CRA
risk analysis

PSA in the USA

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Introduction

Risk Informed (RI) applications

- Risk Informed (RI) Applications are used by nuclear site licensees to optimise safety and maintenance activities.
- This means focussing on the maintenance activities that give the greatest risk benefit.
- Probabilistic Safety Assessment (PSA) models are used as part of RI applications in order to quantify the associated change in risk and identify the most risk significant components.

Introduction

US Regulatory Framework

- The US nuclear industry is regulated by the Nuclear Regulatory Commission (NRC).
- The US NRC has traditionally adopted a deterministic, prescriptive based, approach to regulation.
- They are moving towards a risk-informed, performance based, approach and encourage the use of Risk Informed Applications.

Introduction

US NRC Risk Informed Regulatory Guidelines

Regulatory Guide	Description	Primary Regulation covered
RG 1.174	General approach for using PSA in RI Decisions	10 CFR50.90

Regulatory Guide	Description	Primary Regulation covered
RG 1.175	RI In-Service Testing	10 CFR 50.55a(f)

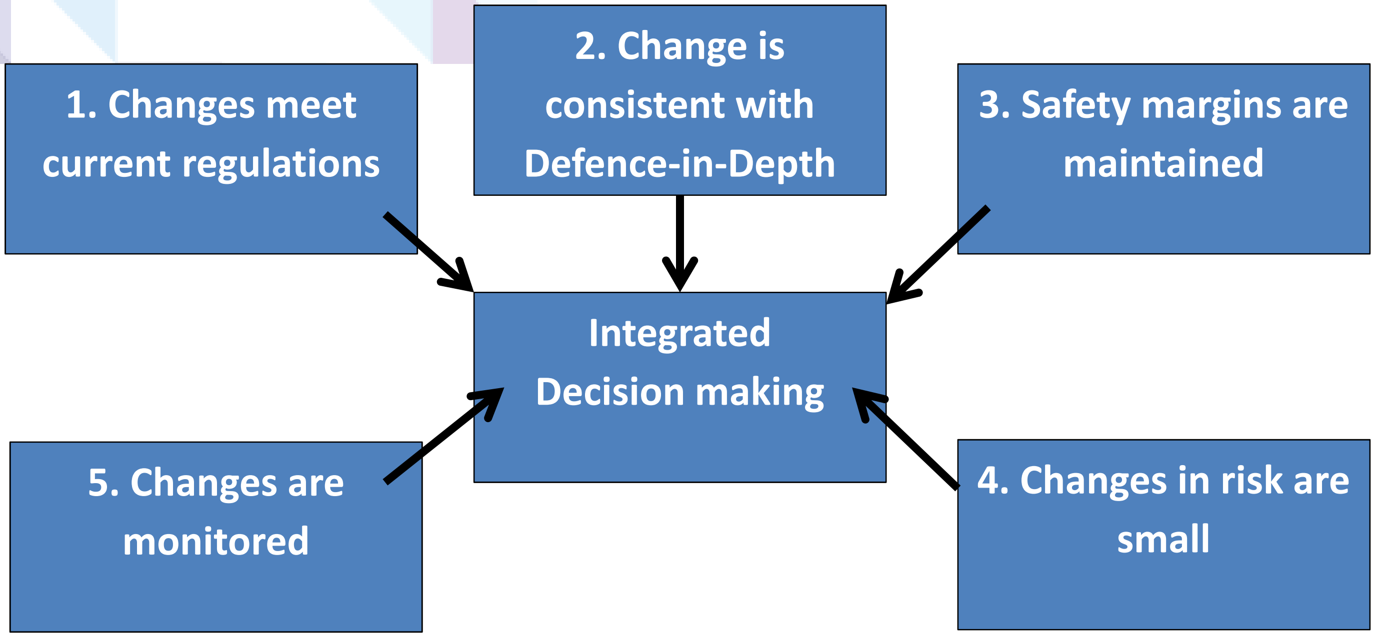
Regulatory Guide	Description	Primary Regulation covered
RG 1.178	RI In-Service Inspection of Piping	10 CFR 50.55(a)(3)(i)

Regulatory Guide	Description	Primary Regulation covered
RG 1.177	RI Technical Specifications	10 CFR 50.36

US NRC Guidelines

General Approach – RG 1.174

- 5 Key Principles:



US NRC Guidelines

General Approach - RG 1.174

- Four steps involved:
  1. Define the proposed change
  2. Perform Engineering Analysis
     a) Deterministic Analysis
     b) Probabilistic Analysis
  3. Define an implementation/monitoring programme
  4. Submit the proposed change
- It is an iterative process

US NRC Guidelines

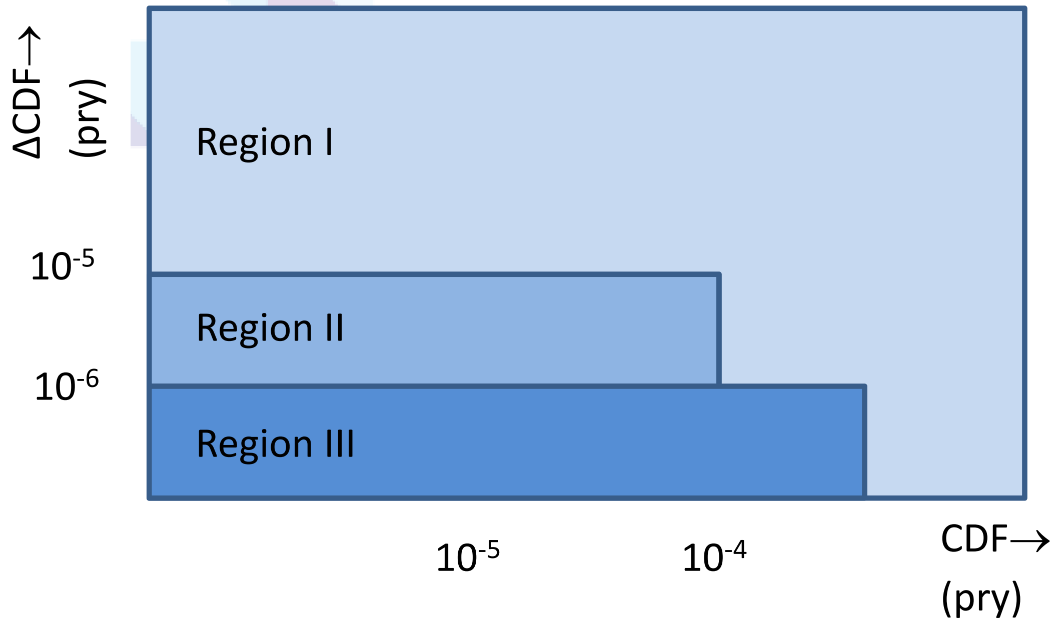
General Approach - RG 1.174

- Engineering Analysis
  - Defence in depth – some considerations:
    - Balance between the layers of defence
    - Preserve adequate capability of design features without overreliance on compensatory measures
    - Preserve system redundancy, independence and diversity
    - Preserve defence against CCFs
    - Preserve defence against human errors
  - Sufficient Safety Margins are maintained
  - Proposed increases in risk are small

US NRC Guidelines

General Approach - RG 1.174

- NRC risk acceptance guidelines are based on two risk metrics:
  - Core Damage Frequency (CDF)
  - Large Early Release Frequency (LERF)



- Shown for CDF only (similar guidelines apply to LERF)
- There is some flexibility (if justifiable)

US NRC Guidelines

General Approach - RG 1.174

- Determine the acceptability of PSA model:
  - Sufficient scope
  - Level of detail
  - Conformance to standards
  - Plant representation
- Determined for the intended application
- There is a separate detailed RG on the acceptability of a probabilistic assessment (US NRC RG1.200) that is referenced from RG 1.174

US NRC Guidelines

General Approach - RG 1.174

- Determine the level of uncertainty in the PSA results:
  - Identify the contributors and scale of the uncertainty
  - Perform sensitivity studies to show the uncertainty is acceptable
  - Limit the change to avoid uncertainty where necessary
- Assessments require an independent peer review

US NRC Guidelines

Specific Applications (Examples)

- Risk Informed Technical Specifications (RG 1.177)
- Risk Informed In-Service Inspection of Piping (RG 1.178)
- Risk Informed In-Service Testing (RG 1.175)

US NRC Guidelines

Risk Informed Technical Specifications – RG 1.177

- Technical Specifications are used to control the operation of nuclear power plants.
- They describe allowable configurations of equipment and give time limits for how long the plant is allowed to operate outside these configurations (Completion Times)
- For Light Water Reactors (LWRs), they also describe maintenance test intervals for safety significant components (Surveillance Frequencies).
- These are the two aspects of technical specifications that are generally the subject of RI proposed changes

US NRC Guidelines

Risk Informed Technical Specifications – RG 1.177

- Reasons for changes to Technical Specifications:
  - Improvement in operational safety
    - Reduce the surveillance frequency where testing leads to excessive wear and reduced reliability
    - Reduce the risk of unplanned shutdowns where the Completion Time is unnecessarily short
  - Reduce burden for the licensee
    - Increase Completion Time, or increase Surveillance Test Intervals for risk insignificant components
    - These changes will lead to an increase in risk, which will need to be justified
- Changes to the Technical Specifications cannot be justified based on PSA results alone

US NRC Guidelines

Risk Informed Technical Specifications – RG 1.177

- A three tiered approach is proposed:
  - Tier 1 – Assess the impact of the TS change on risk metrics
  - Tier 2 – Identify the most risk significant failures when in the Tech Spec configuration
    - Compensatory Measures should be developed (examples to follow)
  - Tier 3 - Do some further investigation into risk significant configurations

US NRC Guidelines

Risk Informed Technical Specifications – RG 1.177

- Examples of Compensatory Measures:
  - Limit the simultaneous testing and maintenance of redundant or diverse trains
  - Incorporate staggered testing
  - Add a test of a redundant train before initiating a scheduled maintenance activity

Risk Informed Technical Specifications – RG 1.177

Examples from Industry – South Texas Project

- Implemented Risk Informed Tech Specs (RI TS) in 2007 – first in US
- Resulted in an extended operational envelope (claimed to be largest amongst any US commercial NPP)
- RI TS used eight times over a four year period to allow plant operation past the original Tech Spec Completion Times
- Examples of RI Completion Times being used to allow the replacement of components when at-power. Original deterministic completion times were too short.
- Compensatory measures in place:
  - Replacement parts fully tested before installation
  - Mock-up training performed
  - Admin controls were used to protect redundant trains, channels and equipment
  - Plans in place for emergent failures of most risk-significant components

Risk Informed Technical Specifications – RG 1.177

Examples from Industry – Vogtle NPP

- Proposal to implement RI Completion Times (RICTs) across the Tech Specs
- Number of controls proposed, e.g.:
  - The RICT may not exceed 30 days;
  - When a RICT is in use, any further plant configuration change must be considered for the effect on the RICT;
  - Use of a RICT is not permitted for voluntary entry into a configuration that represents a loss of a specified safety function;
- PSA reviewed against the proposed RICTs to identify any gaps – led to some changes to the PSA and some CTs being removed from the proposal
- External hazards omitted from the analysis on low frequency grounds

Conclusions/Summary

- In the US, PSA is being used increasingly as part of RI applications.
- The benefit of RI applications is optimised safety and maintenance.
- Its use is encouraged by the US regulator.
- Requires a combination of probabilistic and deterministic analysis.
- Some examples from industry have been presented together with some of the significant benefits/issues raised