NKS PODRIS project

Importance of inspection reliability assumptions on piping failure probability estimates

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Contents

- Introduction
    - Relation to nuclear safety
    - Assessment of structural component reliability
    - Risk-informed in-service inspections
    - Challenges in assessment of failure probabilities and risk reduction related to inspections
- Aims of the PODRIS project
    - Studies of the importance of POD assumptions
    - Benchmarking of structural reliability models
- Preliminary results

Introduction Relation to nuclear safety

Failures of structural components (e.g. piping)

- leakages / ruptures lead to reduction of loss of the pressure retaining capability of the system & can have secondary effects
- contribute to the plant risk

In-service inspections (ISI)

- aim at verifying that defects are not present in components of pressure boundaries
- or, if there are defects, ensuring that these are detected before they affect the safe operation of the plant

Reliability estimates of piping (& other structural components)

- needed e.g. in PSA studies, risk-informed ISI applications, structural reliability assessment

Effectiveness of ISI

- Affects the reliability of piping components by increasing the knowledge of the state of the inspected components

Introduction

Assessment of reliability of structural components

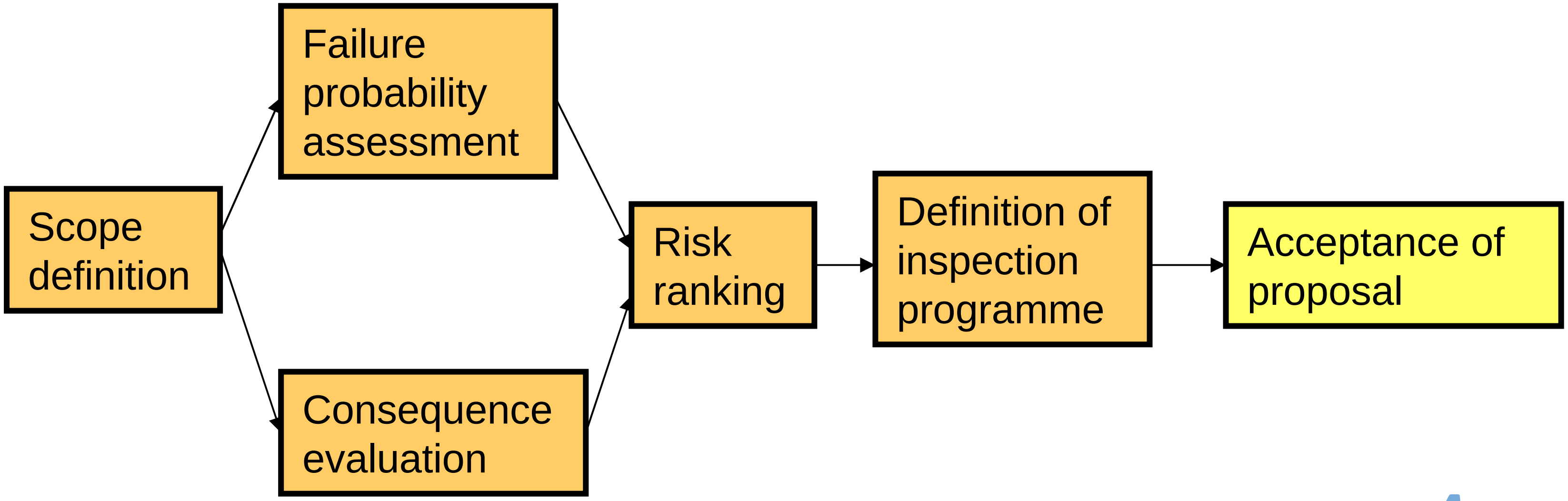
Failure probabilities of structural components are assessed by

- Estimating from operating experience data
- Performing probabilistic fracture mechanics calculations
- Using expert judgement

- Assessment of the ISI influence on failure probability difficult (impossible?) from operating experience data
- Probabilistic fracture mechanics models can account for the ISI effectiveness and interval, and allow sensitivity studies

Introduction Risk-informed in-service inspections

- RI-ISI aims at rational in-service inspection management by taking into account the results of plant-specific risk analyses
- The fundamental idea is to identify high-risk locations where the inspection efforts should be concentrated

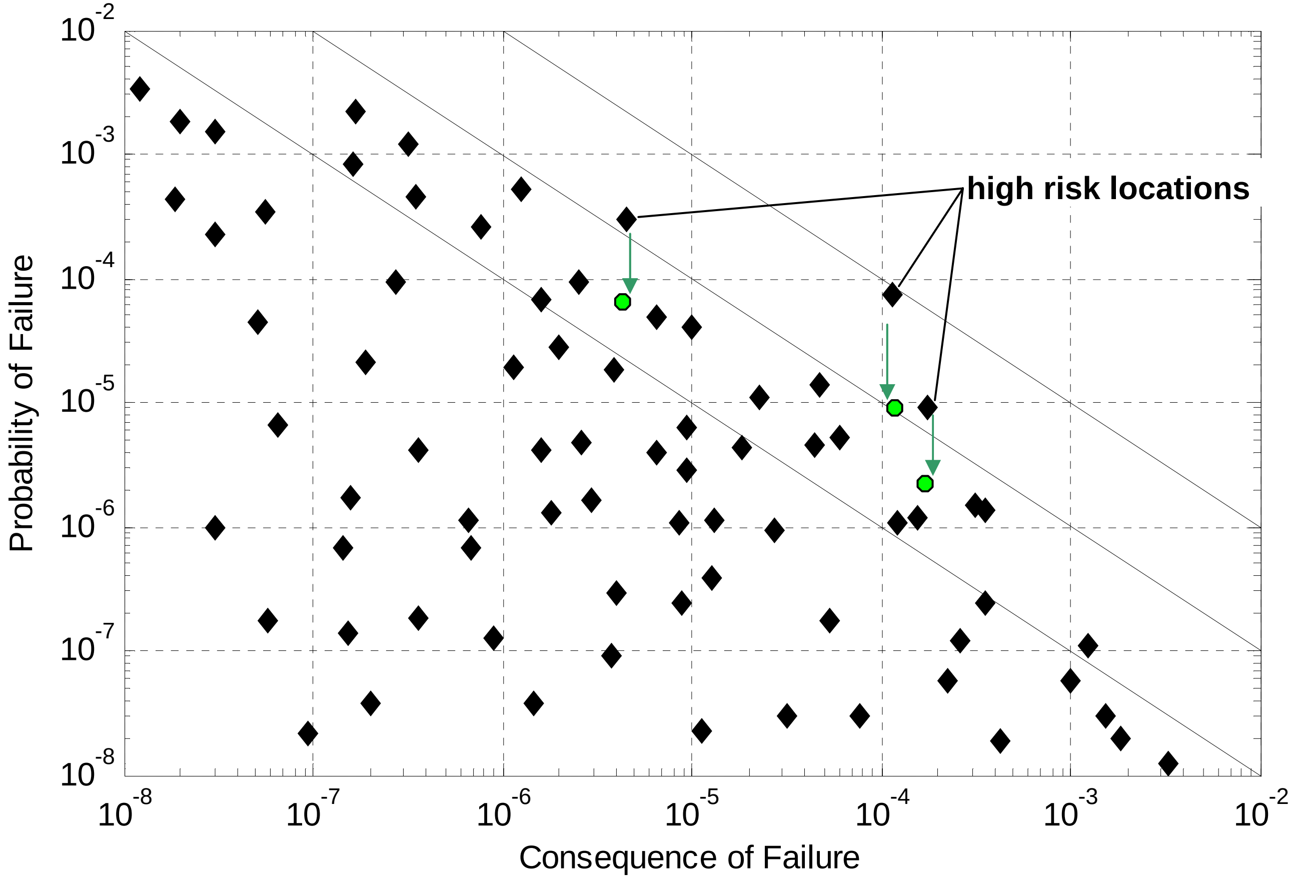


Risk = *pof* x *cof*

Consequence of failure

Probability of failure

Best benefit of inspections is obtained when inspections are focused to high-risk locations, and the reliability of these inspections is high



Introduction

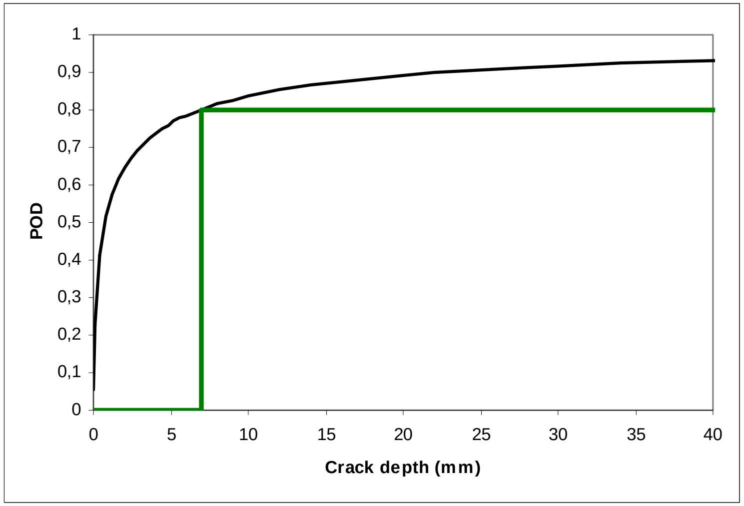
Challenges in assessment of failure probabilities and risk reduction related to inspections

Lack of confidence in probabilistic fracture mechanics calculations due to e.g. large uncertainties in input parameters

- Even if calculated absolute failure probabilities can be questioned, often provides a plausible relative ranking

Lack of confidence in probability of detection (POD) estimates

- POD typically expressed as function of flaw depth, but it depends on several factors
- Very difficult and expensive to produce statistical data to estimate PODs
- How detailed PODs are needed in e.g. RI-ISI applications?
- Could simplified (conservative) estimates be used? (More easily acceptable)



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Aims and expected results:

- Study the effect of POD assumptions on failure probability and thus to risk impact
- Compare structural reliability calculations of selected cases
- Depending on the benchmarking results, the study either identifies differences and their reasons, or (if results are coherent) provides added confidence on the use of benchmarked approaches.
- The results can be utilised in application and evaluation of quantitative RI-ISI analyses
- The results might justify the use of rather simple POD curve assumptions in RI-ISI. Such simplified POD curves would be much easier to derive and justify e.g. from the inspection qualification process than more complex functions
- In some cases the result may also justify relaxation of the required inspection capability and qualification

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Selection of a set of cases to be analysed:

- Piping welds under varying loading and environmental conditions
- A set of probability of detection (POD) functions are defined

Analyses of selected cases:

- Using independently various tools of the participants to calculate the same base cases
- Sensitivity studies

Comparison of results:

- Benchmarking of the tools
- Evaluation of the impact of various assumptions on the results, especially POD

Reporting in a NKS report (June 2009)

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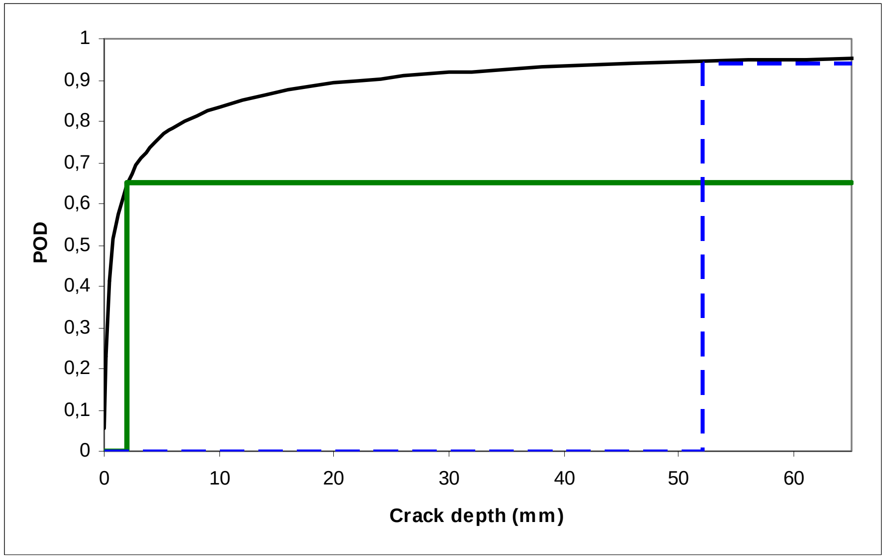
Example of analysis / preliminary results:

PWR primary loop, wall thickness ~ 65 mm, degradation mechanism stress corrosion cracking



Risk reduction compared to the case without inspections:

	TeamA	TeamB
Full-POD	99 %	99,9%
"Low" POD	94 %	98 %
"high" POD	25 %	17 %

Relatively small effect of the POD simplification from "full POD" to conservative step function with low detection threshold