# General Concept for the Integrity of Pressurized Components
# (Integrity Concept for Safety Significant Systems in NPP's)

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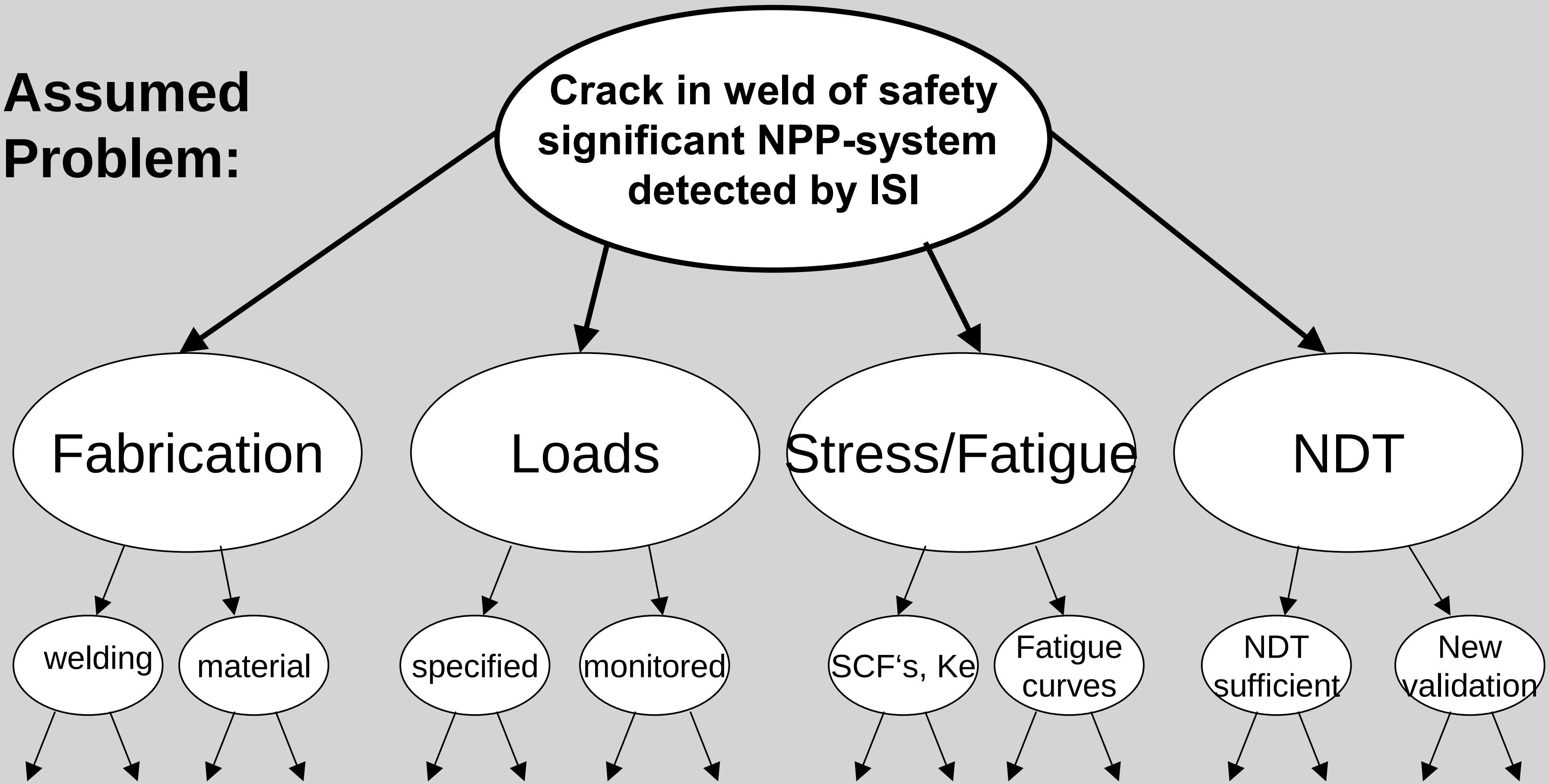
# Scope of Presentation

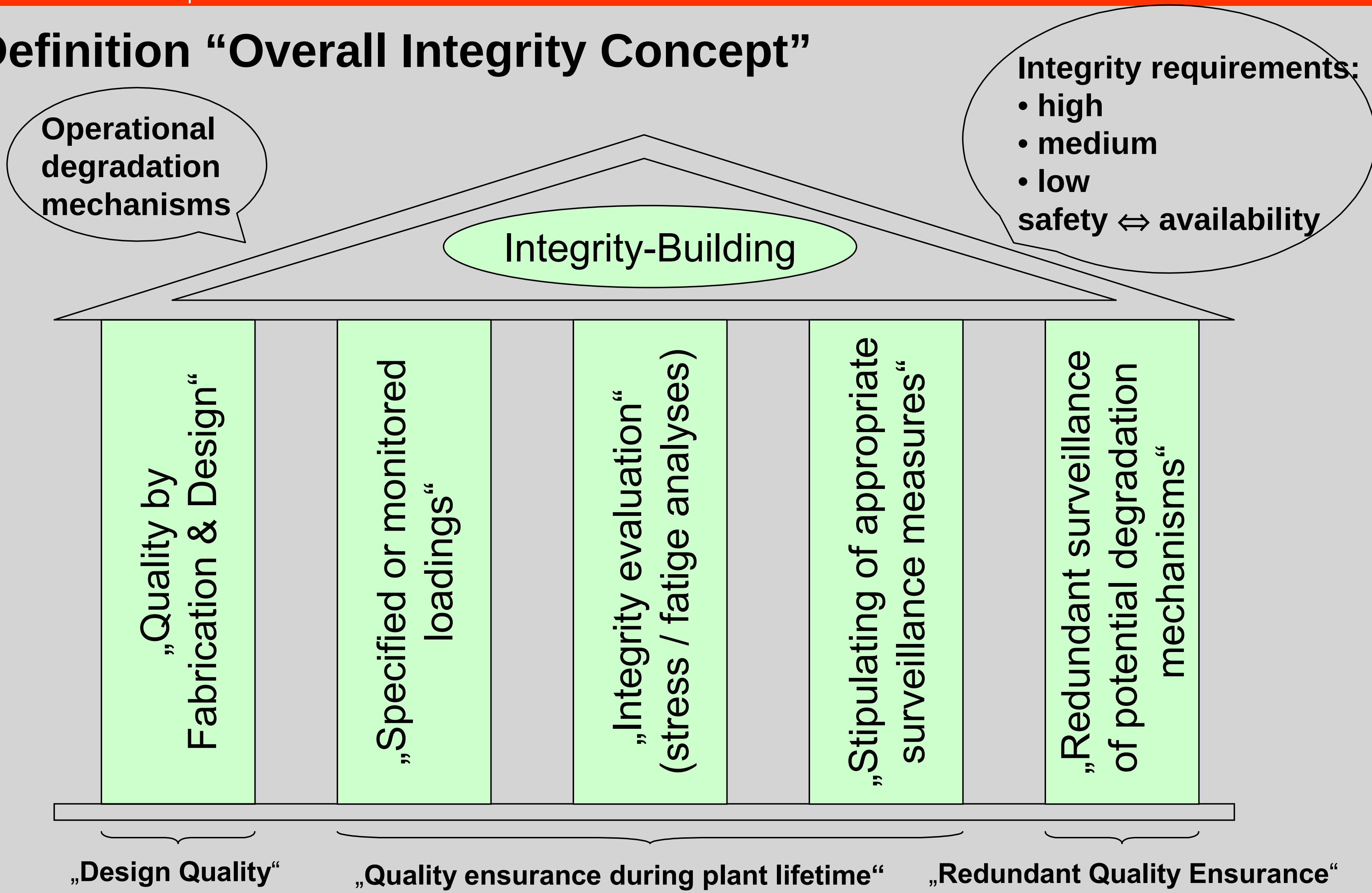
- Definition „Overall Integrity Concept“ (Integrity Building)
- Field of „Overall Integrity Concept“ Applications
- German Safety Regulations
- Integrity Concept Elements and Mutual Interaction
- Application Examples

# Example of “No Concept Approach”

**Assumed Problem:**



# Definition “Overall Integrity Concept”



# Field of “Overall Concept Applications”

- **Periodic Safety Analysis (PSA)**
- **Leak before Break Assessments (LBB Break Preclusion)**
- **Optimization of NDT-Measures (Extending intervalls, Optimization of NDT-Extents)**
- **Ageing Management**
- **General Integrity Evaluations**

# German Safety Regulations

- **German Atomic Law**
- **German Safety Criteria for Nuclear Power Plants**
- **Reactor Safety Commision (RSK) -Guide Lines (German Basic Safety Concept)**
- **Problem Specific RSK-Statements and GRS-Generic Letters**
- **Plant Specific Requirements imposed by Local Safety Authority**

contain basic requirements for **continuous precaution measures** according to “the state of the art”

including demands concerning
**surveillance of safety relevant systems** and
**redundant safety measures**

# Codes & Standards (Fulfilment Rules)

German KTA-Rules for Class 1-Components:

KTA 3201.1 - Materials
KTA 3201.2 - Design and Analysis
KTA 3201.3 - Fabrication
KTA 3201.4 - In-service Inspection and Surveillance

to compare with
ASME III (Design) and Related ASME-Sections
ASME XI (Operation) and Related ASME-Sections

# Integrity Concept Criteria

- **Define System/Component Safety/Availability Significance**
- **Determine Current System/Component Quality Status**
  - **Quality originally provided by design and fabrication affected by relevant effects from operation so far?**
    - **The root causes of operational degradation mechanisms are known and under surveillance?**
    - **Resulting impacts on the integrity have been evaluated and and conclusions have been drawn?**
    - **Redundant ISI-/surveillance-measures of potential consequences of operational degradation mechanisms are still appropriate?**
  - **Relevant changes of "the state of the art" have been considered?**

- **Administrative procedures must be established for transparent documentation and delivery of results (e. g to safety authority)**

# NPP-Safety Relevant Systems

Class 1-Systems and Systems required for safe Plant Shut Down.

Further ranking within these safety relevant systems

*Group 1 component criteria:* — *high safety reqirements*

"guarantee" required component quality

*Group 2 Redundant components' criteria:* — *medium safety requirements*

"preserve" required component quality

*Group 3 component criteria:* — *lower safety requirements*

Replace component after failure

# Group 1 Component Safety Criteria

"Guarantee" required component quality
"Component must not fail!"

- Reactor Pressure Vessel
- Systems with "leak before break" requirements
- Others? (for specific safety or plant availability reasons?)

Evaluate Present System Quality Status
(Originally provided by design and fabrication and affected by relevant effects from operation so far, if appropriate)
+
Proactive surveillance/monitoring of root causes of operational degradation mechanisms (e. g. loadings )
+
Reactive surveillance of consequences of operational degradation mechanisms (ISI, NDE, Others)
+
Proactive considering of "the state of the art"

Proactive Approach: Avoid/Minimize premature degradation effects
Reactive Approach: Deals with degradation effects after they have been detected

# Group 2 Redundant Components' Safety Criteria

"Preserve" required Component Quality

Singular Case Failure no Safety Problem (No common cause failure acceptable)

- e. g. Valves
- Others? (for specific safety or plant availability reasons?)

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Evaluate Present System Quality Status

(Originally provided by design and fabrication and affected by relevant effects from operation so far, if appropriate)

+

Reactive surveillance of consequences of operational degradation mechanisms (ISI, Maintenance, NDE)

+

Proactive considering of "the state of the art"

Proactive Approach: Avoid/Minimize premature degradation effects

Reactive Approach: Deals with degradation effects after they have been detected

**Additional proactive approach required for specific safety or plant availability reasons?**

# Group 3 Component Safety Criteria

"Component Replacement after Failure"
Singular Case Failure no Safety Problem (No common cause failure acceptable)

- e. g. Small Components
- Others?

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Establish Present System Quality Status provided by Design and Fabrication
+
Reactive replacement, if consequences of operational degradation mechanisms occur (ISI)
+

Reactive Approach: Deals with degradation effects after they have been detected

**Additional proactive approach required for specific safety or plant availability reasons?**

# Integrity Concept Elements

**Evaluate Present System Quality Status**
(Originally provided by design and fabrication and affected by relevant effects from operation so far, if appropriate)

- ***Proactive approach to avoid/minimize premature degradation***
  Surveillance/Monitoring of root causes of operational degradation mechanisms (loads, water chemistry).
  Demonstrate that system loads actually occurring do not exceed design loads or detected new loads are clearly defined as input for integrity evaluations,

- Perform System/Component integrity evaluation status and

- Draw conclusions in terms of required additional actions

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- ***Reactive approach***
  Redundant measures (ISI, NDE, others)
  Surveillance of consequences of relevant degradation mechanisms).

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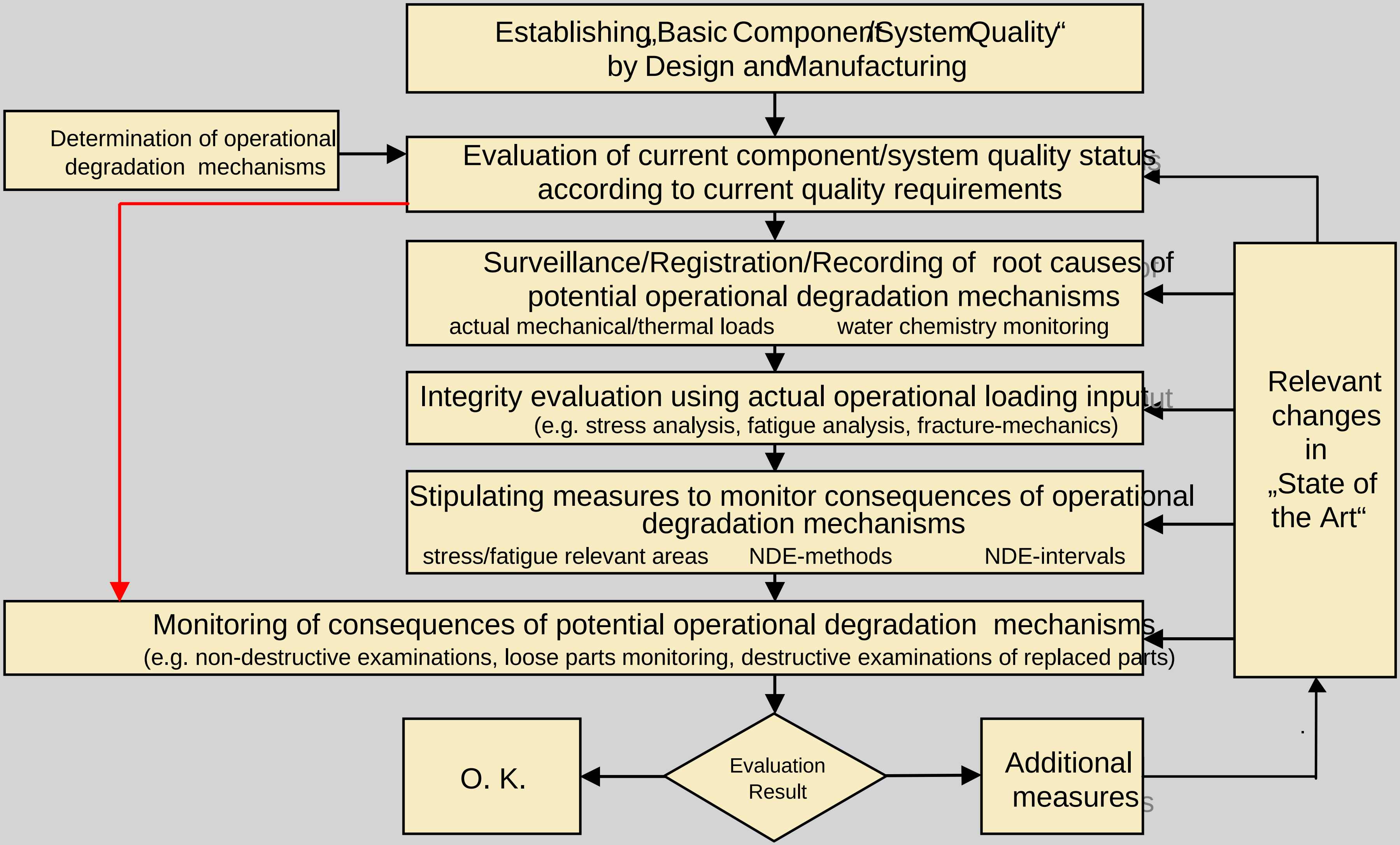
**Additionally, consequent consideration of changes in the "state of the art" in terms of new experiences in other plants leading to an impact on the plant under consideration**

# Overall Integrity Evaluation Concept for Safety Relevant Structures i

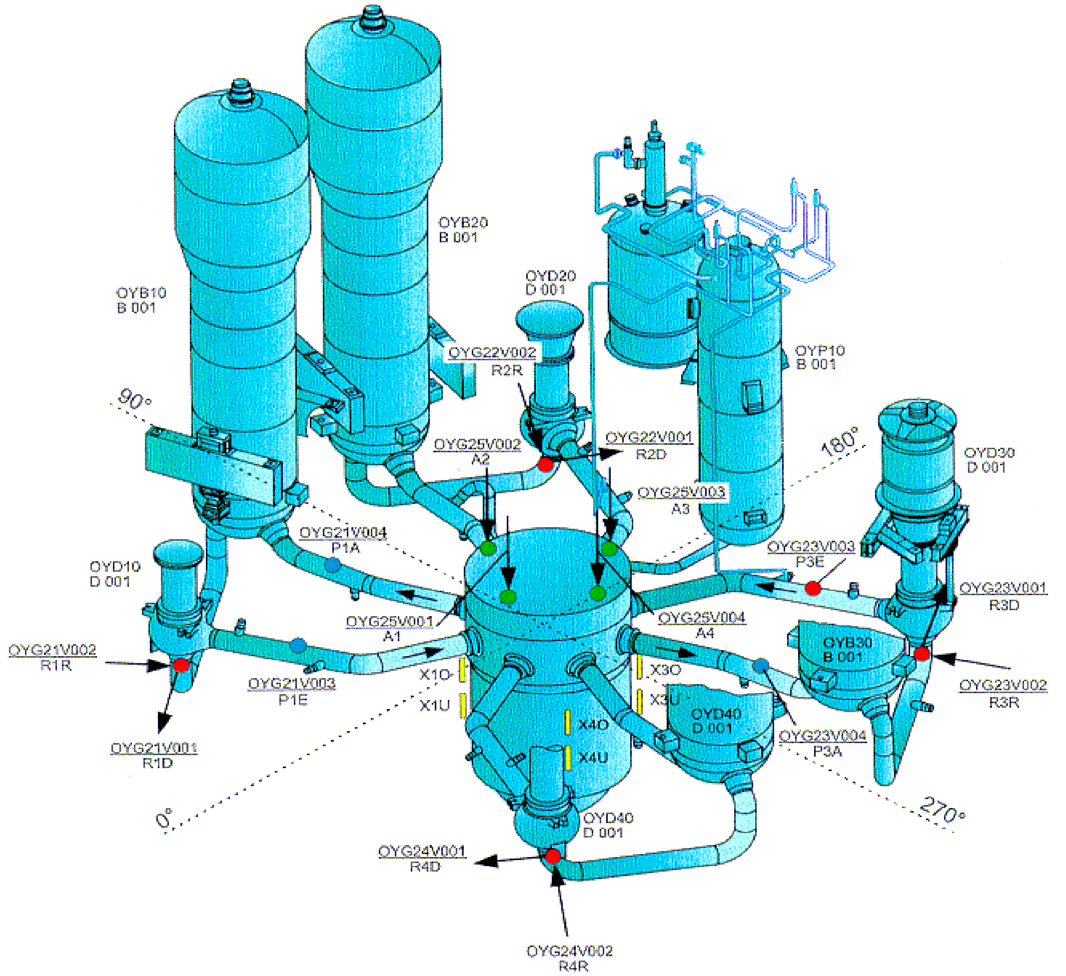


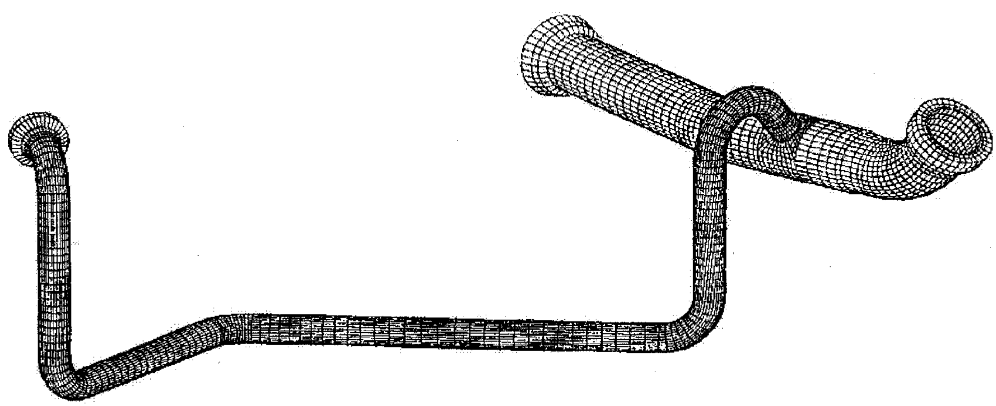
# Application Examples

- PWR-Primary Circuit Fatigue Assessment (proactive)
- Consequences of Flaws detected by NDE (reactive)
- Consequences of Code & Standard Changes (proactive)
- Small diameter piping system vibration effects (reactive)
- SG-tube behaviour (reactive with proactive attitude)

**Check plant specific safety and availability requirements!**

# PWR Primary Curcuit



# Primary Circuit PWR - Temperature Loadings

"Main" Components

- RPV/SG/MCL/ MCP/Pressurizer

⇒ $\dot{T} < 50$ K/h

➢ No Fatigue Relevance

⇒ Monitoring of "Global" Operational Data

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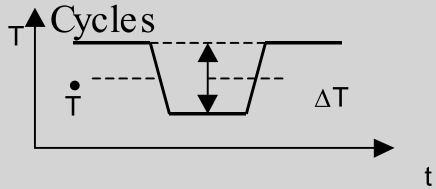
Piping Systems Connected to the Main Coolant Line

- Volume Control System
- Emergency Cooling System

⇒

- Higher ΔT
- Steeper Gradients
- Low Number of Load Cycles




⇒ Monitoring of "Global" Operational Data
+
Local Thermocouple Instrumentation

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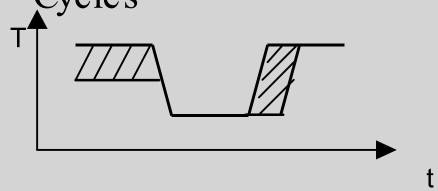
- FW-Lines, SGL, Spray Lines
- Fatigue Relevant Systems

⇒

- High ΔT/Gradients
- High Number of Load Cycles




⇒ Monitoring of "Global" Operational Data
+
Local Thermocouple Instrumentation
+
Cycle Counting

# Summary and Conclusions (1)

As pointed out, a „no concept approach“ may lead to a single effect solution but is not suitable for „higher level integrity evaluations“.

To demonstrate the integrity safety margins for safety relevant systems an „overall integrity concept“ considering the balanced relevance and interaction of the concept elements has to be applied.

According to the system safety requirements and with respect to the potential operational degradation mechanisms the load and stress aspects have to be evaluated as well as the load bearing capacity of the structure under consideration.

Surveillance and inspection measures support the integrity evaluation results and assist to minimize the “unknown” (“Factor X”).

Relevant changes of “the state of the art” are considered, if appropriate.

# Summary and Conclusions (2)

A proposal for a safety relevant ranking of components has been presented.

According to this ranking the integrity concept methodology encompasses a proactive and/or a reactive approach.

The proactive approach intends to avoid/minimize the effects of premature degradation. The reactive approach deals with degradation effects after they have been detected.

The selection of the approach type may also be determined by plant availability considerations (in addition to system safety requirements).

The application of the concept has been demonstrated with different examples.