Process Simulation of Aluminum Reduction Cells

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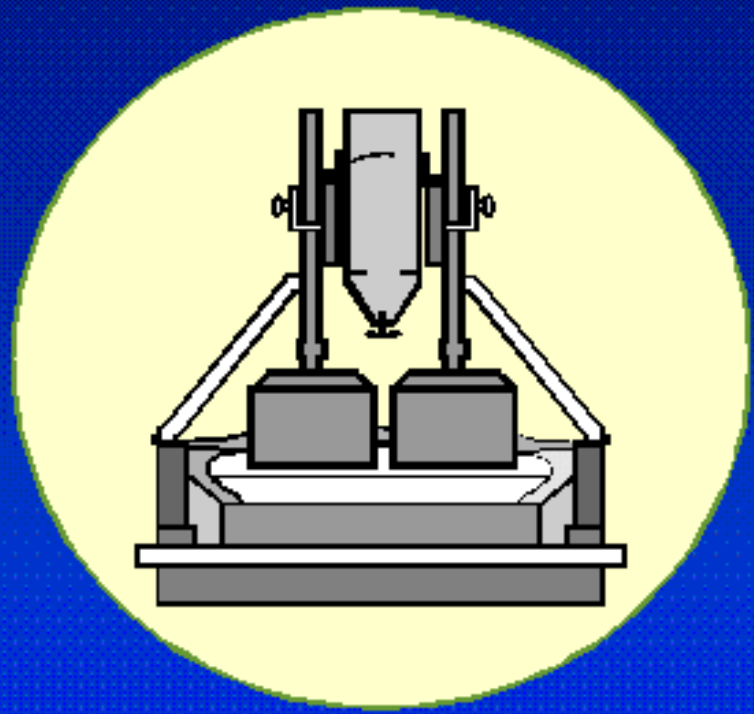
Program Overview

Process Model



Control Model

Constitutive Equations

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Constitutive Equations

- **Idealized system consists of the :**
  - Liquid Zone (Bath and Metal)
  - Solidified Ledge
- **13 differential equations characterize the :**
  - Heat Balance
  - Mass Balance of 11 Chemical Species
  - Anode to Cathode Distance (ACD)

Constitutive Equations

Dynamic Variables

- **Liquid Temperature**
- **Mass of Species**
  - Bath, metal and sludge
  - Dispersed and dissolved Al_2O_3
  - Excess AlF3
  - Bath additives (CaF_2 , LiF , MgF_2)
- **Average Thickness of Ledge**
  - Adjacent to bath layer
  - Adjacent to metal layer
- **ACD**

Heat Balance Equation

- Internal Heat
- Global Heat Loss
- Heat Accumulated in the System
  - Melting / Forming Ledge
  - Increasing / Decreasing the Operating Temperature

Heat Balance Equation

Internal Heat

- **Evaluated by computing the voltage break down:**
  - Bath Composition
  - Bath Resistivity
  - Bath Liquidus
  - Current Efficiency
  - Bath Voltage
  - Electrolysis Voltage
  - Equivalent Voltage to Make Metal

Heat Balance Equation

Global Heat Loss

- **Four surfaces are defined for losing heat:**
  - Anode Panel
  - Cathode Panel
  - Ledge Adjacent to Bath Layer
  - Ledge Adjacent to Metal Layer

Mass Balance Equations

- **11 Chemical species each with its own equation:**
  - Metal
  - Bath (cryolite, excess AlF_3 , dissolved Al_2O_3 , CaF_2 , LiF , MgF_2)
  - Ledge Adjacent to the Bath Layer
  - Ledge Adjacent to the Metal layer
  - Al_2O_3 Dispersed in the Bath
  - Sludge in the Metal

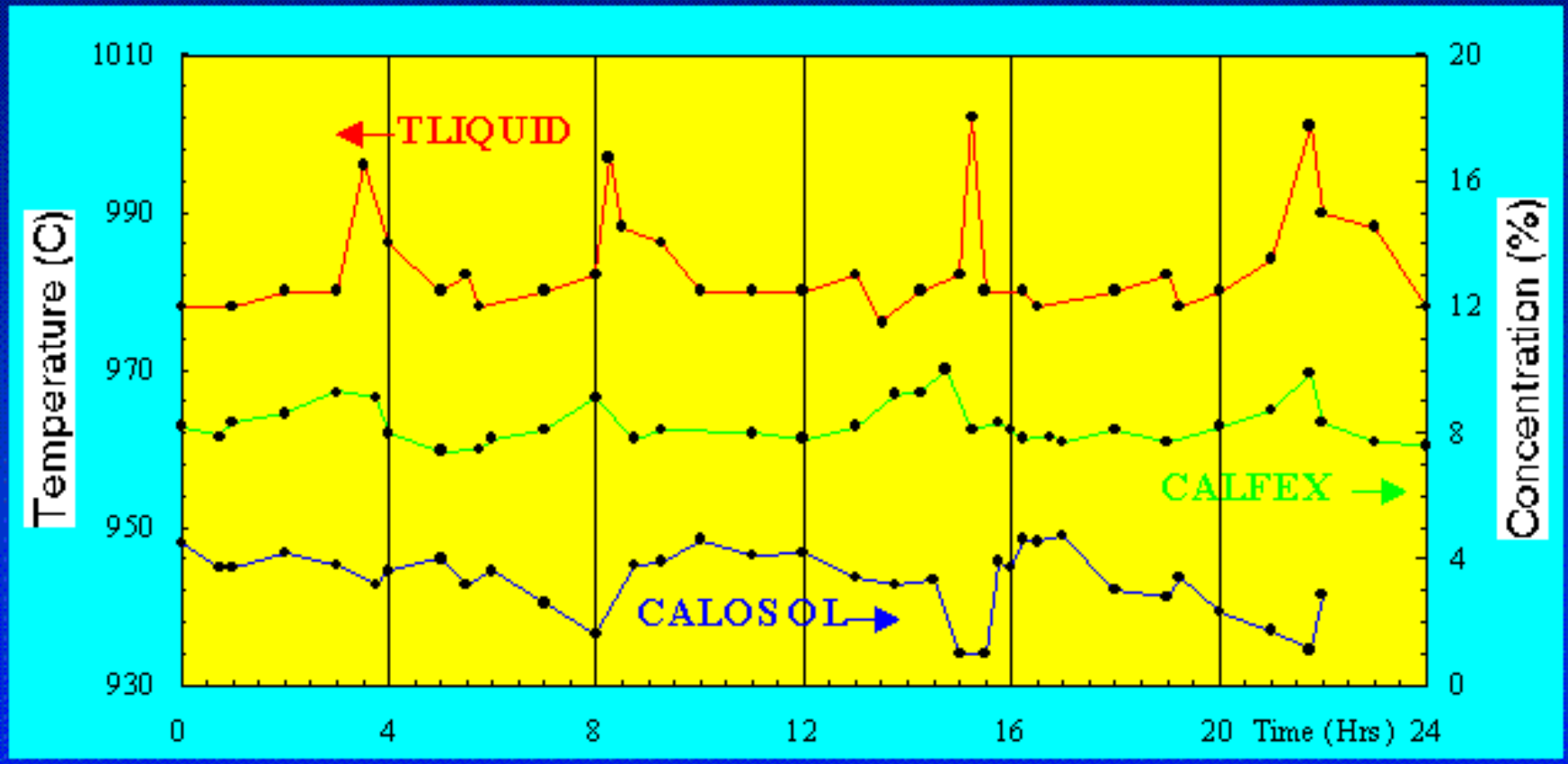
Control Model

- **Operational Events**
  - Alumina Feeding and Resistance Control
- **Scheduled Events**
  - Metal Tapping, Anode Change, Anode Beam Raising, Ratio Adjustment and Bath Transfusion
- **Exception Events**
  - Anode Effects and Cell Instability
- **Cell States**

Program Validation

- **Verification of Program Execution**
  - Input Data
  - Built-in Equations and Control Logic
- **Comparison with Measured Data**
  - Aratu Cell

Measured Response



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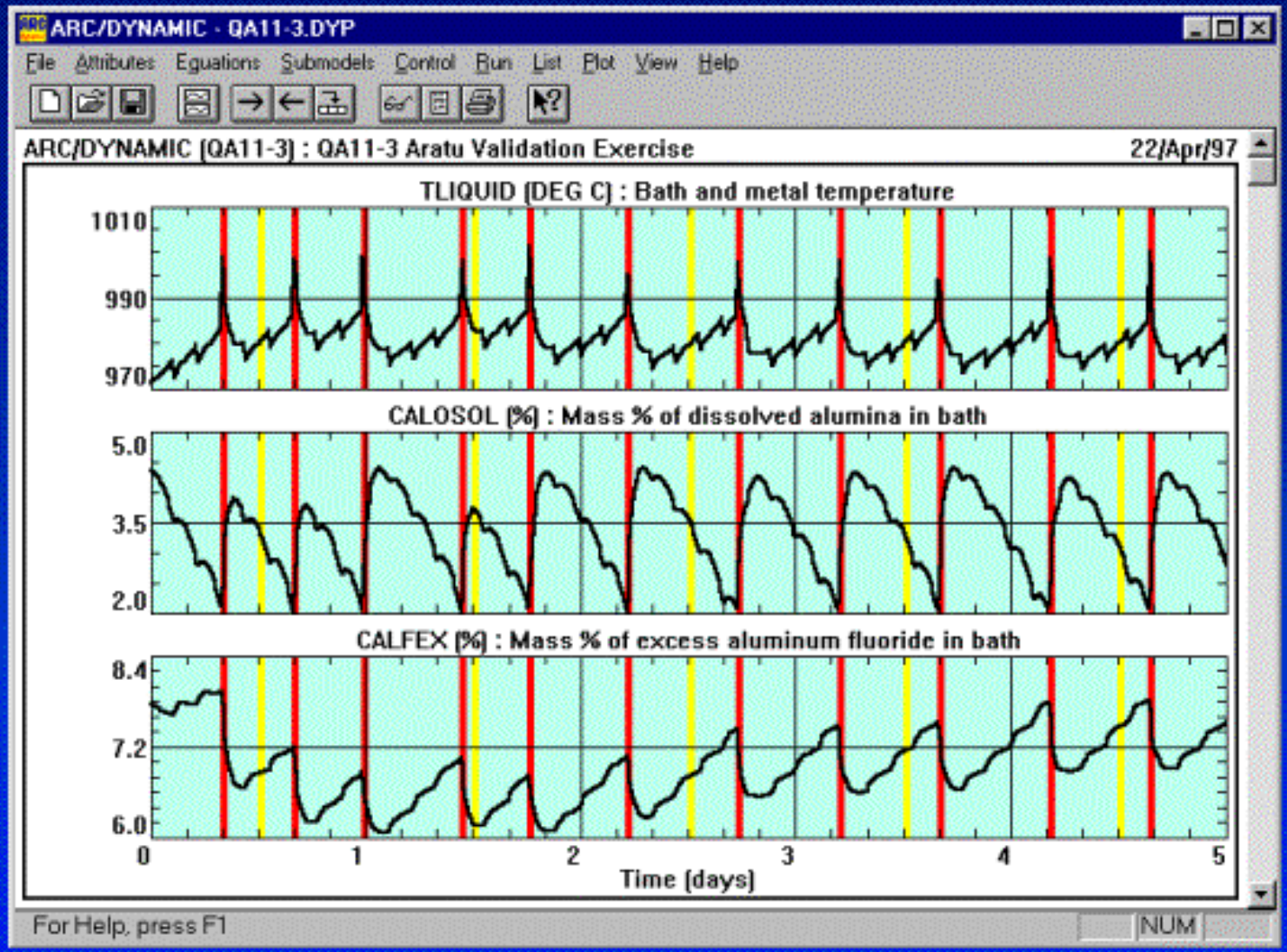
Calculated Response



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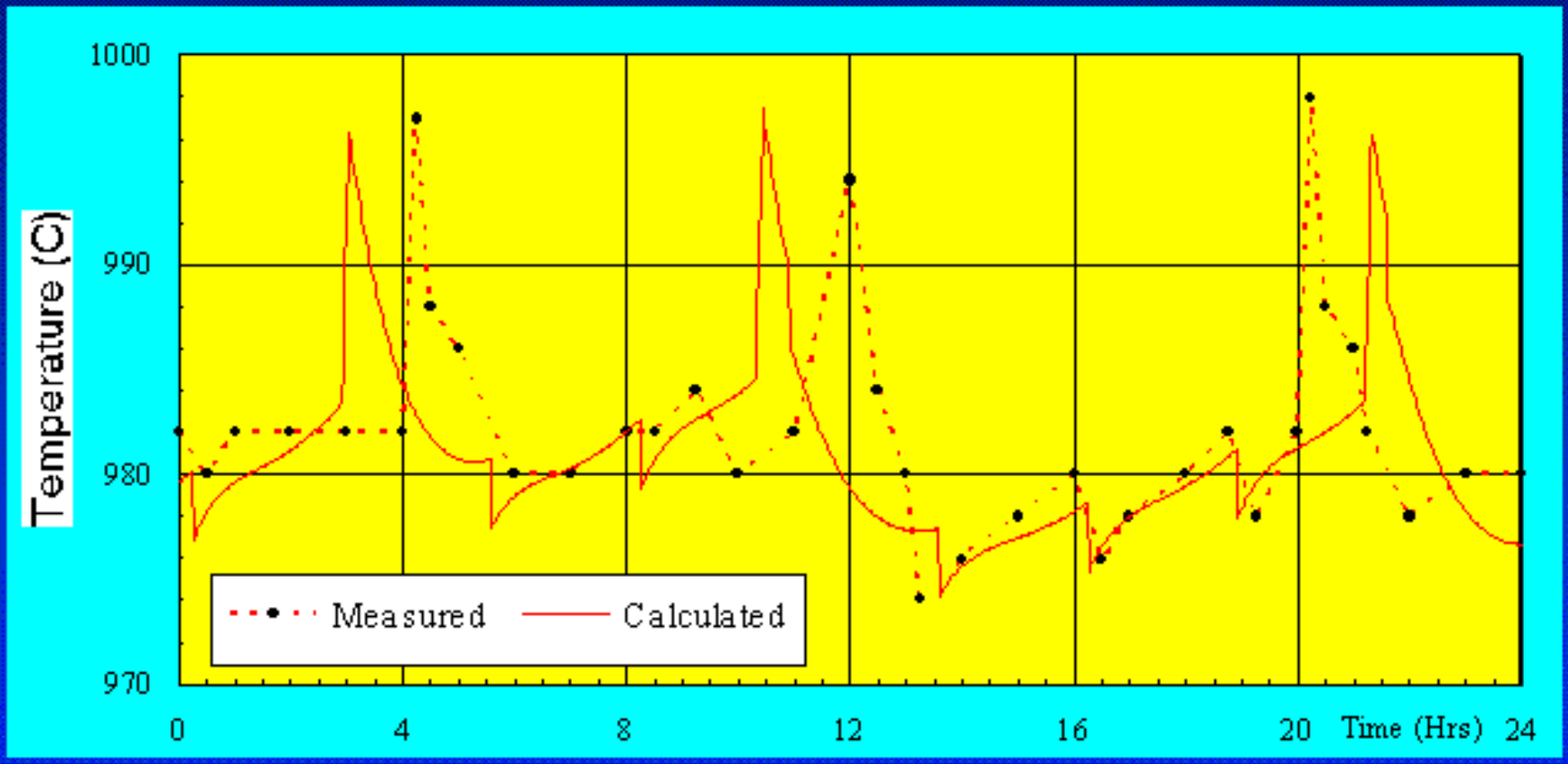
Temperature



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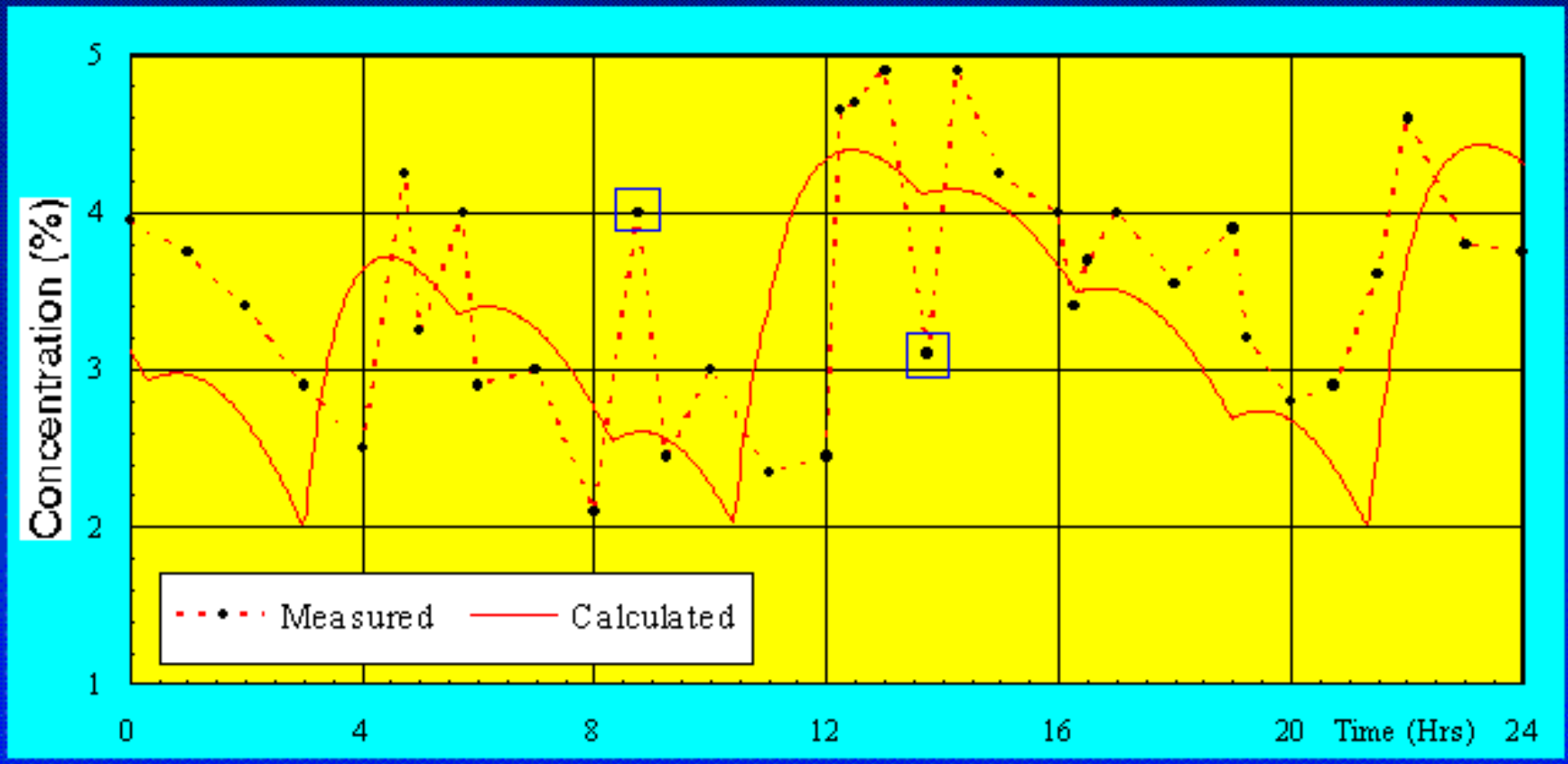
Alumina Concentration



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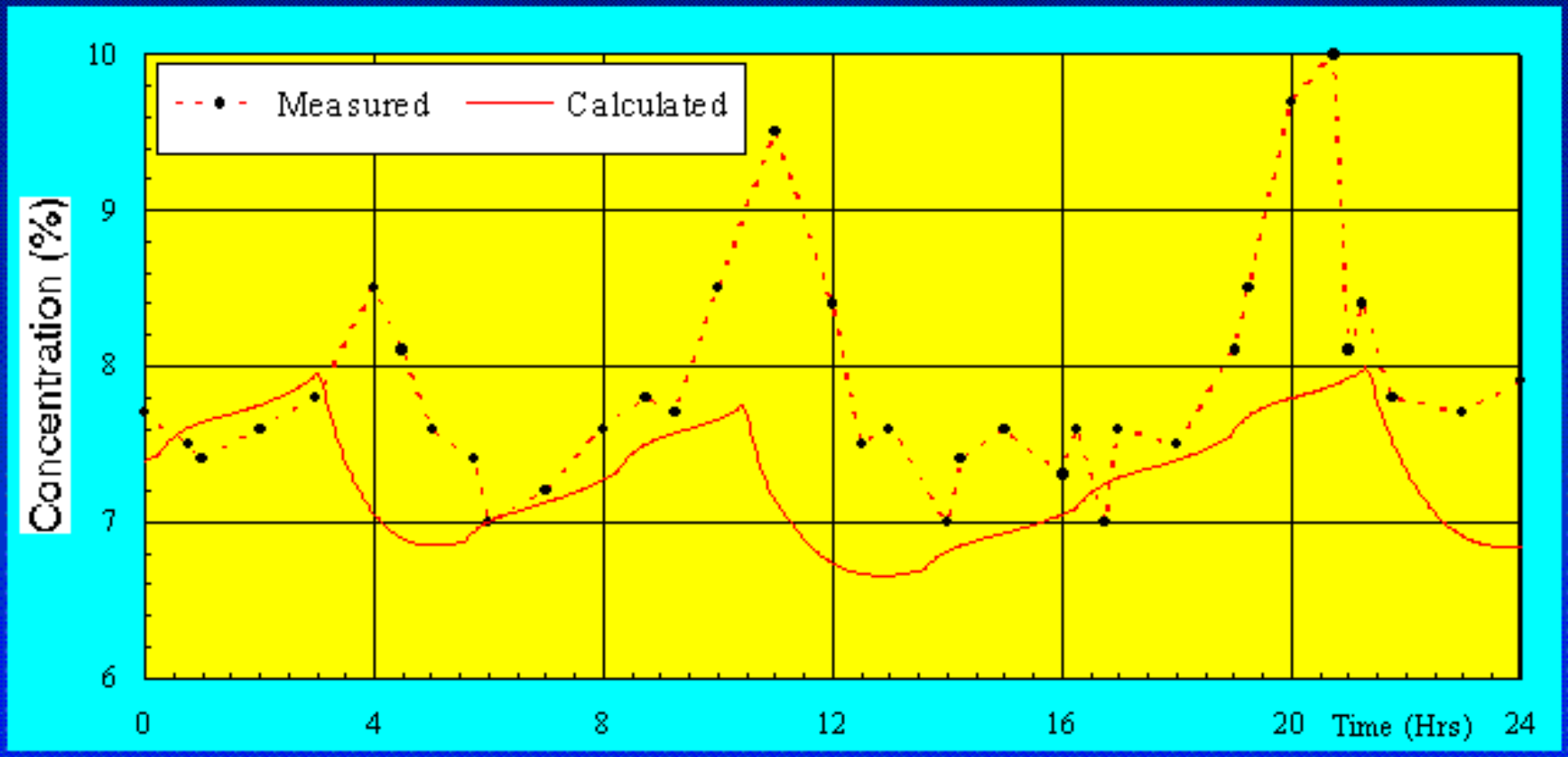
Concentration of Excess AlF_3



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Conclusions

- A program has been developed to model the dynamic behavior of reduction cells.
- The program has been successfully used to simulate the behavior of an operating VS cell.

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