AREVA

Consultancy Meeting on Update and upgrade of IAEA-TECDOC on Ageing Management of Steam Generators

Steam Generator Cleanliness Control Strategy

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Presentation Outline

- *This presentation aims to answer the questions:*
  - *Are my SG's sensitive against corrosion?*
  - *To what extent is it due to SG soiling?*
  - *Do I need to clean my SG's?*
  - *When I need to clean them?*
  - *How should I clean them?*
- *How to use plant data to assess the SG cleanness and answer those questions?*
- *Conclusions*

How to Assess the SG Cleanness?

> *Plant data can be used to assess the SG situation:*

- *Plant operating data*
  - *Chemistry parameters,*
  - *Hide-out measurements,*
  - *Hide-out return chemistry, and*
  - *Fouling measurements*
- *Outage activitiy results*
  - *Visual inspections*
  - *Tube sheet lancing*
  - *Oxide thickness measurements*

Which Operating Chemistry Parameters Can be Used?

During power operation following parameters can be used

- *Corrosion product mass balance,*
- *Hydrazine decomposition,*
- *Evaluation of "out of spec" situations*
  - *Condenser leaks,*
  - *Polisher resin leaks*
  - *SG blowdown demineralizer malfunction*
  - *Any other incident causing high impurity ingress into the cycle*

Power Operation: Corrosion Product Mass Balance

- *Objective: to follow-up the SG sludge loading rate*
- *SG sludge loading can be assessed by mass balance of FW and SG iron concentration*
- *The assessment can be completed with analysis of sources (condenser, heater drains)*
- *Grab samples are inadequate and insufficient for determination of corrosion products!*
  - *Local sampling system*
  - *adequate sampling methodology and analysis are required*

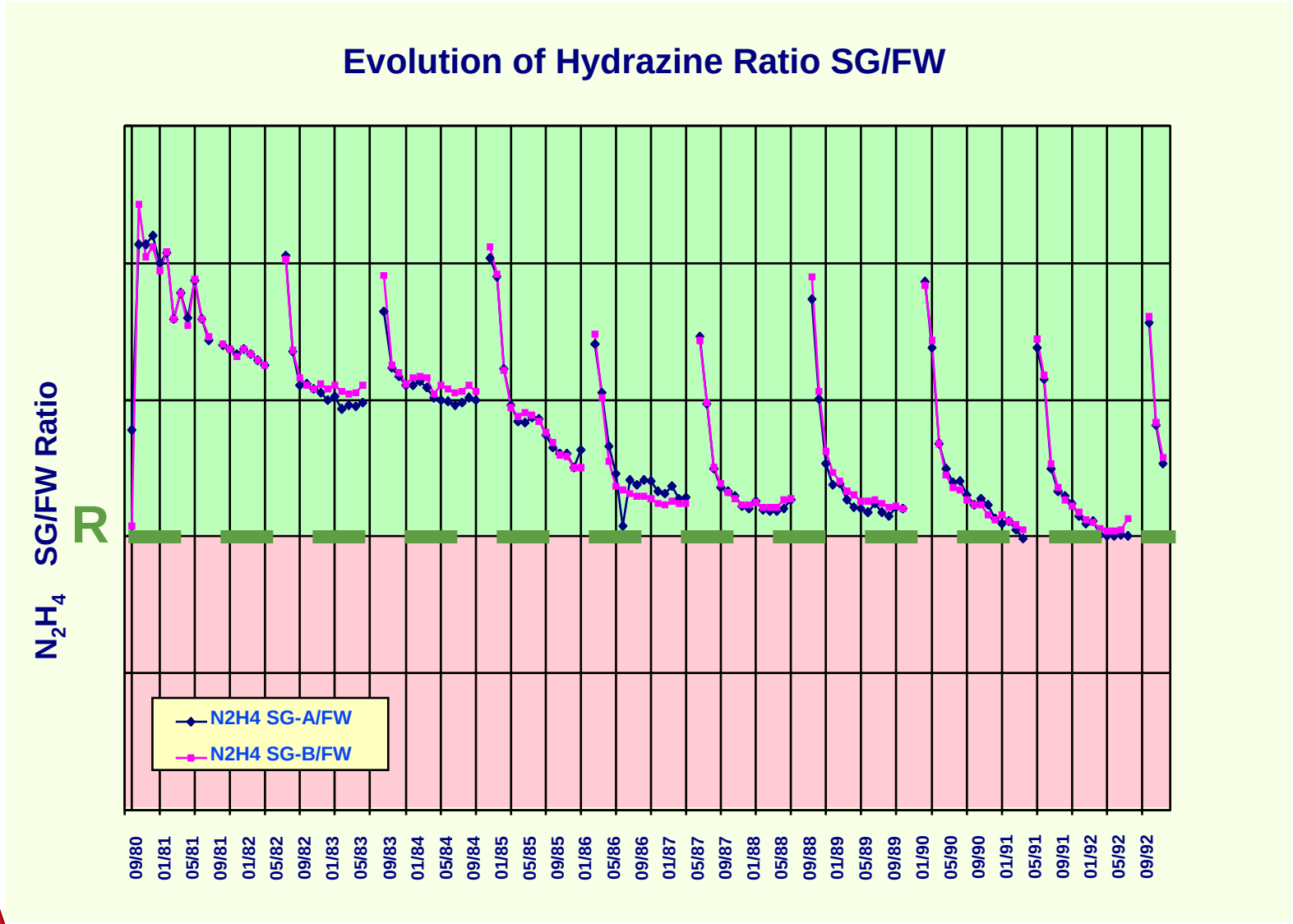
Corrosion Product Mass Balance *(cont'd)*

- *Increase of the deposit amounts can*
  - *Increase the impurity local concentration (increase of corrosion risk),*
  - *Extend the corrosion area (No. of tubes affected),*
  - *Increase the tube fouling*
- *Significant deposit loading should sensitize the operators for more care in*
  - *Plant chemistry,*
  - *Visual inspections*

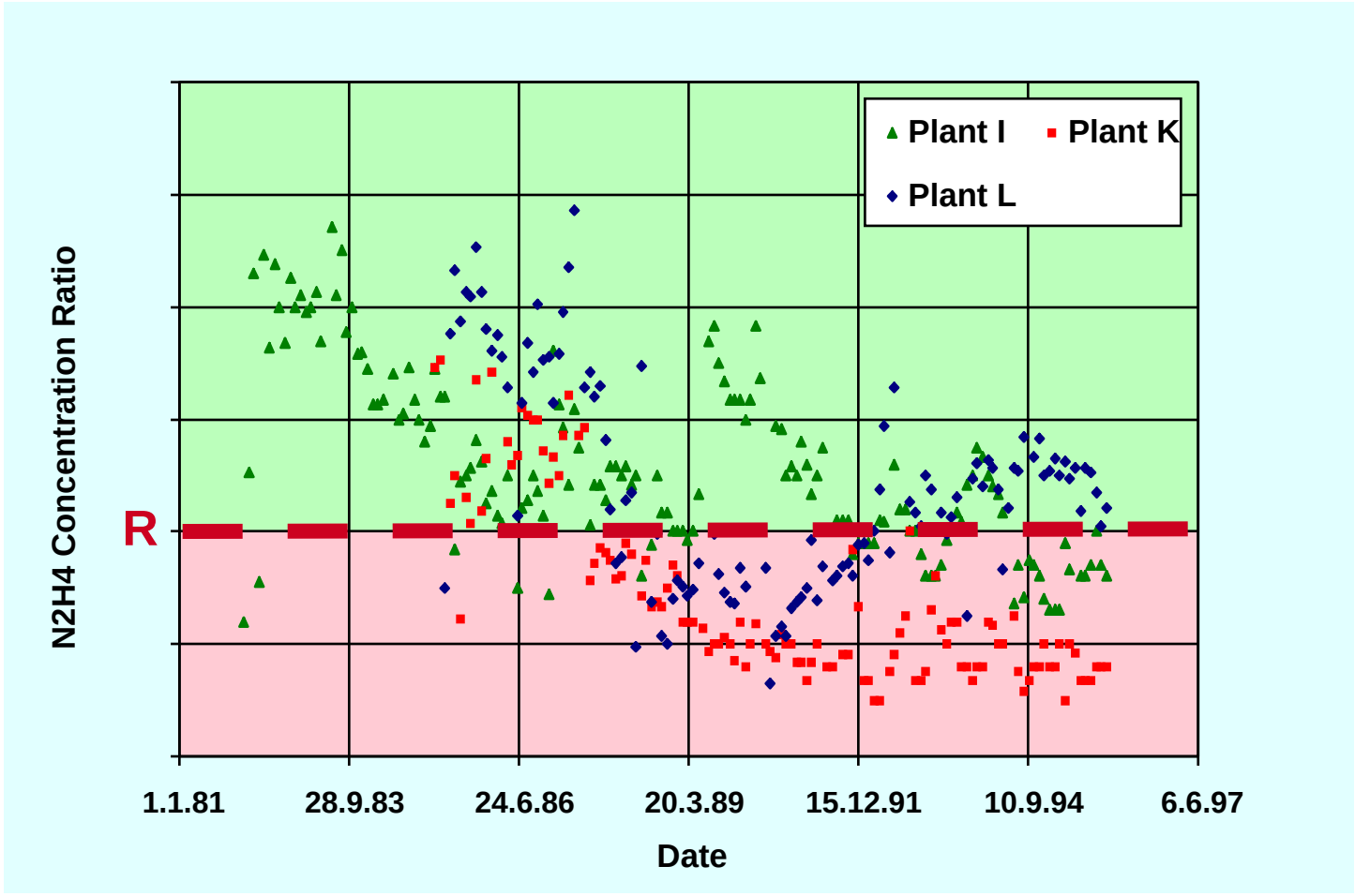
Power Operation: Hydrazine Decomposition in Steam Generator

- N_2H_4 concentration in SG decreases by
  - Thermal decomposition
  - Consumption by oxidizing species
- Corrosion products catalyze N_2H_4 decomposition
- The SG/FW N_2H_4 concentration ratio decreases
  - with operating time
  - influenced by iron concentration in feed water
- Increase of the SG/FW N_2H_4 concentration ratio is observed after SG chemical cleaning

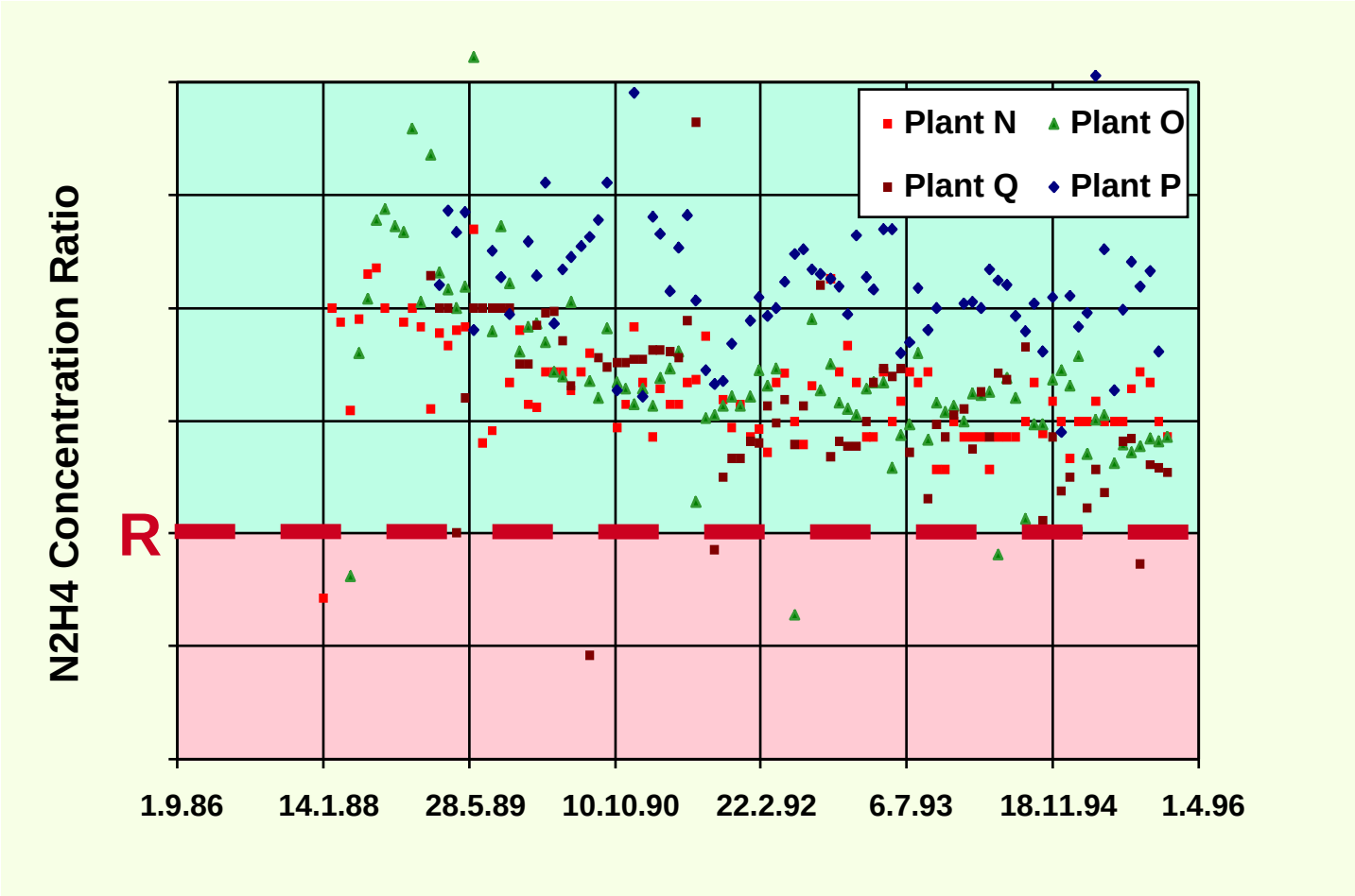
Hydrazine Ratio Time Evolution



Hydrazine Ratio in Newer PWR's
(Feedwater Fe Concentration 1-2 ppb)



Hydrazine Ratio in New PWR's
(Feedwater Fe Concentration < 1 ppb)



Power Operation: Evaluation of "Out of Spec" Situations

- *Impurity accumulation in SG is controlled by*
  - *FW impurity content (input),*
  - *SG blow-down (output),*
  - *Steam carry over (output) , and*
  - *Hide – out (accumulation)*

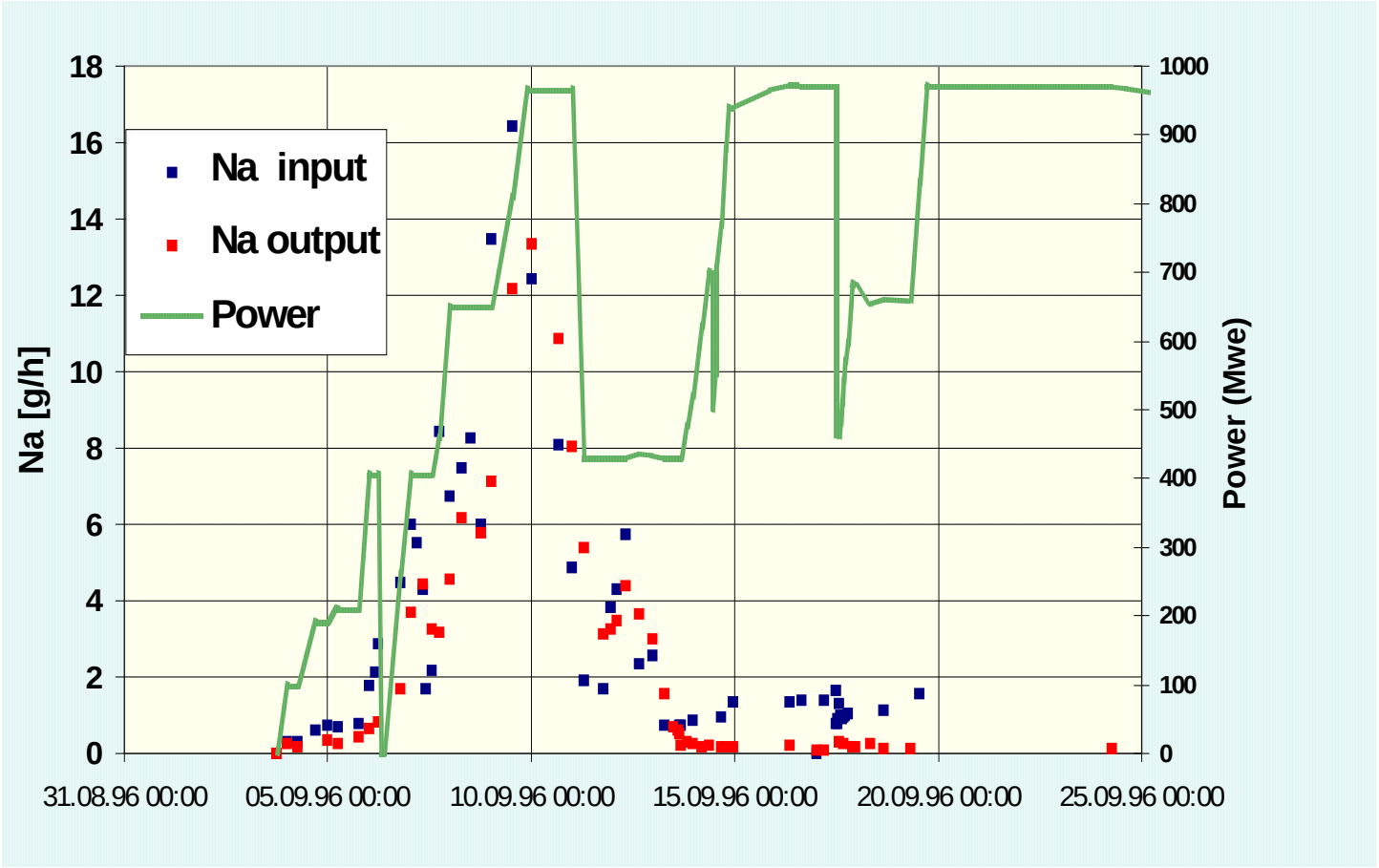
- *If impurity concentration in SGs can be controlled mainly*
  by SG blow-down, there is no need to apply counteractions
  - *Improve chemistry*
  - *SG cleaning*

Evaluation of “Out of Spec” Situations
Hideout Measurement

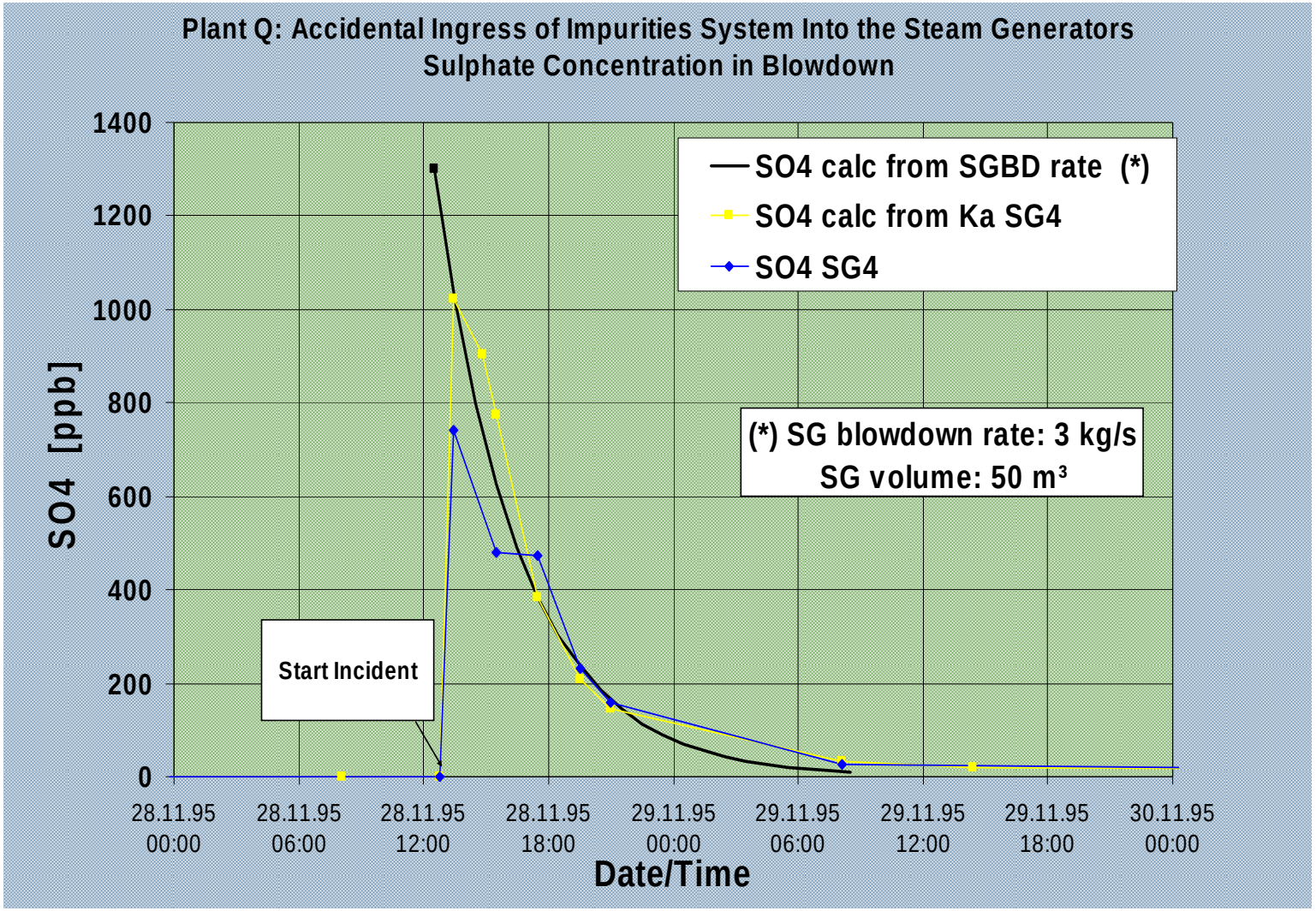
- *Chemistry incidents, like condenser leaks, SGBD demineralizer perturbations, can be used to obtain useful information concerning SG condition*
  - *Hideout can be measured by unbalance between the impurity input and output*
  - *For that, procedures must be available to start a special measurement plan in case of occurrence of such incidents*
    - *Impurity measurement in feed water*
    - *Impurity measurement in SG blow down*
  - *Under normal operation conditions this is not possible, since the impurity concentrations in FW are below detection limit*

Evaluation of Condenser Leak
Sodium Balance in SGs

PLANT A - Severe condenser leak by start-up



Evaluation of Polisher Resin Leak
Sulphate Balance in SGs



Powe Operation: Hideout Measurements

Tests using tracers, commonly associated with steam carry over measurements

> *Performed by injection of radio nuclides in FW and follow-up of activity in SG blow down*

- *Na-24: t(1/2): 15,03 hrs*
- *S-35: t(1/2): 87,5 days*
- *Na-24 is also used for steam carryover tests*

> *Also chemicals can be used:*

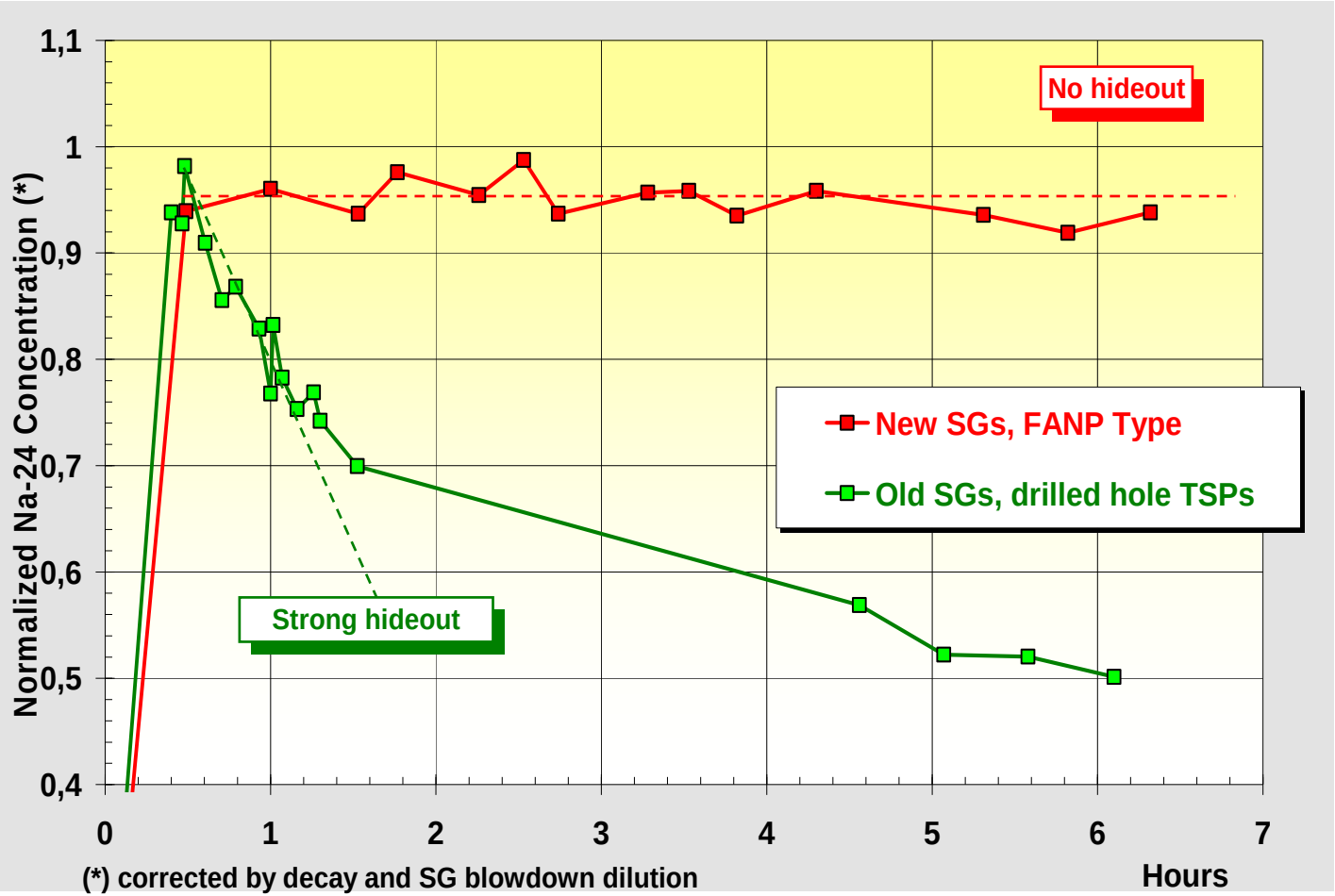
- *Li injection*

> *The higher the hide-out, the higher the corrosion risk*

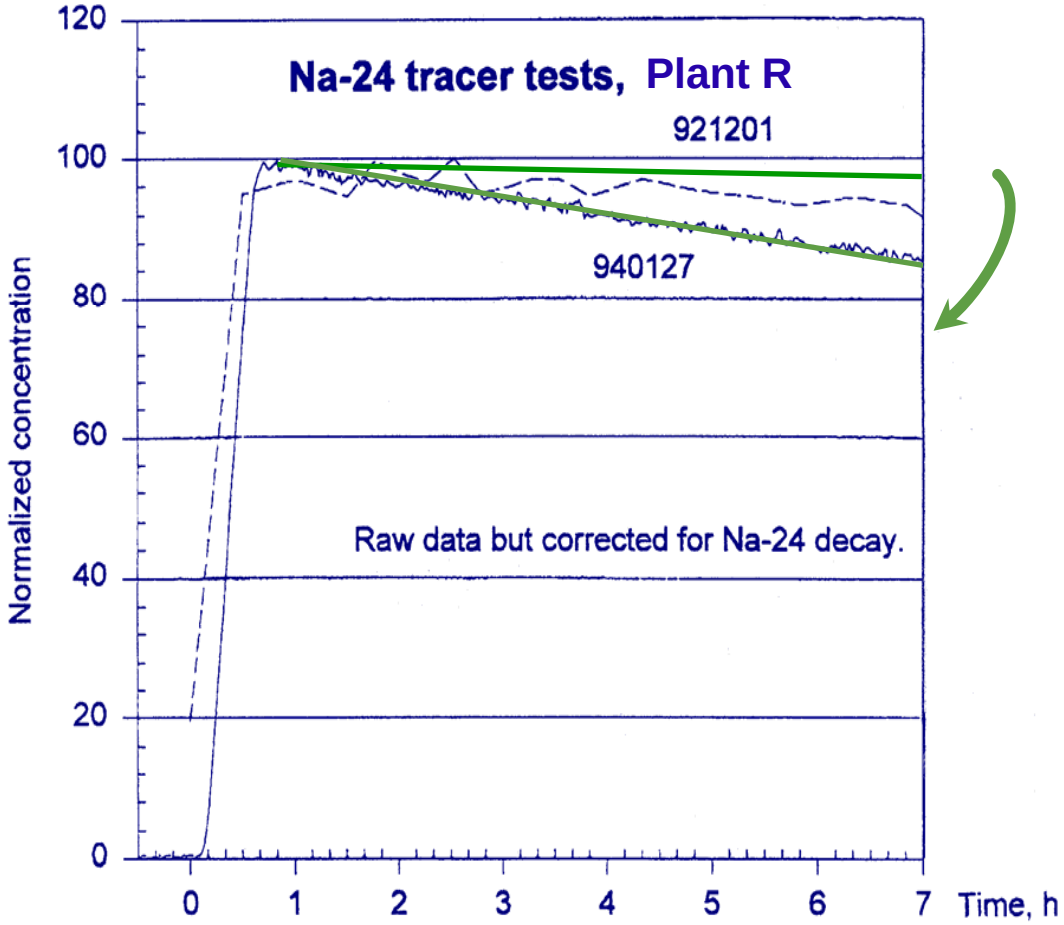
> *Hideout is expected to increase with operating time*

Evaluation of Hideout by Radioactive Tracers
Na-24 Balance

Plant R – Hide-Out Before and After SG Replacement



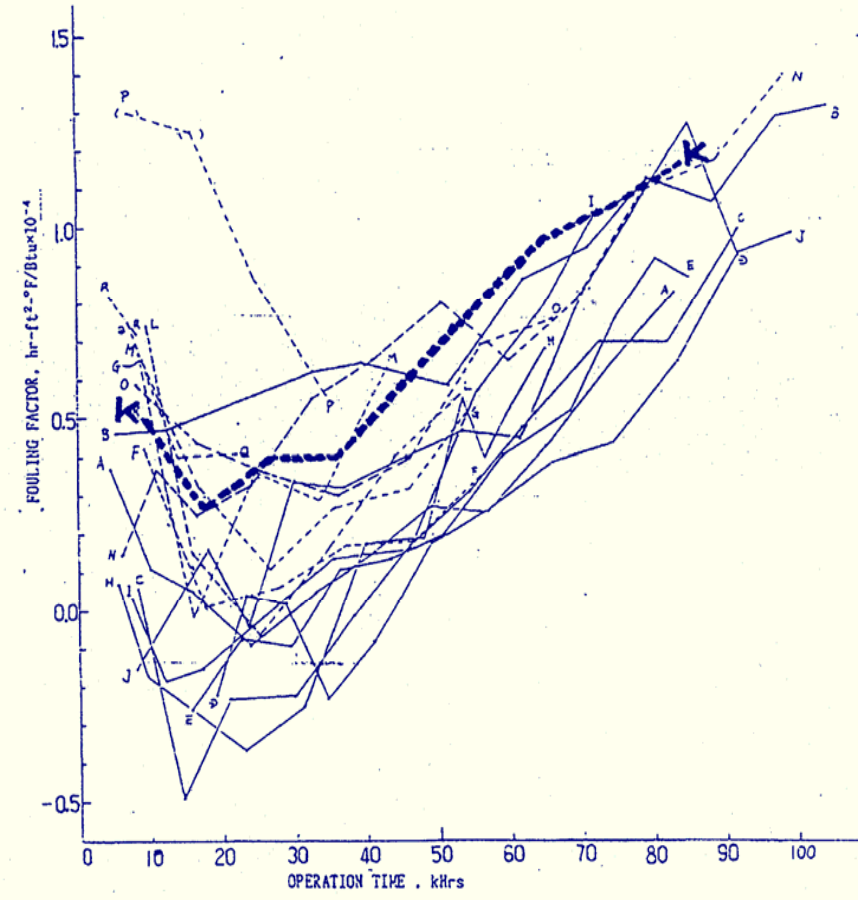
Hide-Out Increase With Operating Time



Power Operation: Steam Generator Tube Fouling

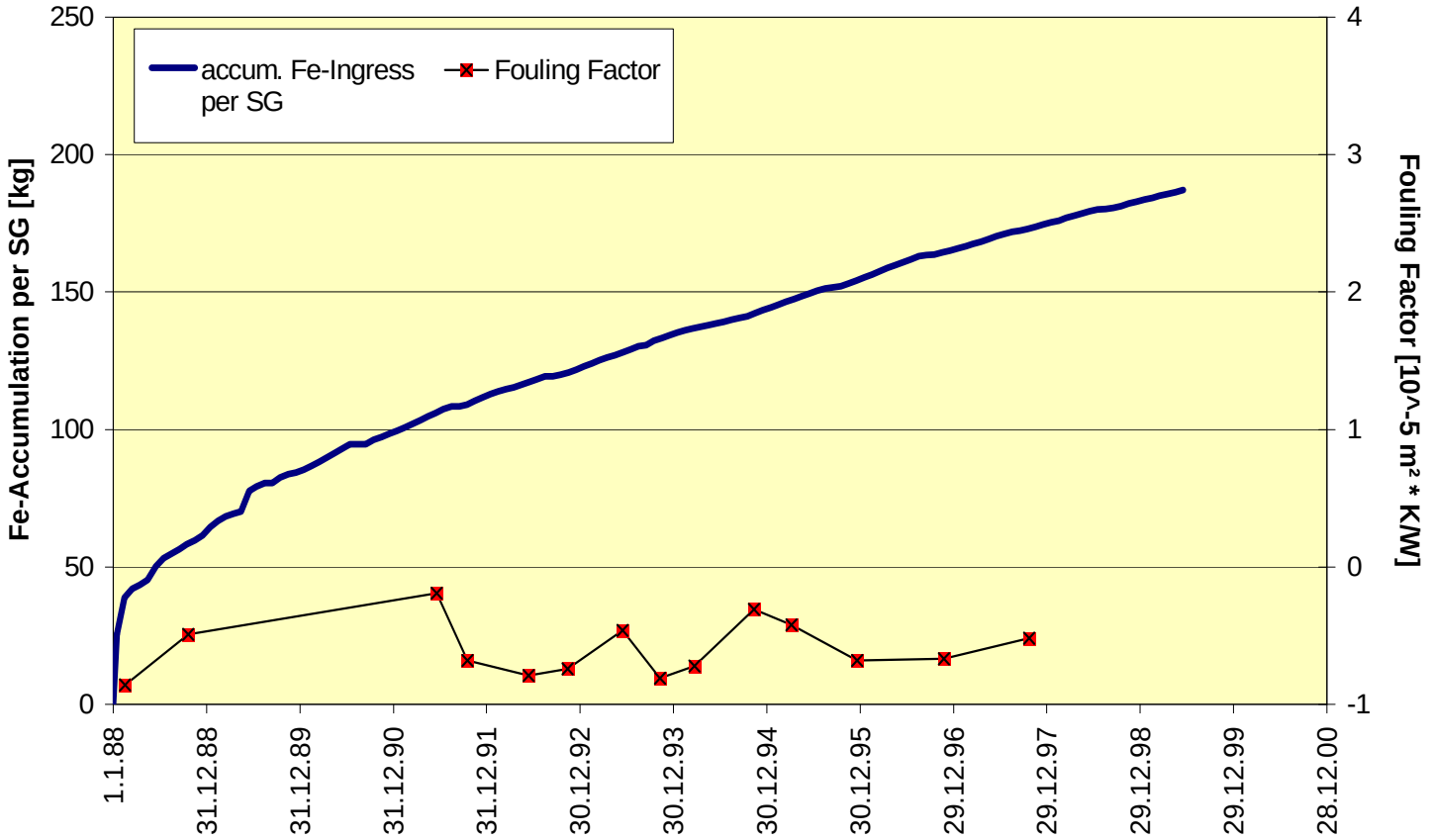
Long Term Fouling Trends - Experience Values

- *Tube scales determine the SG fouling*
  - *Scale morphology*
  - *Scale hickness*
- *Scale growth increases the tube internal surface at the beginning*
  - *Increase of tube heat transfer*
- *With further increasing, the heat transfer resistance starts to be dominant*



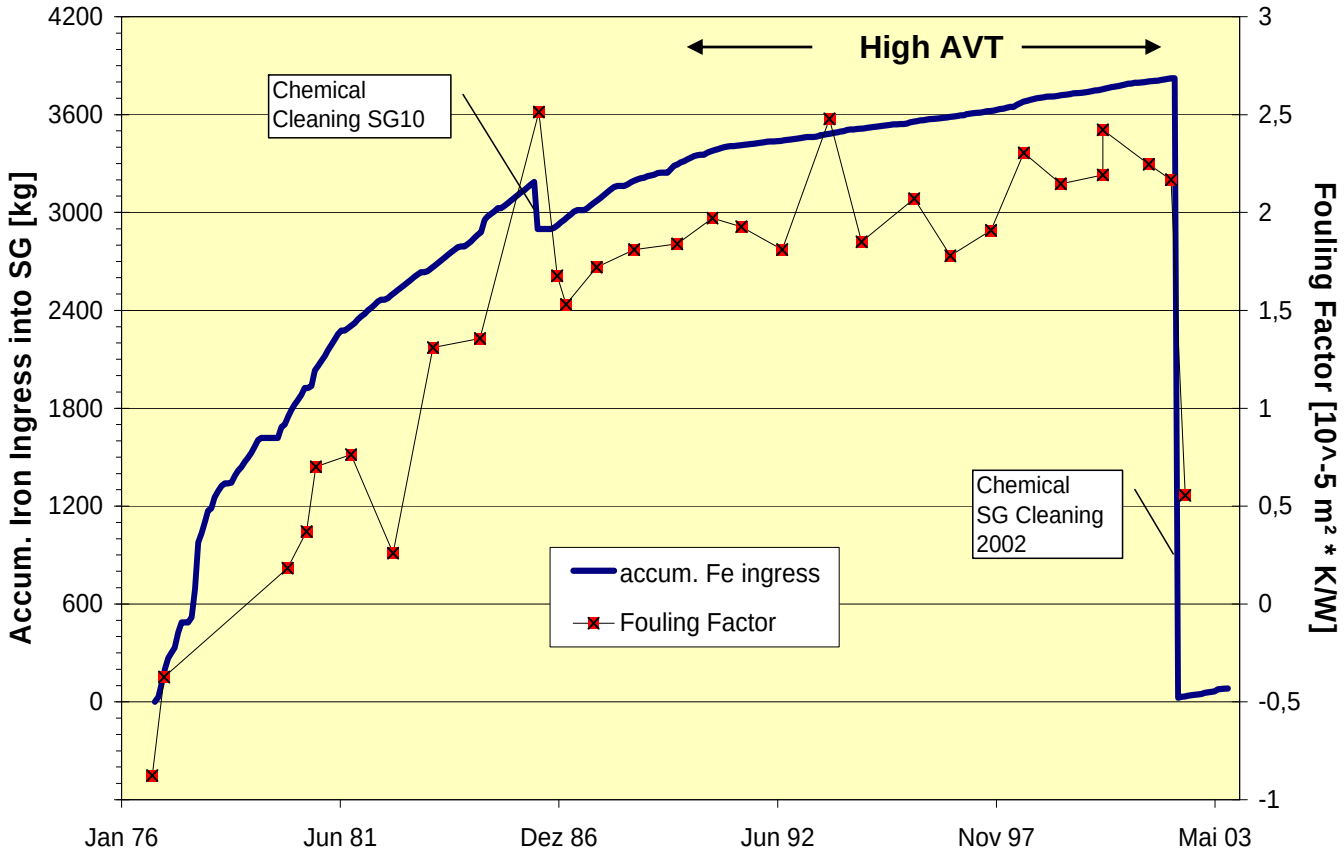
Steam Generator Tube Fouling
Long Term Fouling Trends – High AVT Operated Plants

Plant N – Konvoi Siemens Plant



Steam Generator Tube Fouling
Long Term Fouling Trends – Older Plants

Plant G – Old Siemens Plant



Information Obtained in Outage Activities: Hide-Out Return Measurements

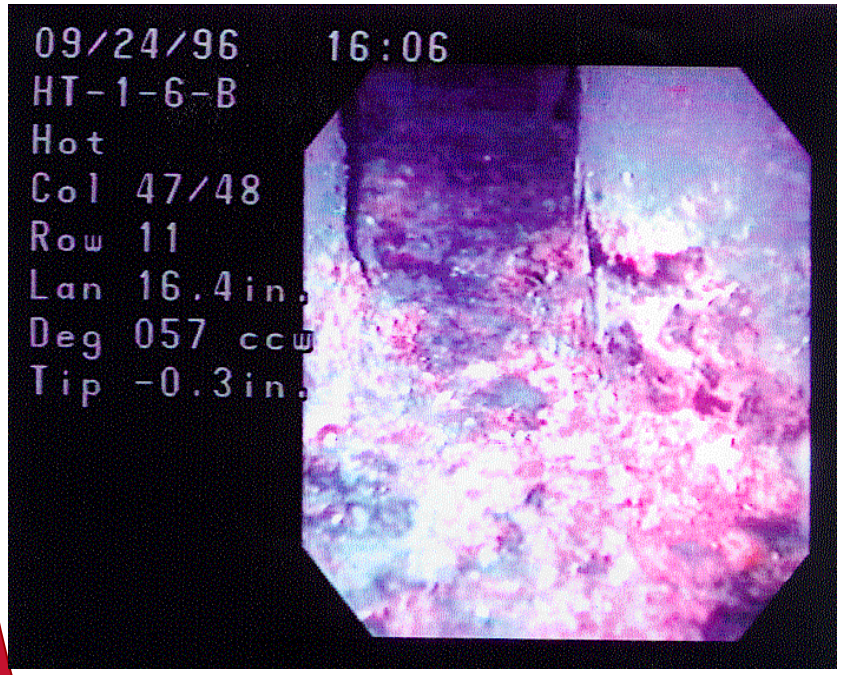
- *High hideout return figures are indicative of impurity concentration (enrichment) in corrosion product deposit areas.*
  - *Long term increasing trend ➔ Alert*
- *Besides, they can provide information about the composition of the impurities concentrated in deposits, and help to assess the pH values in these areas*
- *How to determine the local pH in impurity enrichment areas?*
  - *These can be used to perform pH calculations based on concentration models (e.g. MULTEQ code).*
  - *There is a risk for corrosion at*
    - *pH values < 5*
    - *pH values >8*

Outage Activities
Visual Inspections

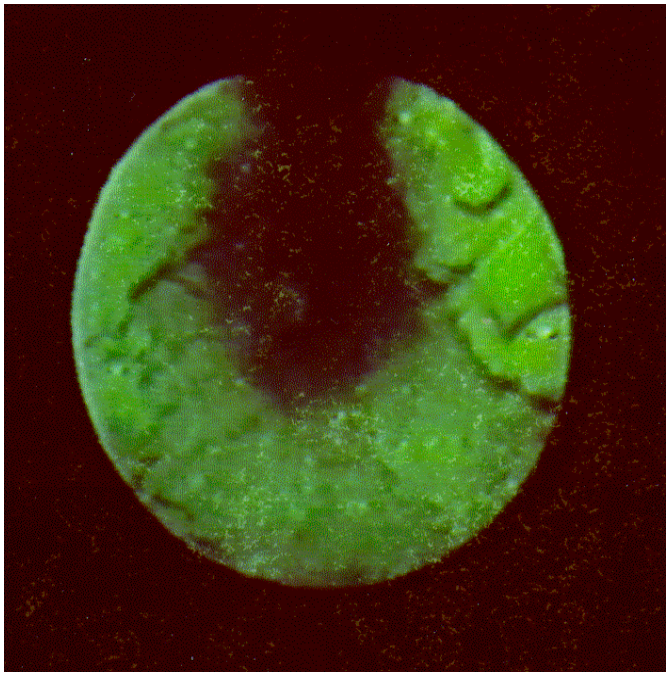
- *Visual inspections required to follow-up the deposit growth on the tube sheet, looking towards*
  - *Amount (pile height)*
  - *Extension (amount of tubes involved)*
  - *Appearance (consistency, colors).*
- *Based on field experience tube sheet sludge, if not removed it becomes hard in 3-4 years and therefore not or hardly removable by mechanical methods*
- *Deposit colors may indicate salt concentration Hard deposits represent a risk for*
  - *Impurity concentration*
  - *Corrosion*

Visual Inspection
Appearance of Tube Sheet Deposits

Colored, hard deposits



Normal magnetite deposits



Outage Activities
Tube Sheet Lancing / Tube Scale Thickness

> *Tube sheet lancing:*

- *Amount: Removal of > 10 kg / SG indicates high iron ingress into SG's*
- *Long term trend: useful for predictive assessment*
- *Analysis of dissolved impurities in the lancing water*
  - *Amount*
  - *Composition*
  - *Trend*

> *Tube scale thickness measurement (oxide mapping):*

- *Scale thickness growth of > 10 µm per cycle indicate high iron ingress into SG's.*

Decision Criteria for SG Cleaning

Parameter	Yes	No
N_2H_4 ratio	<< 1	> 1
Out of Spec. Conditions	Impurity control by HO	Impurity control by Blow down
Hide-Out	> 20 %	< 20 % ?
HO-Return	Acidic / Caustic	Neutral
Tube Fouling	Power loss	Insignificant
Visual Inspection	Colors	Black
TSL	Hard sludge, impurities	No hard sludge, No impurities
Tube scale thickness	High growth rates	Low growth rates

Long-Term Trend Analysis !

Conclusions

- *Plant data are available to assess the long term SG performance*
- *A comprehensive data analysis may enable*
  - *To answer the questions regarding improvement measures*
  - *To establish SG cleaning strategy*
  - *To perform SG performance oriented maintenance*
- *Not individual but all data should be collectively used for decision*
  - *Look to all available parameters*
  - *Establish general trends*
  - ➔ *Take a decision*