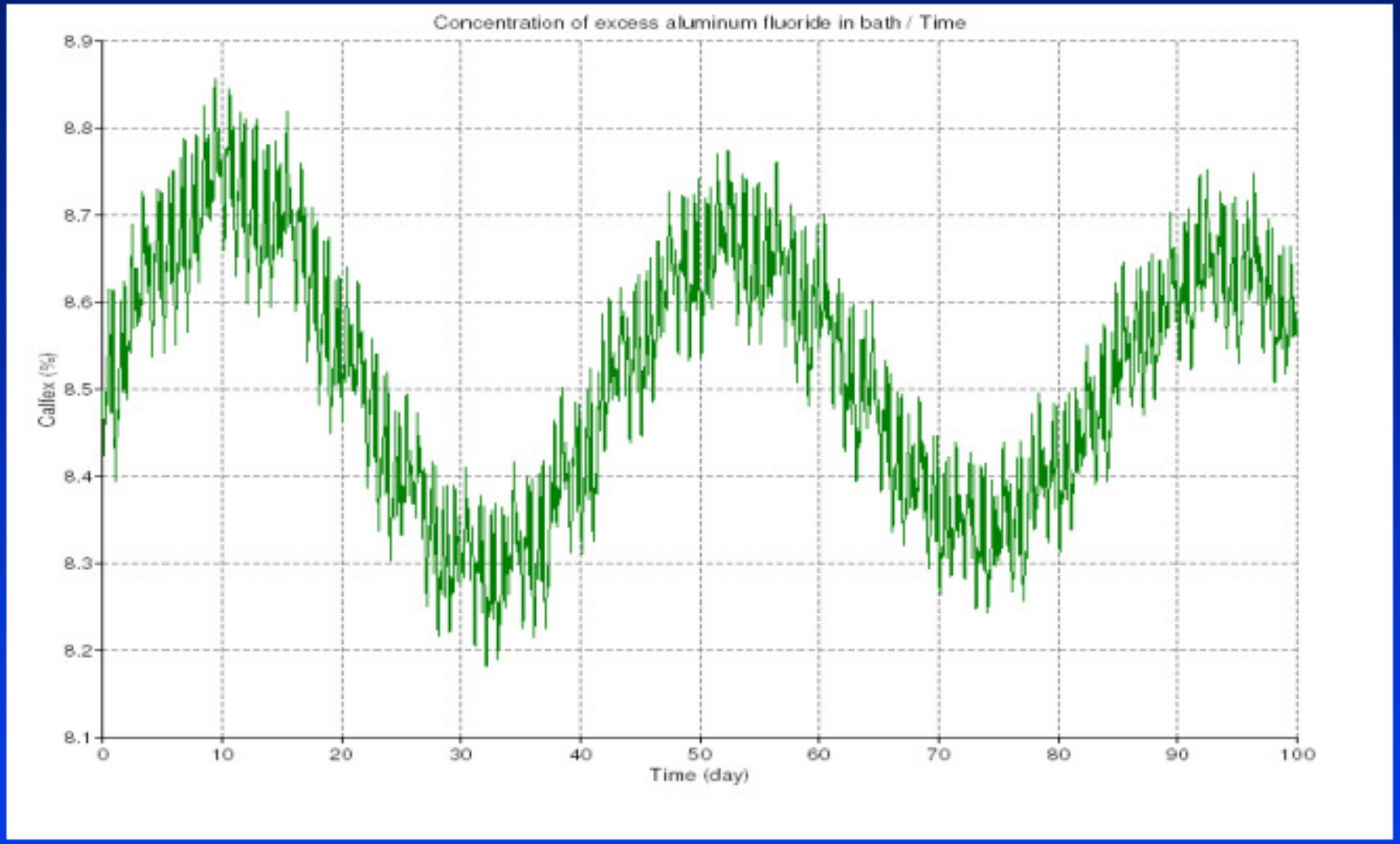
Control logic based on bath sampling



100 days response without feedback control

GENISIM

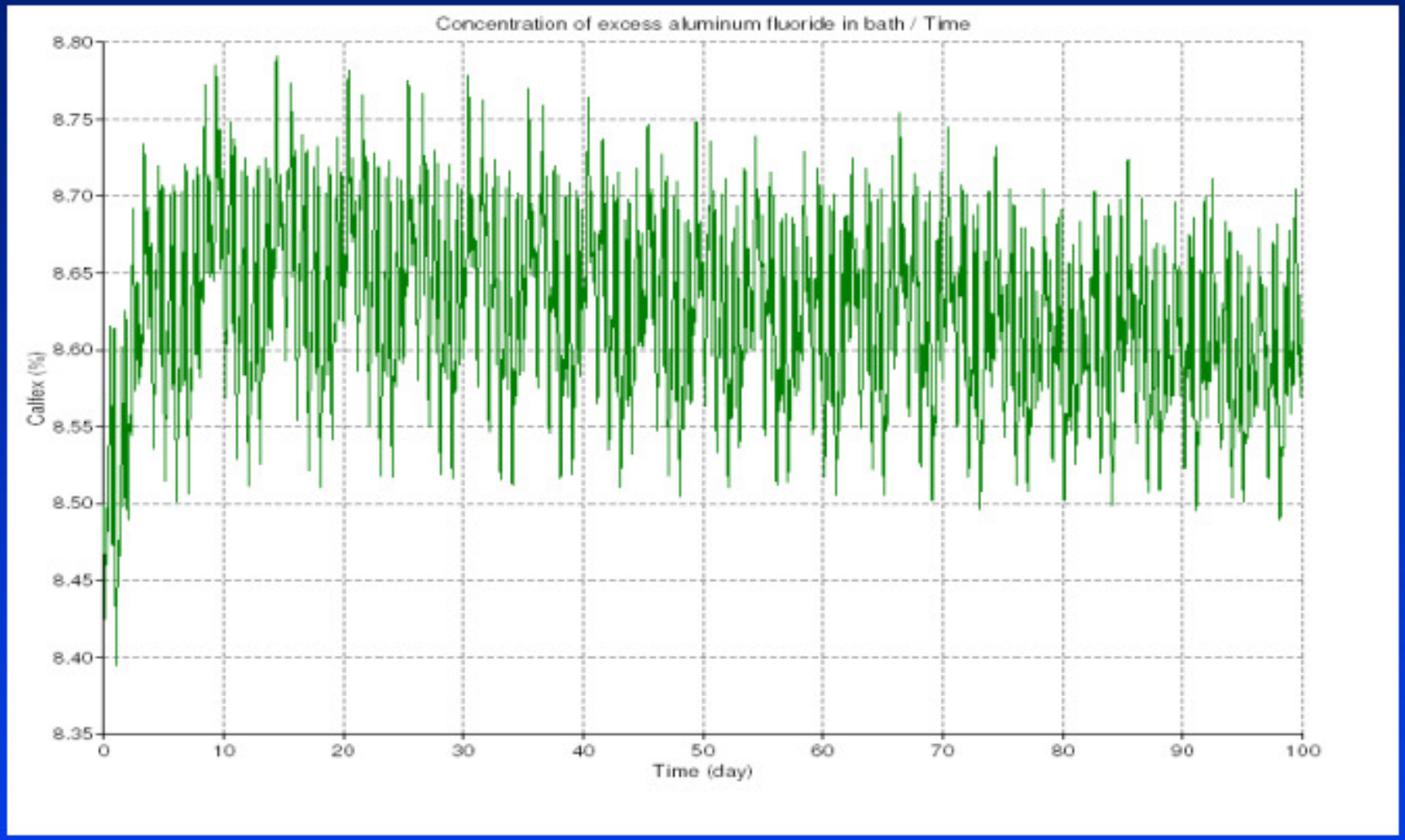
Control logic based on bath sampling



Integral control 10%/%, 1 sample per day, 1 day delay

GENISIM

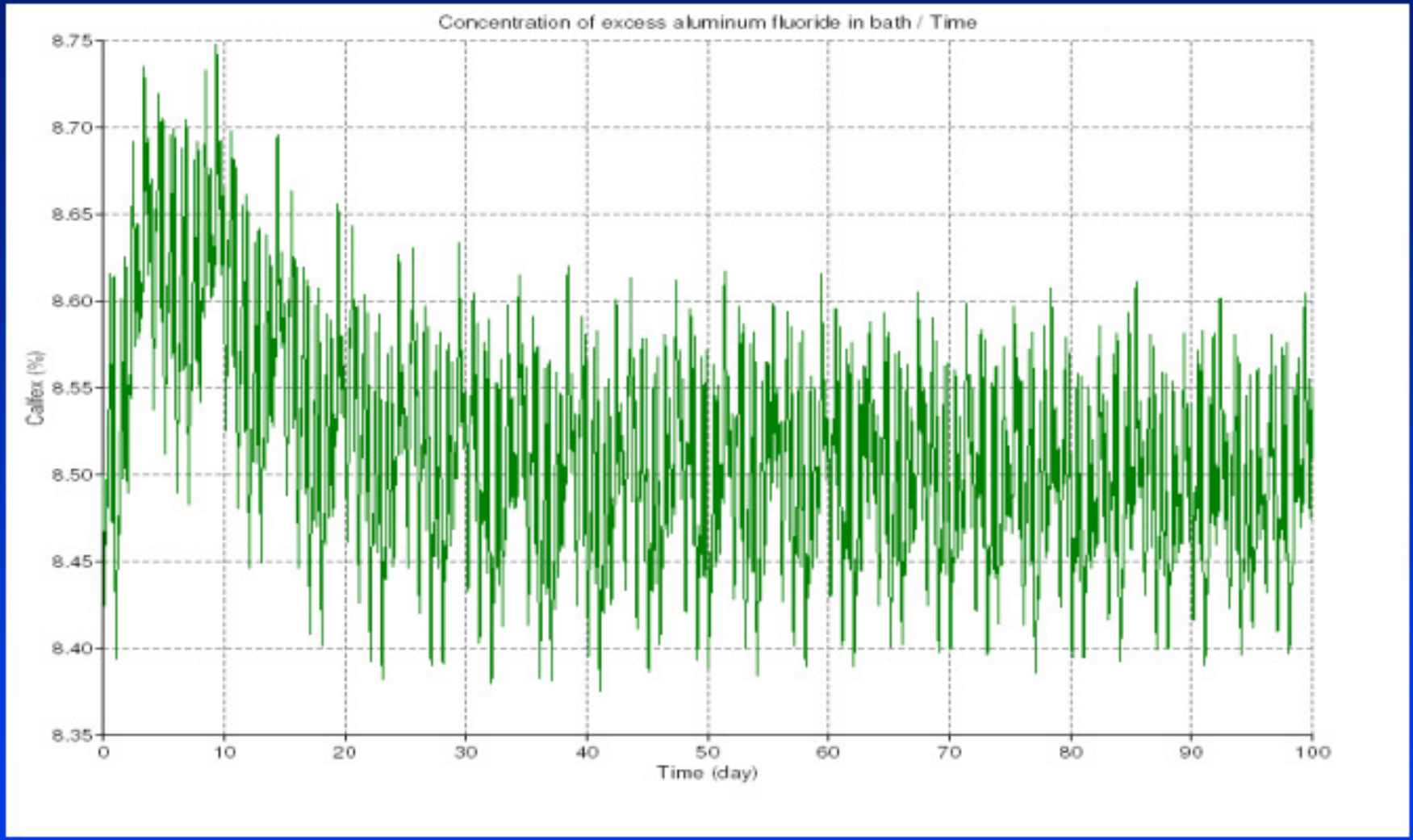
Control logic based on bath sampling



Proportional control 1 kg/hr%, 1 sample per day, 1 day delay

GENISIM

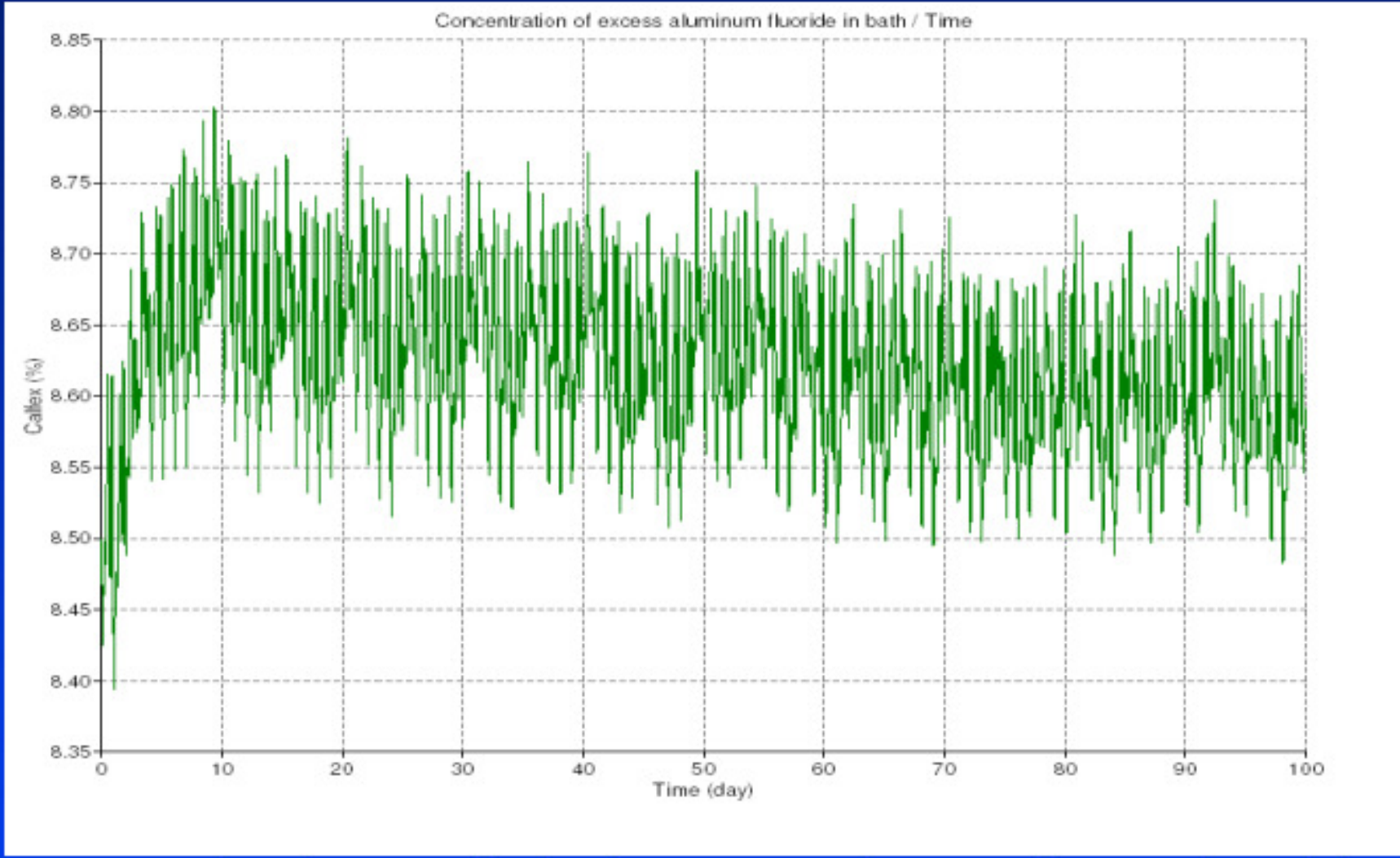
Control logic based on bath sampling



PI control 1 kg/hr% and 10%/%, 1 sample per day, 1 day delay

GENISIM

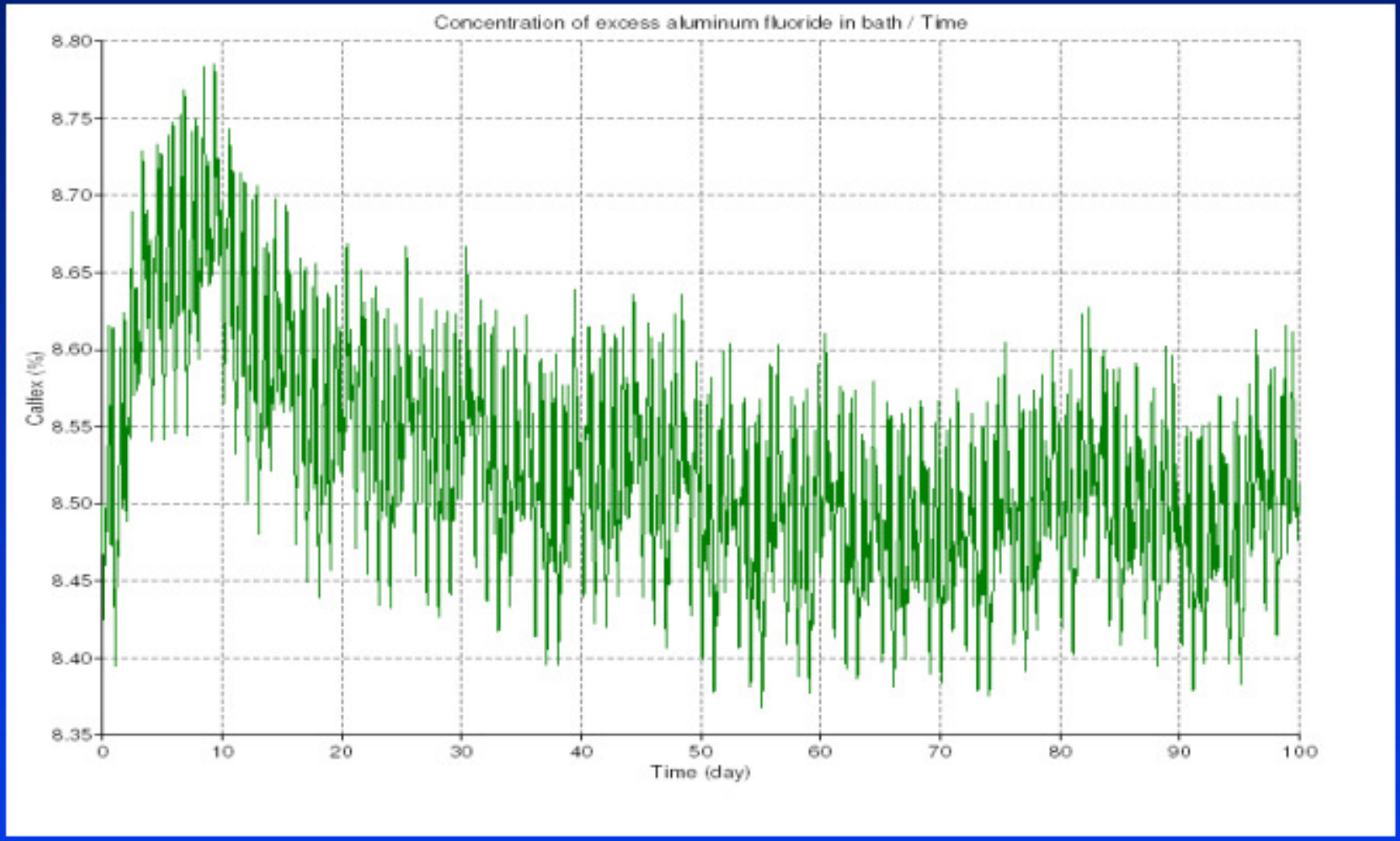
Control logic based on bath sampling



Proportional control 1 kg/hr%, 1 sample per 2 days, 2 days delay

GENISIM

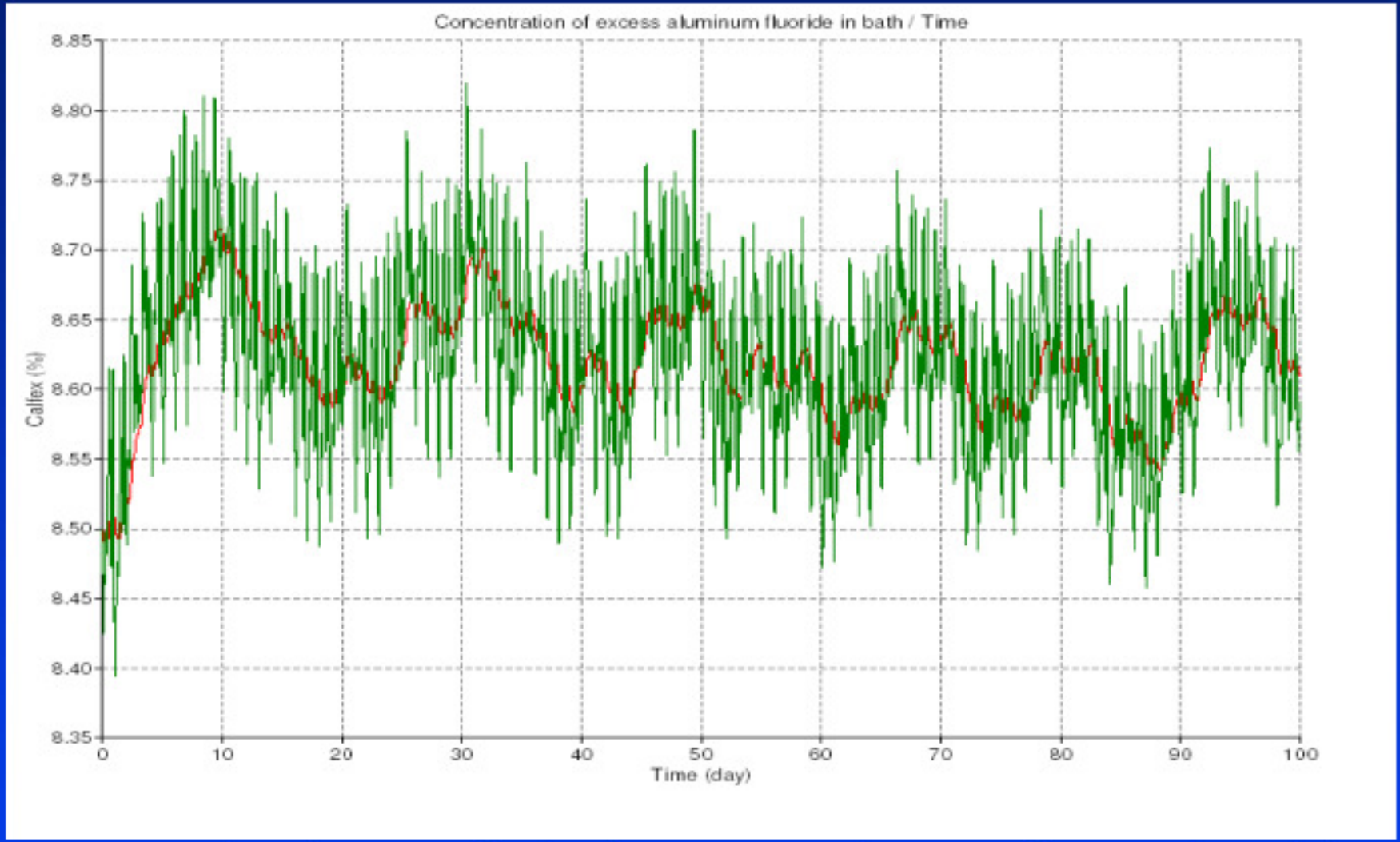
Control logic based on bath sampling



PI control 1 kg/hr% and 10%/%, 1 sample per 2 days, 2 days delay

GENISIM

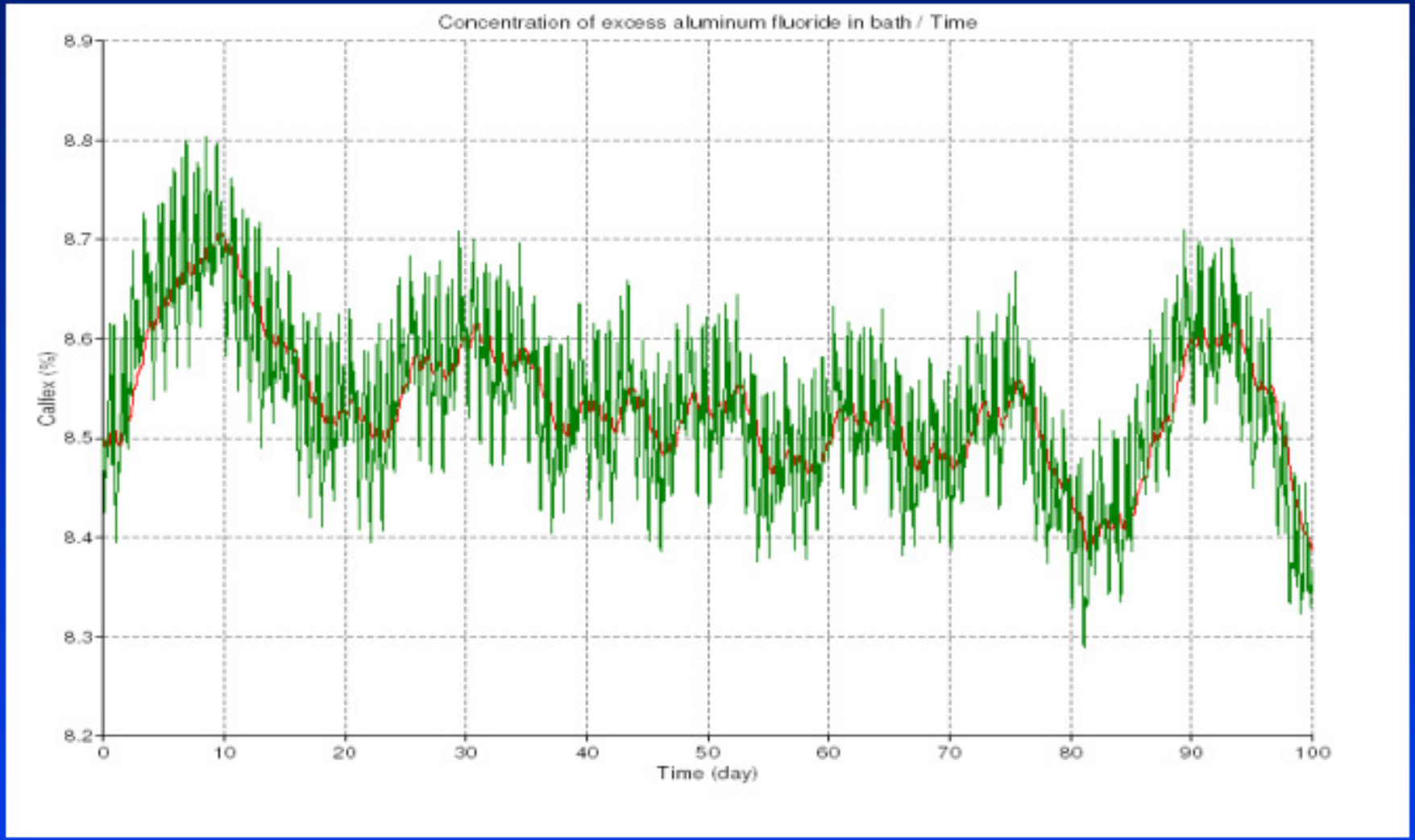
Control logic based on bath sampling



Proportional control 1 kg/hr%, 1 sample per 3 days, 3 days delay

GENISIM

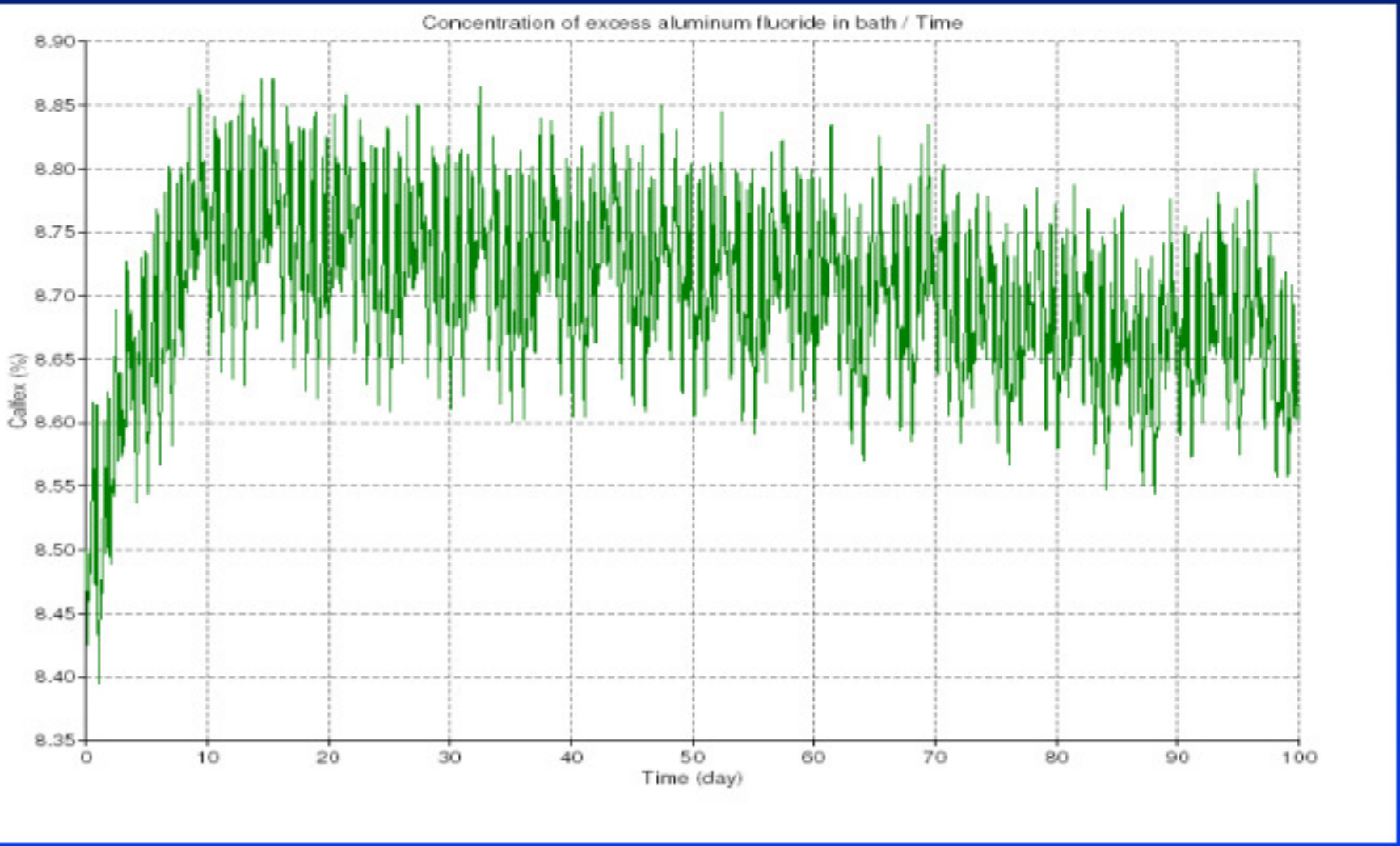
Control logic based on bath sampling



PI control 1 kg/hr% and 10%/%, 1 sample per 3 days, 3 days delay

GENISIM

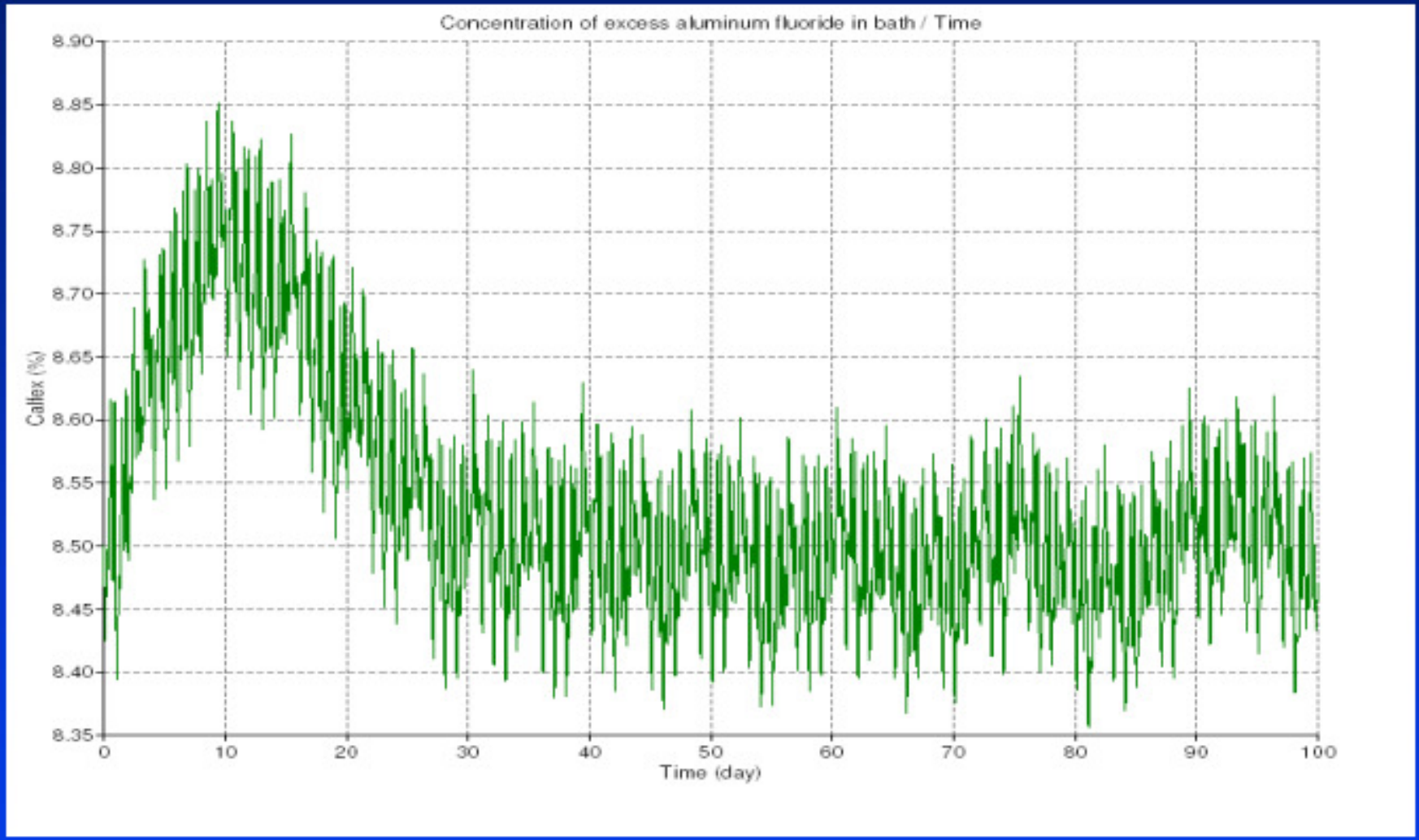
Control logic based on bath sampling



Proportional control 0.5 kg/hr%, 1 sample per 3 days, 3 days delay

GENISIM

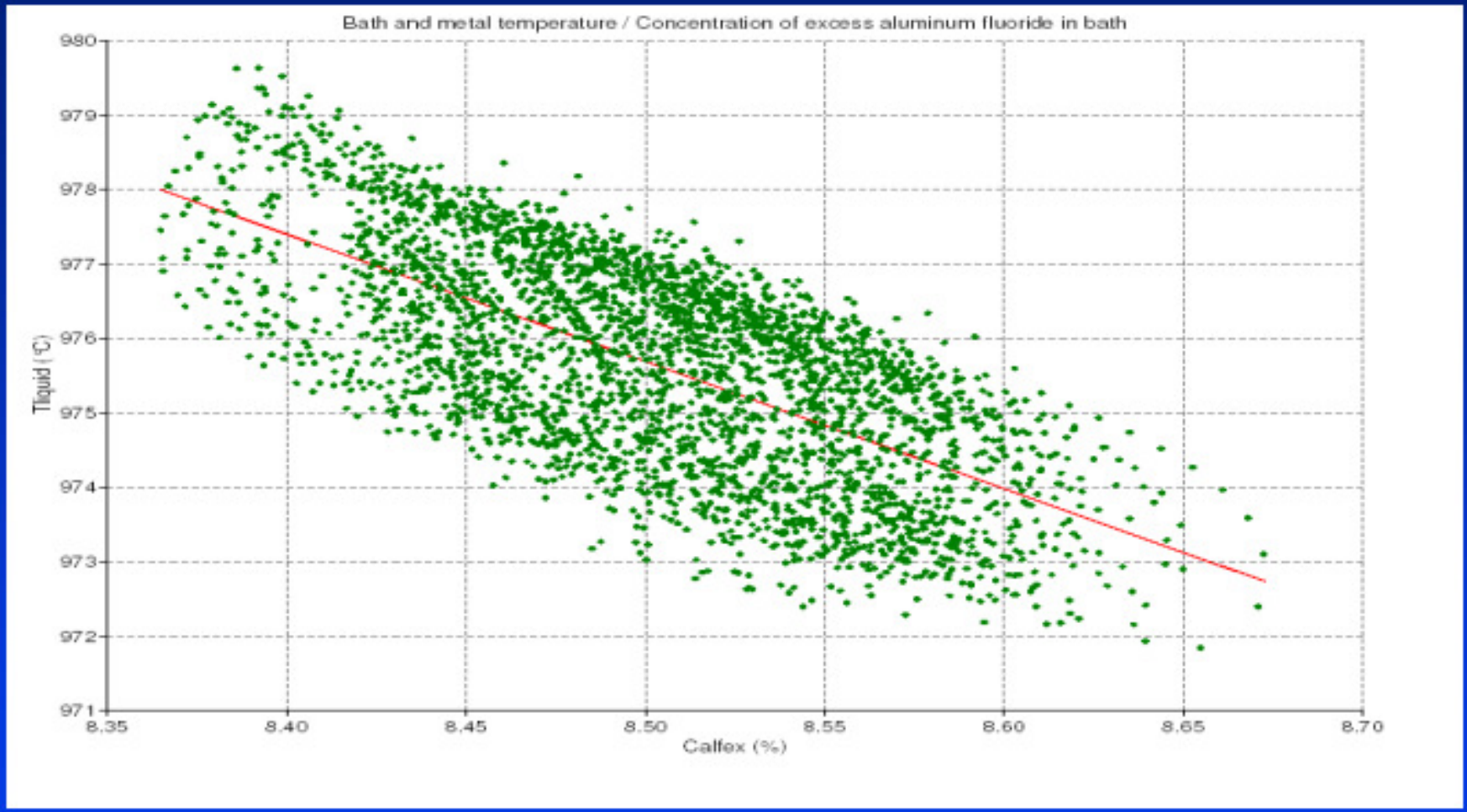
Control logic based on bath sampling



PI control 0.5 kg/hr% and 10%/%, 1 sample per 3 days, 3 days delay

GENISIM

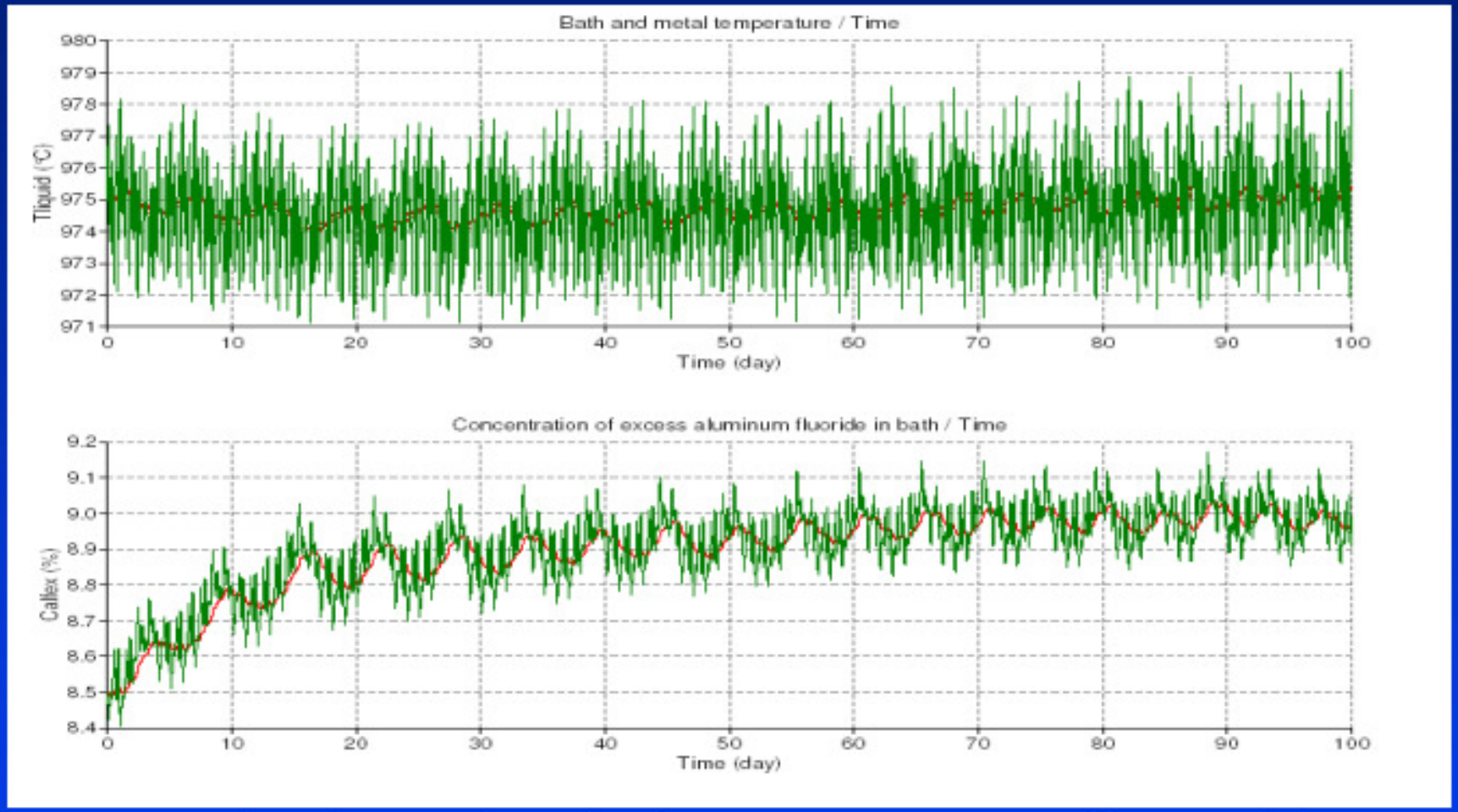
Control Logic Based on Bath Temperature Measurement



Correlation between excess AlF3 temperature and bath temperature 3% CaF_2

GENISIM

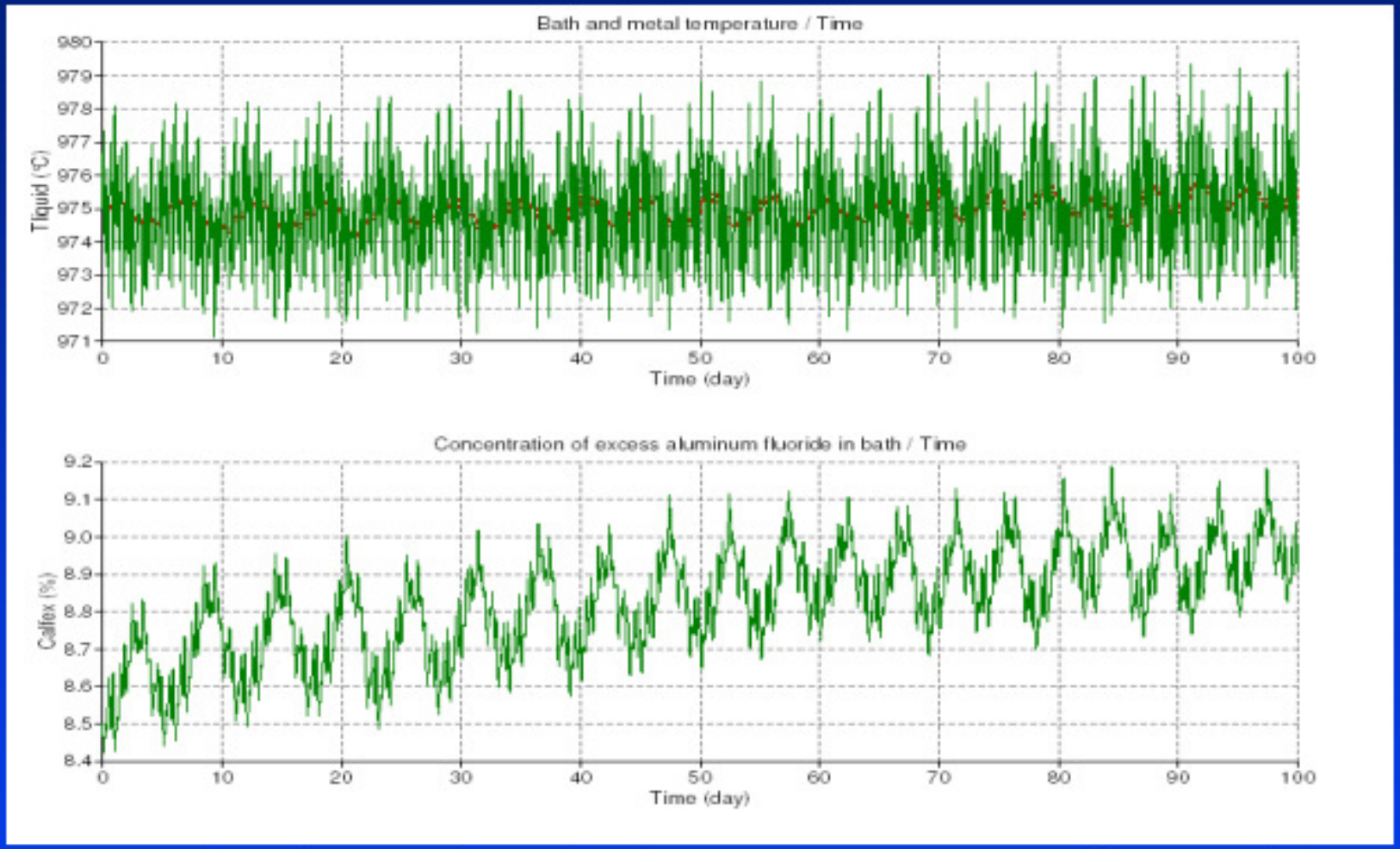
Control Logic Based on Bath Temperature Measurement



Proportional control 0.1 kg/hr°C, 1 measure per day, no delay

GENISIM

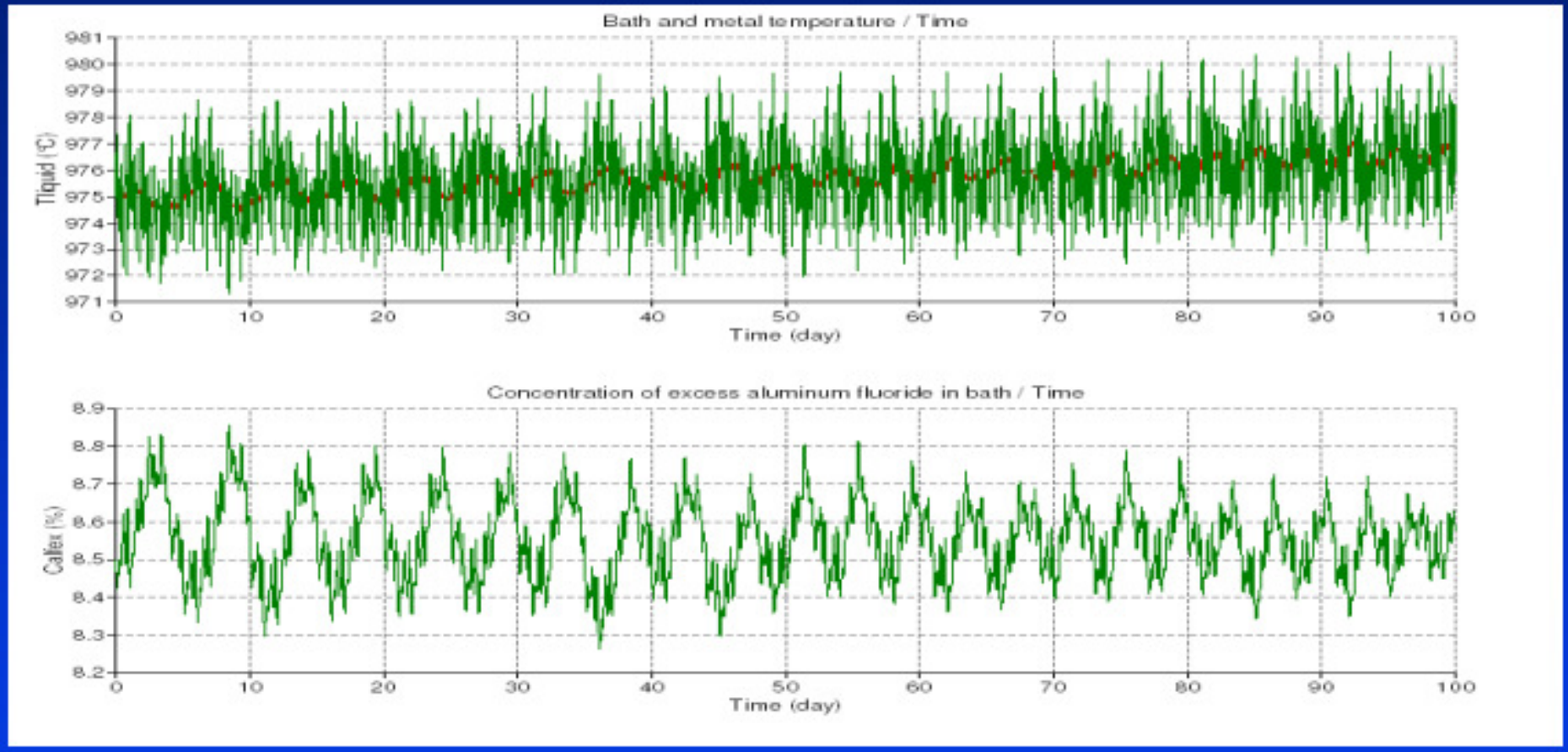
Control Logic Based on Bath Temperature Measurement



Proportional control 0.3 kg/hr°C, 1 measure per day, no delay

GENISIM

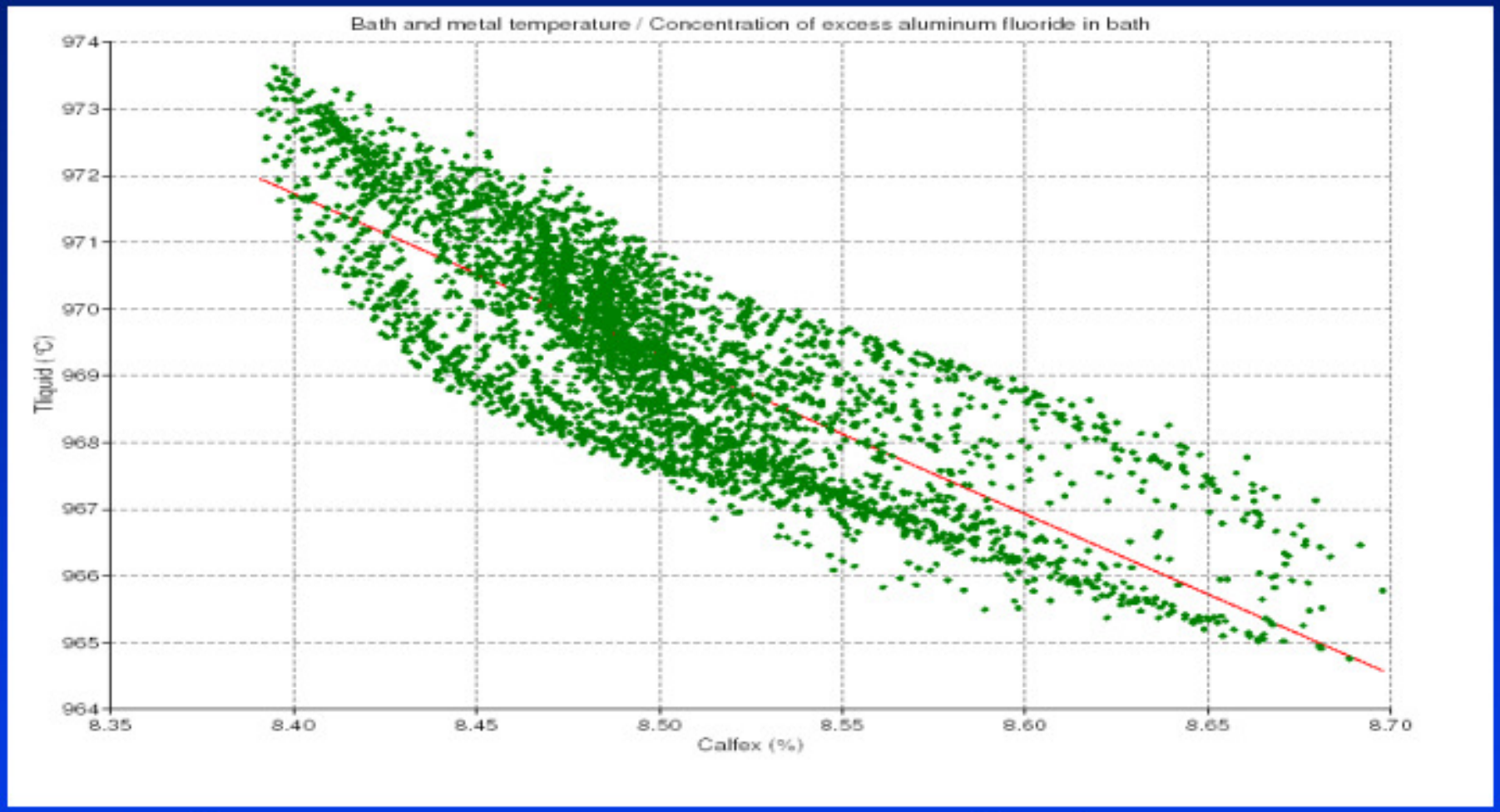
Control logic based on both bath sampling and bath temperature measurement



PI mixed control 1 kg/hr% and 10%/%, 1 sample per day, 1 day delay, 0.3 kg/hr°C, 1 temperature measurement per day, no delay

GENISIM

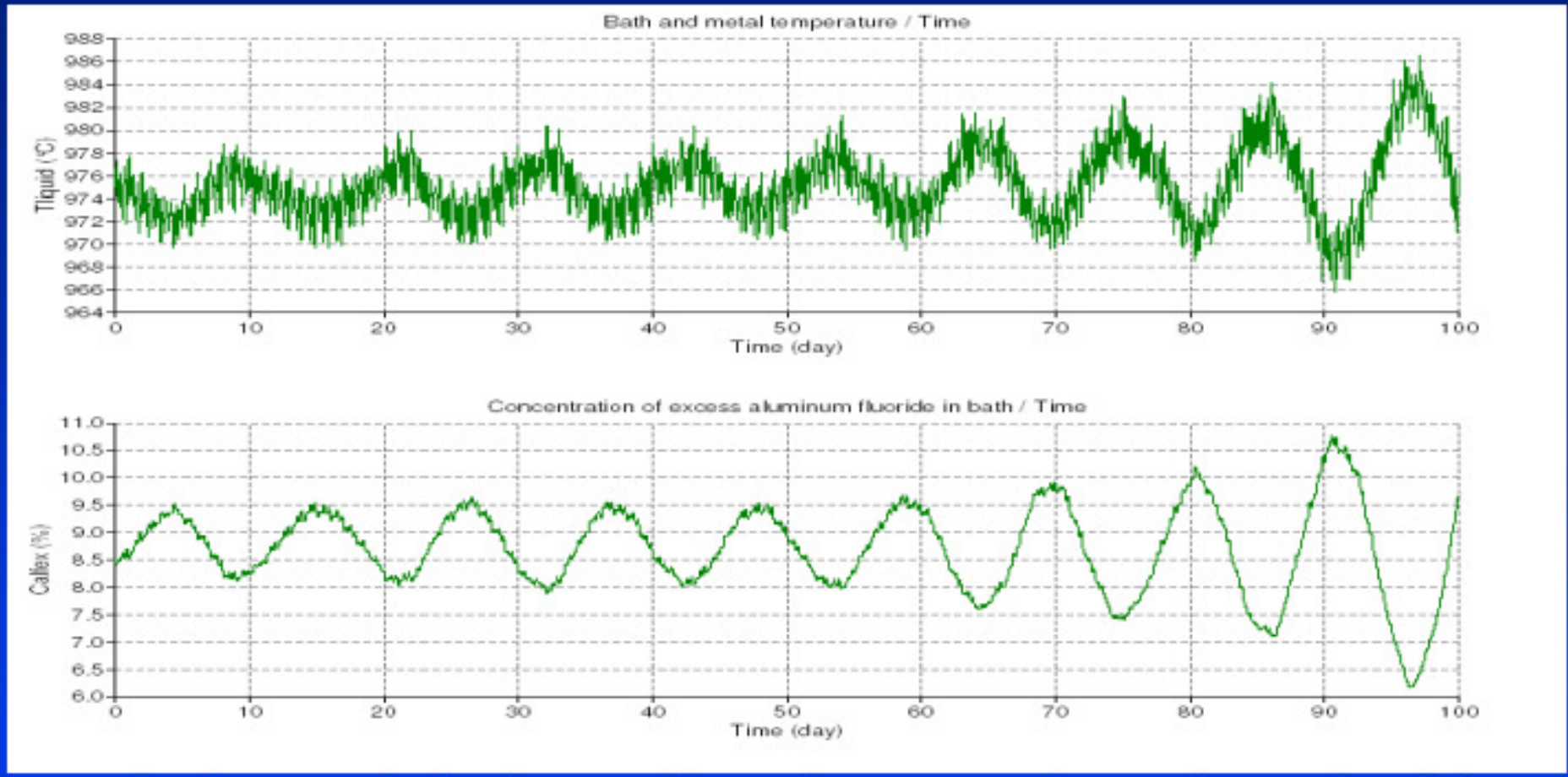
Control logic based on both bath sampling and bath temperature measurement



Correlation between excess AlF3 temperature and bath temperature 8% CaF_2

GENISIM

Control logic based on both bath sampling and bath temperature measurement



PI mixed control 1 kg/hr% and 10%/%, 1 sample per day, 1 day delay, 0.3 kg/hr°C, 1 temperature measurement per day, no delay, 970 °C setpoint

GENISIM

Conclusions

- Clearly, using a mixed bath sample analysis and bath temperature double targets control strategy is a very bad choice of control strategy. Is there any other industrial process that is essentially using 2 controllers to control the same process variable?
- Using the cell operating temperature alone to control the excess AlF3 concentration in the bath is not very efficient either as the daily evolution of the bath temperature is much more influenced by other parameters like feeding regime than it is affected by the excess AlF3 concentration in the bath.
- Directly using the bath sample analysis results seems to be the most effective control strategy despite the fact that it involves the introduction of a time lag in the feedback loop.
- A time lag of up to 3 days between the sample collection and the report of the results is even manageable if the proportional constant is set appropriately in order to avoid overshooting.