RIC 2005

Research Activities Materials Degradation, Session C3

Current Issues – Development and Challenges

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Contents

- Regulations
- Research and experience in materials degradation
- New challenges
- Future challenges
- Research plans

Regulations (1)

Umbrella regulations (SKIFS 2004:1)

- any deficiency in defence in depth shall be evaluated and classified, categories 1 - 3
- licensee obligations include: updated safety and quality system, well prepared safety decisions, sufficient and qualified personnel, feedback of experience, and the continuous development of safety

Regulations (2)

Mechanical Components (SKIFS 2000:2)

- more specific than 2004:1, but still very general
- requires inspection and other programs to ensure integrity
- only qualified inspection and repair procedures permitted
- report and investigate all degradation (according to category within 30 days or annually)
- expand inspection sample up to 100 % if degradation found

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Research activities materials degradation

- In order to ensure the integrity of mechanical components they are inspected in accordance with programmes based on anticipated degradation mechanisms.
- For these inspection programmes to be effective it is essential that the factors which affect the degradation mechanisms are well understood, and that the morphology is well defined so that appropriate inspection techniques can be developed.

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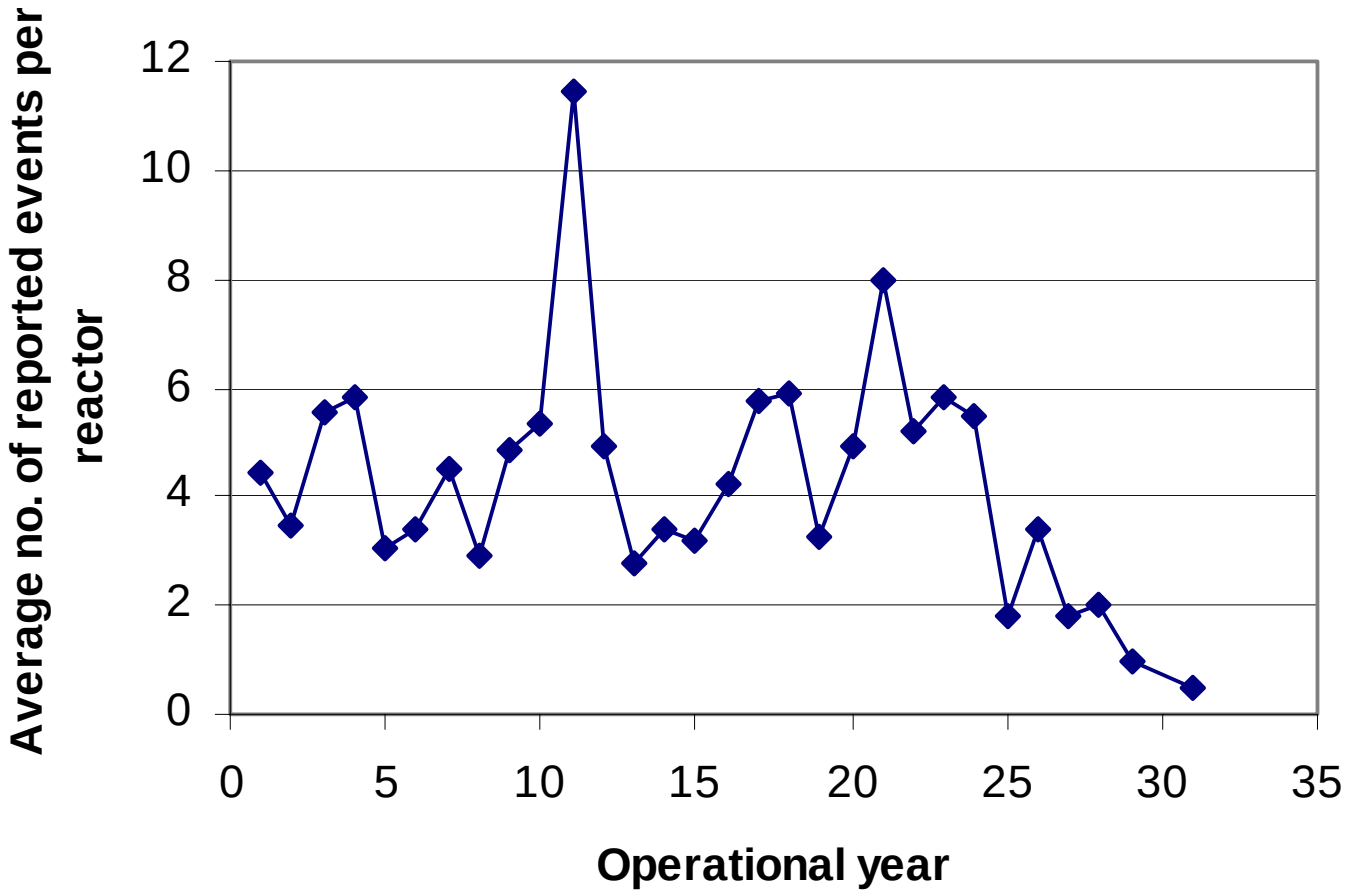
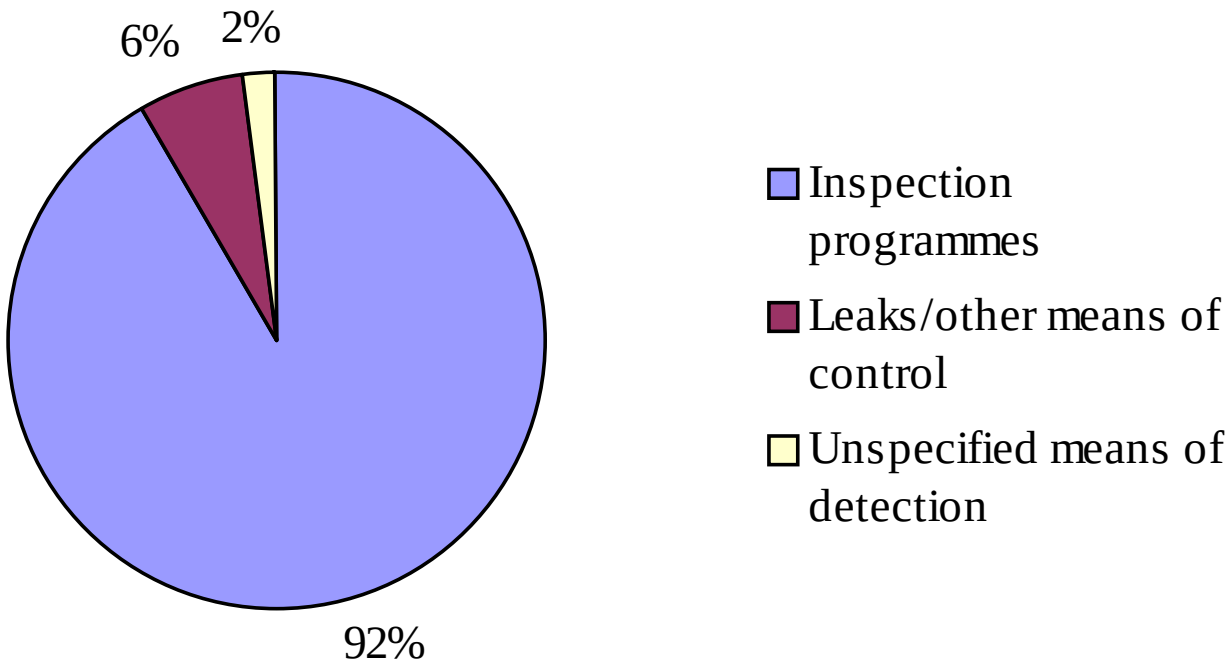
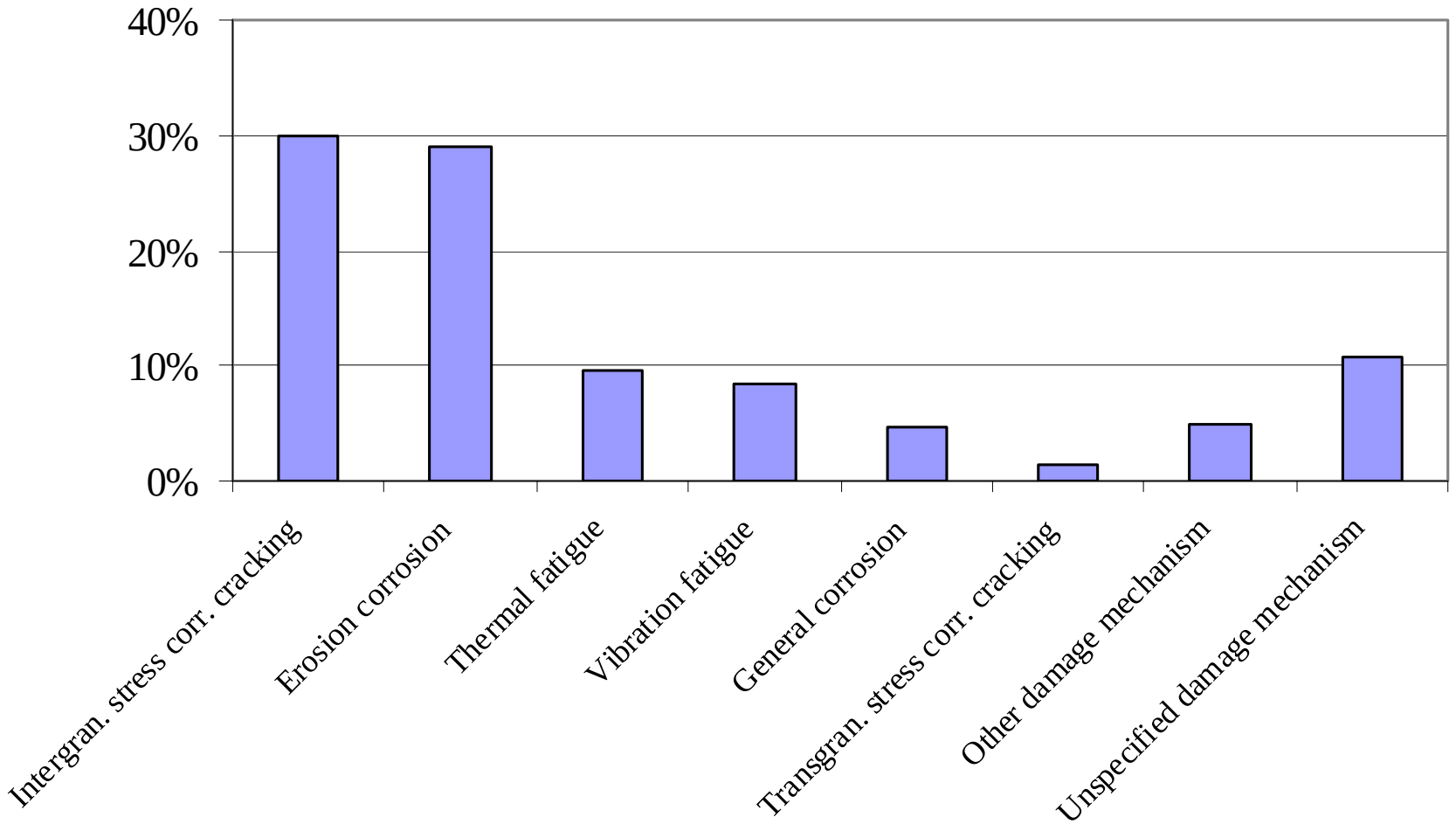
Database of reported degradation



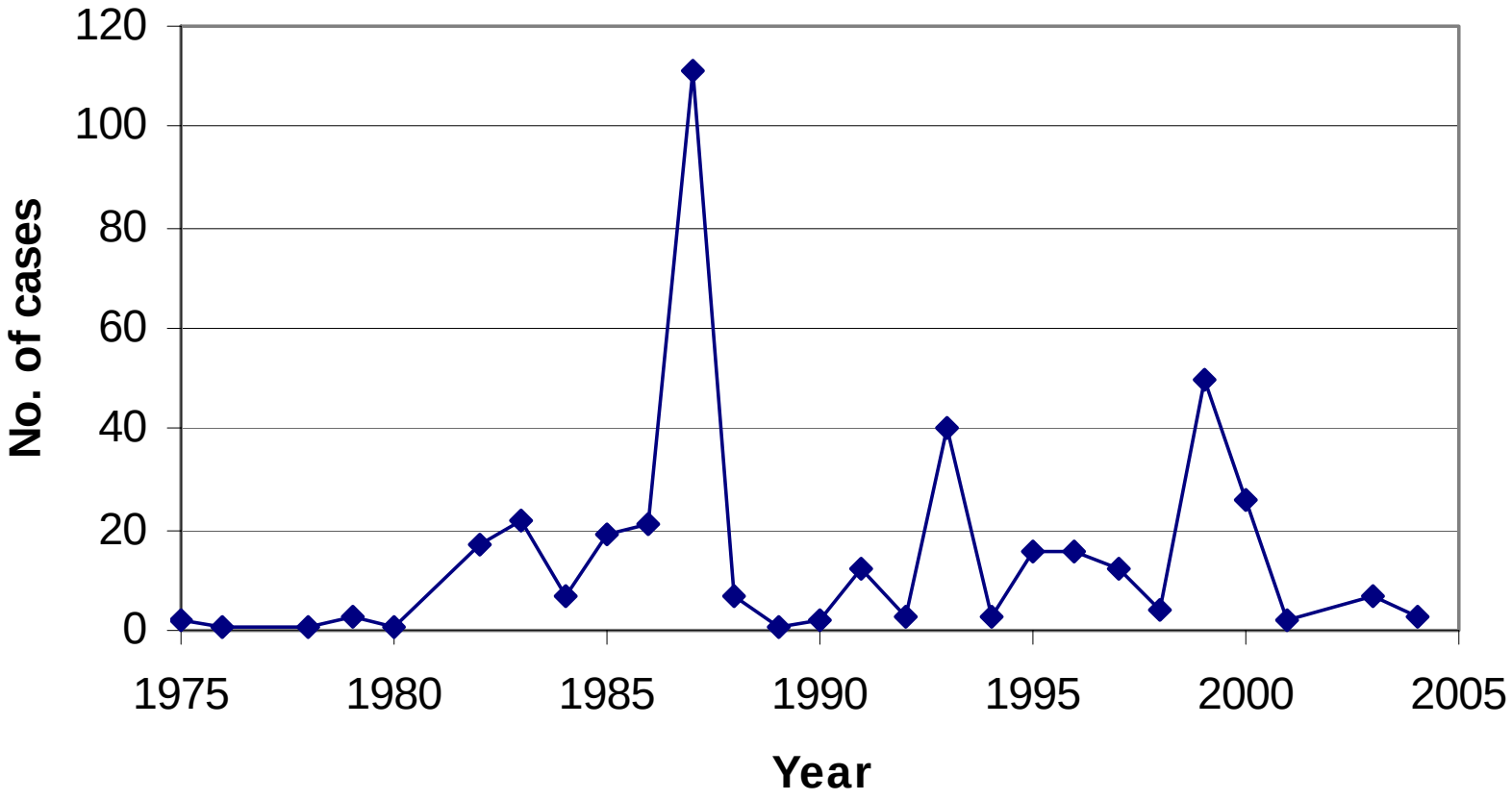
Effectiveness of Swedish inspection programmes: Damage detected in mechanical components



Most frequent degradation mechanisms in Swedish reactors

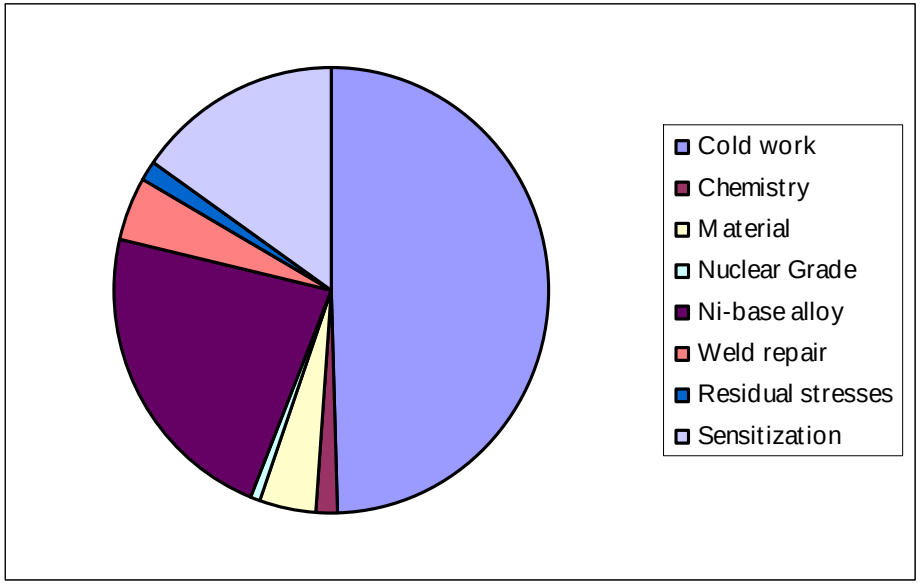


Cases of intergranular stress corrosion cracking (IGSCC) from STRYK database



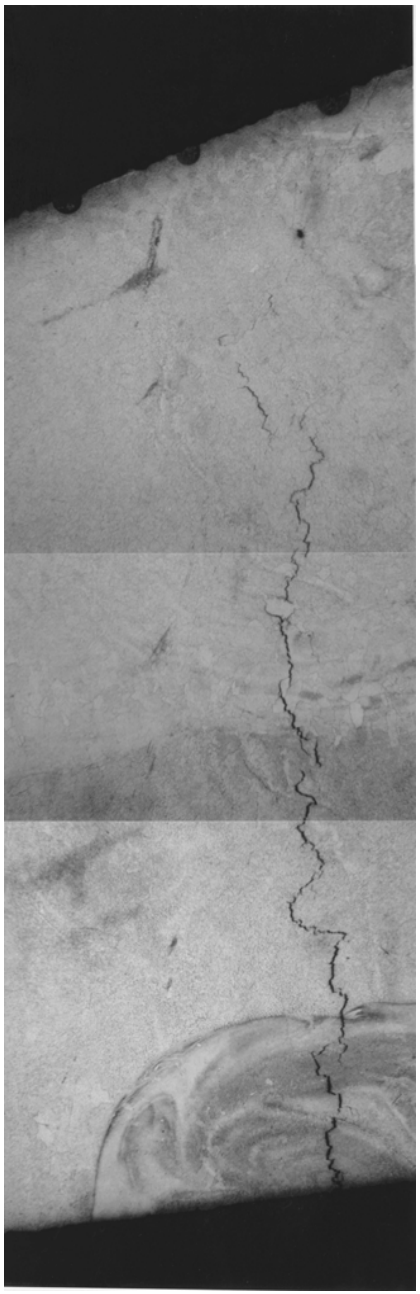
Primary causes of IGSCC

- Cold work dominant not only pipe bends but also as result of surface deformation
- Nickel-base alloys (182, 600, X750) including some associated with weld repairs
- Sensitisation first in third place most cases with C > 0,04 %
- Repairs often found in affected welds



New challenges

- Experience shows that degradation is found in components manufactured of material previously considered immune:
- Nuclear Grade stainless steel in BWR
- Nickel base alloys in PWR
- An important tool in these cases is the removal of the cracks from the plant for further characterisation.



Crack in Inconel 182 weld metal from Ringhals 4 safe end, showing the complicated morphology and repair weld.

The crack is tight, and discontinuous, making ultrasonic detection and sizing difficult.

The characterisation of real defects can help in the development of simulated defects for qualification of NDE techniques.

On going research: Stress corrosion cracking

- Participation in Swedish and Japanese collaborative programmes on the initiation and propagation of stress corrosion cracking in Nuclear Grade material in BWR:s.
- Participation in NRC:s collaborative programme on NDE and morphology of stress corrosion cracking in nickel base alloys in PWR:s.

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Future challenges

- Deregulation
- Power uprates
- Aging management
- Risk informed inspection

Future challenges – Deregulation

- Qualification of NDE techniques for both detection and sizing of degradation must not be compromised in a regime where cost reduction is a leading factor.
- The effectiveness and quality of NDE plays a key role in risk informed inspection programmes.
- Knowledge of degradation mechanisms and their propagation rates aids assessment of the need for immediate measures or interim actions enabling a well planned repair and/or mitigation techniques.

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Future challenges – Power uprates

- Temperature increase
  - Corrosion processes (including stress corrosion cracking) are temperature dependent - increasing the temperature increases the corrosion rate
  - Creep of reactor pressure vessel nozzles?
- Flow rate effects
  - Increases in flow rates can affect erosion corrosion
  - Changes in flow rates and flow patterns can subtly change the loading conditions leading to vibration fatigue
- Higher neutron doses
  - Increase reactor pressure vessel embrittlement
  - Increase risk for Irradiation Assisted Stress Corrosion Cracking of reactor vessel internals
  - Swelling?

Future challenges – Aging management

Knowledge of under which conditions different degradation mechanisms can occur is essential

- for an effective control and inspection programme which will guarantee that damage is detected early before the integrity of a component has deteriorated to an extent which can threatens defence in depth in particular for components for which mitigation measures (including replacement with new materials) are inadequate
- assessment of the effectiveness of the utilities aging management programmes

Future Challenges - Risk Based Inspection

- An understanding of the potential degradation mechanisms is essential for assessing risk based inspection programmes.
- Trend analysis of the occurrence of degradation mechanisms in different plants and materials is a valuable tool for such assessments.
- Containment to be included in the revised regulations for mechanical components which are expected to come into force before the end of 2005.

Research plans

- The Office of Reactor Safety has recently revised its research plan to ensure that these and other regulatory challenges will be supported by its research in the coming years.