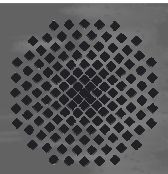

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Energietechnik

Application of Lifetime Management for Mechanical Systems, Structures and Components (SSC) in Nuclear Power Plants

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TÜV SÜD Energietechnik

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- Current activities
- Methodology
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Introductory remarks

The German atomic energy act requires that

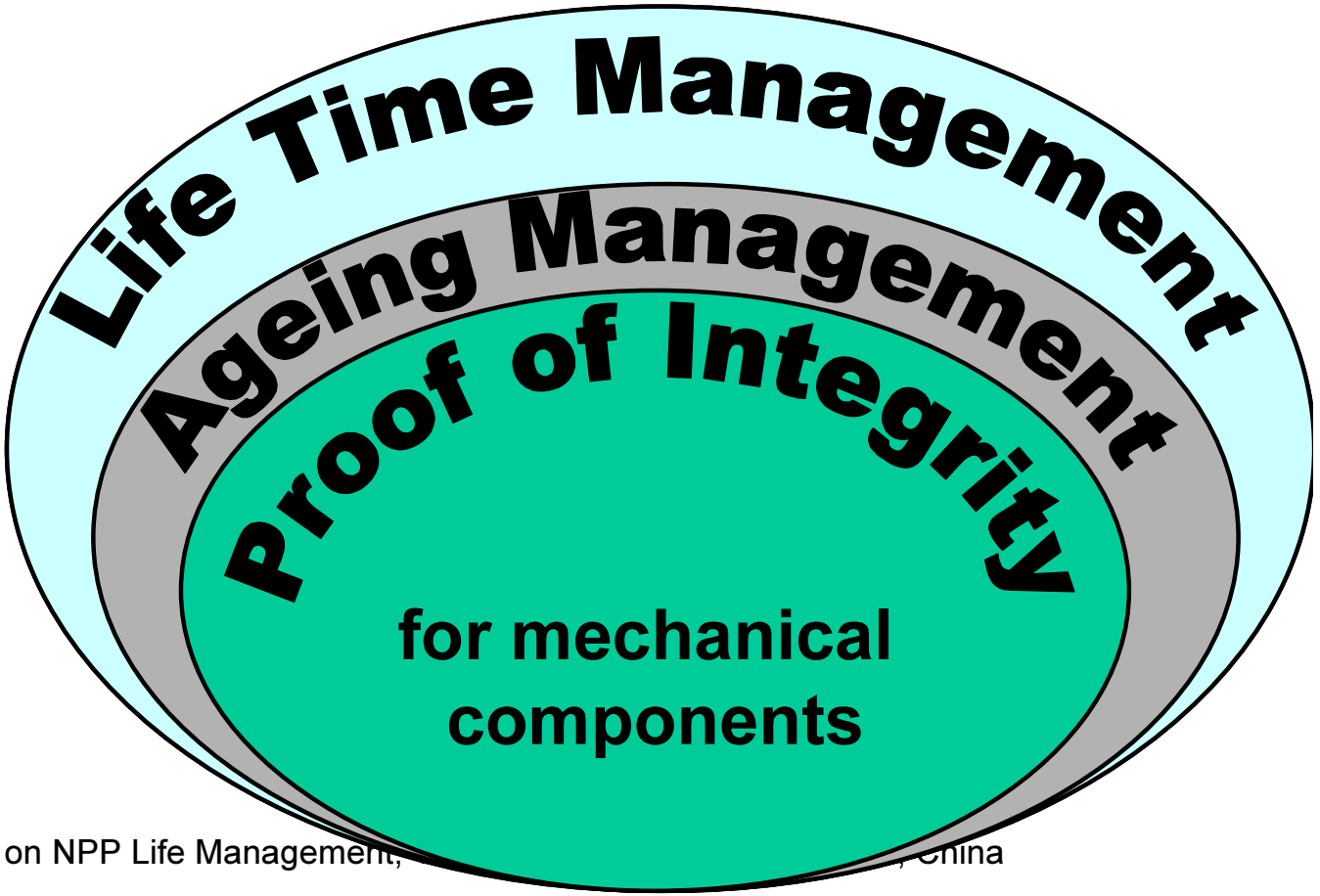
"... every necessary precaution has been taken in the light of existing scientific knowledge and technology to prevent damage resulting from construction and operation of the installation. ..."

This has been realised in guidelines and in the nuclear standards.

- **Safety resp. the quality of the systems, structures and components (SSC) is provided by the design, the material and manufactureing.**
- **The quality of the SSC shall be guaranteed and documented through-out the lifetime (extensive quality assurance during manufacture, construction, and operation).**
- **Operational parameters of the stressors relevant to the integrity of the SSC are monitored.**
- **Operational experience is recorded and evaluated safety related.**

Introductory remarks

Guidelines and standards contain all the demands for safe operation throughout the life time (life time management), for control of the ageing phenomena (ageing management - AM) as well as for the proof of integrity (for mechanical SSC). Within this approach AM is a key element.



Introductory remarks

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Definitions

Life time management - integration of ageing management and economic planning for SCC in order to

- **optimise the operation, the maintenance and the life time of the plants**
- **maintain an accepted level of safety and performance as well as**
- **maximize return on investment over the life time of the plant**

Ageing - time-dependent gradually change of features and properties related to their function

- **the engineering (mechanical SSC, buildings, electrical equipment)**
- **the systems and control devices relevant to the operation of the plant**
- **the specifications and the documents as well as**
- **the operating staff**

Introductory remarks

Definitions

Ageing management (AM) - engineering and organisational actions to guarantee safe operation during the life time including control of the ageing phenomena. Guarantee the safe operation of the SSC for the life time by engineering measures and maintenance actions to control within acceptable limits ageing phenomena.

Ageing phenomena

- **Conceptual (modification of requirements of safety and philosophy)**
- **Technological (latest results on possible in-service damage mechanisms, on material resp. properties of components, on test methods, on analysis methods, on assessment methods, etc.)**
- **Material-mechanical or physical (in-service ageing mechanisms generally caused by the material resp. change in material characteristics, by the operational loads and by the operational environmental conditions up to now)**

Introductory remarks

Definitions

Technological and material-mechanical ageing denotes all technical and organisational measures that guarantee the recording, monitoring and control of all possible in-service damage mechanisms.

Within the proof of integrity it has to be demonstrated that the bearing capacity is given for all relevant operational loads as well as accidental loads for the life time taking into account the specified or monitored number of load-cycles.

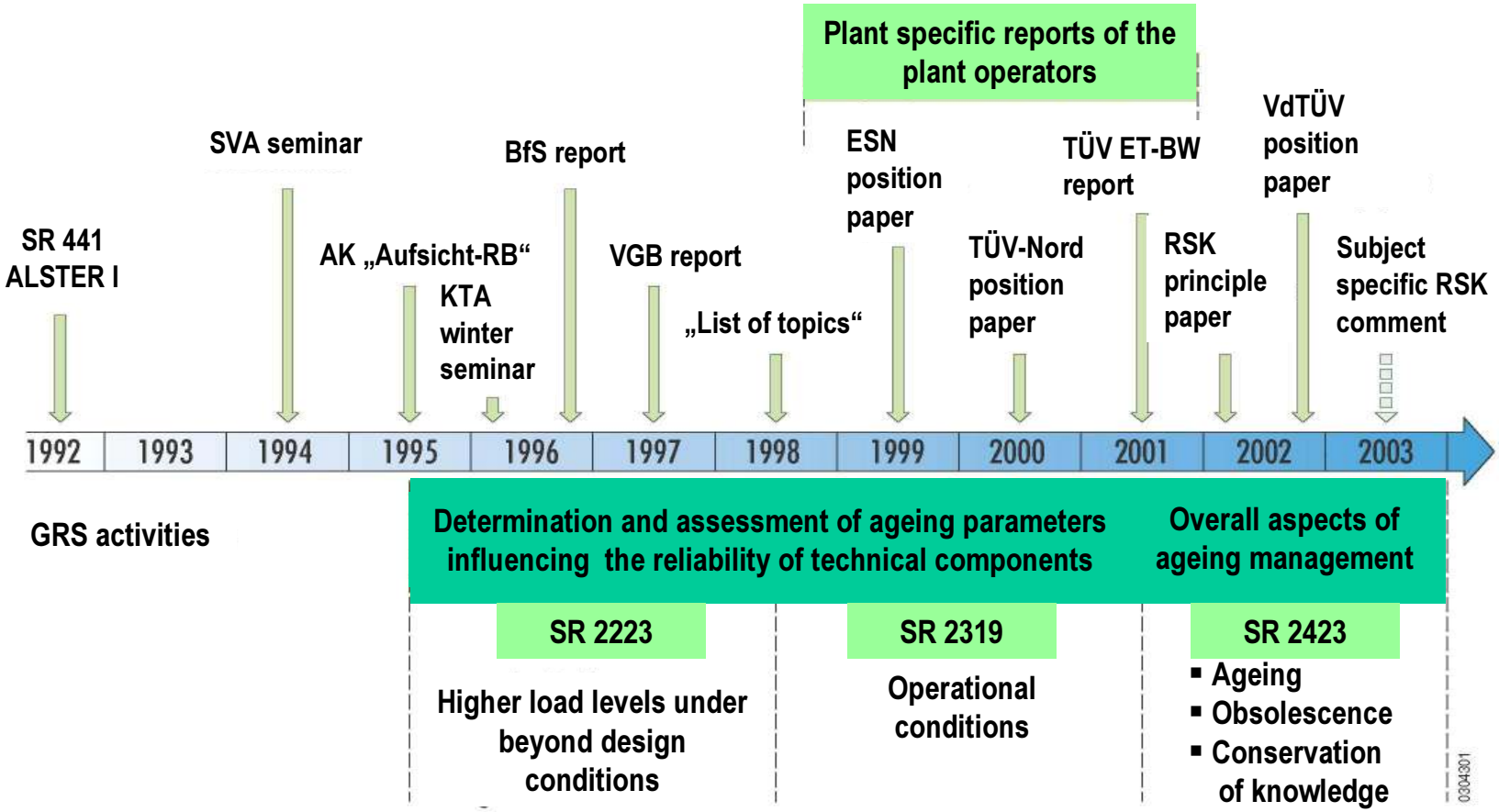
These definitions and considerations agree well with the international procedures.

In the following the focus is on

- **material-mechanical ageing**
- **proof of integrity**

Introductory remarks

Retrospective view - Essential aktivities in Germany in the past



Source: GRS (2003) Cologne

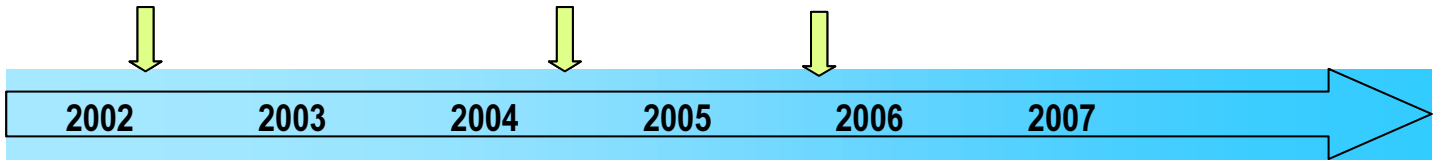
Introductory remarks

Retrospective view - Essential aktivities in Germany

On 26 April 2002 the "Act on the structured phase-out of the utilisation of nuclear energy for the commercial generation of electricity" entered into force.

RSK recommendation and subject specific RSK comments for ageing management

Decision of the Nuclear Safety Standards Commission (KTA) to prepare a new nuclear safety standard KTA 2301 „Ageing Management of NPP“



Current activites

RSK - Comments and Recommendation on „Management of Ageing Processes at NPP“ (July 22, 2004)

- An effective AM concept shall to be implemented for the SSC with regard to the safety-related relevance.
- The plant relevant ageing mechanisms shall to be identified and pursued.
- AM shall to be implemented as a permanent task on a high management level in connection with the management responsible for safety.
- An annual report on AM shall be submitted to the competent supervisory authority of the different German states.

Current activites

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Prepareing a new Safety Standard KTA 2301 „Ageing Management of NPP“

Contents of the KTA 2301

- Fundamentals
- Scope
- General principles
- Application to mechanical SSC
- Application to buildings and structures
- Application to electrical and I&C SSC
- Application to operating supplies

Basic Principles of Ageing Management

- An effective AM is the basis to preclude possible losses of quality and is distinguished by well-aimed countermeasures on a broad knowledge base.
- Shall be applied to mechanical SSC, to structural SSC (buildings), to electrical and I&C SSC and to operating supplies.
- General aspects are
  - Component selection and grouping (based on the safety relevance)
  - Evaluation of possible degradation/ageing mechanisms in opeation
  - Control the relevant degradation/ageing mechanisms all the life time
  - Evaluation of the efficiency of the AM

Basic Principles of Ageing Management

- Grouping of the SSC depends on the safety relevance:
  - Group 1 - SSC shall not fail all the life time (proof of integrity - "proactive approach" prevents damage)
  - Group 2 - SSC may fail in a single case, but a common mode failure shall be excluded (preventive maintenance)
  - Group 3 - the SSC may fail, no specific requirments
- A proactive knowledge-based ageing management shall be implemented process oriented, based on e.g. a PDCA cycle (Plan – Do – Check – Act).
- The efficiency of the AM shall be evaluated/qualified in periodical intervals.

Classification of the mechanical components

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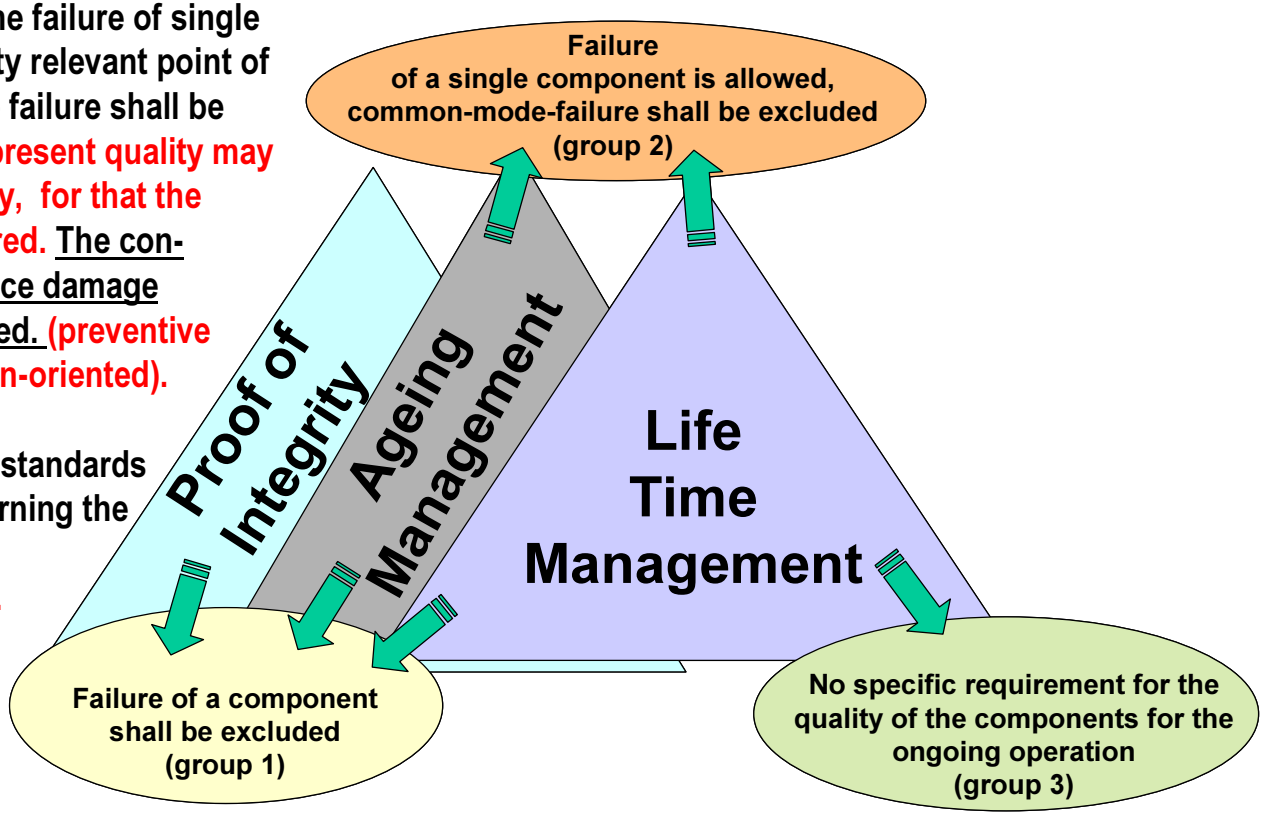
Group 1: Failure of the SSC shall to be excluded to avoid subsequent damage. The required quality shall be guaranteed for the total life time. The causes of possible in-service damage mechanisms shall be monitored and controlled (proof of integrity).

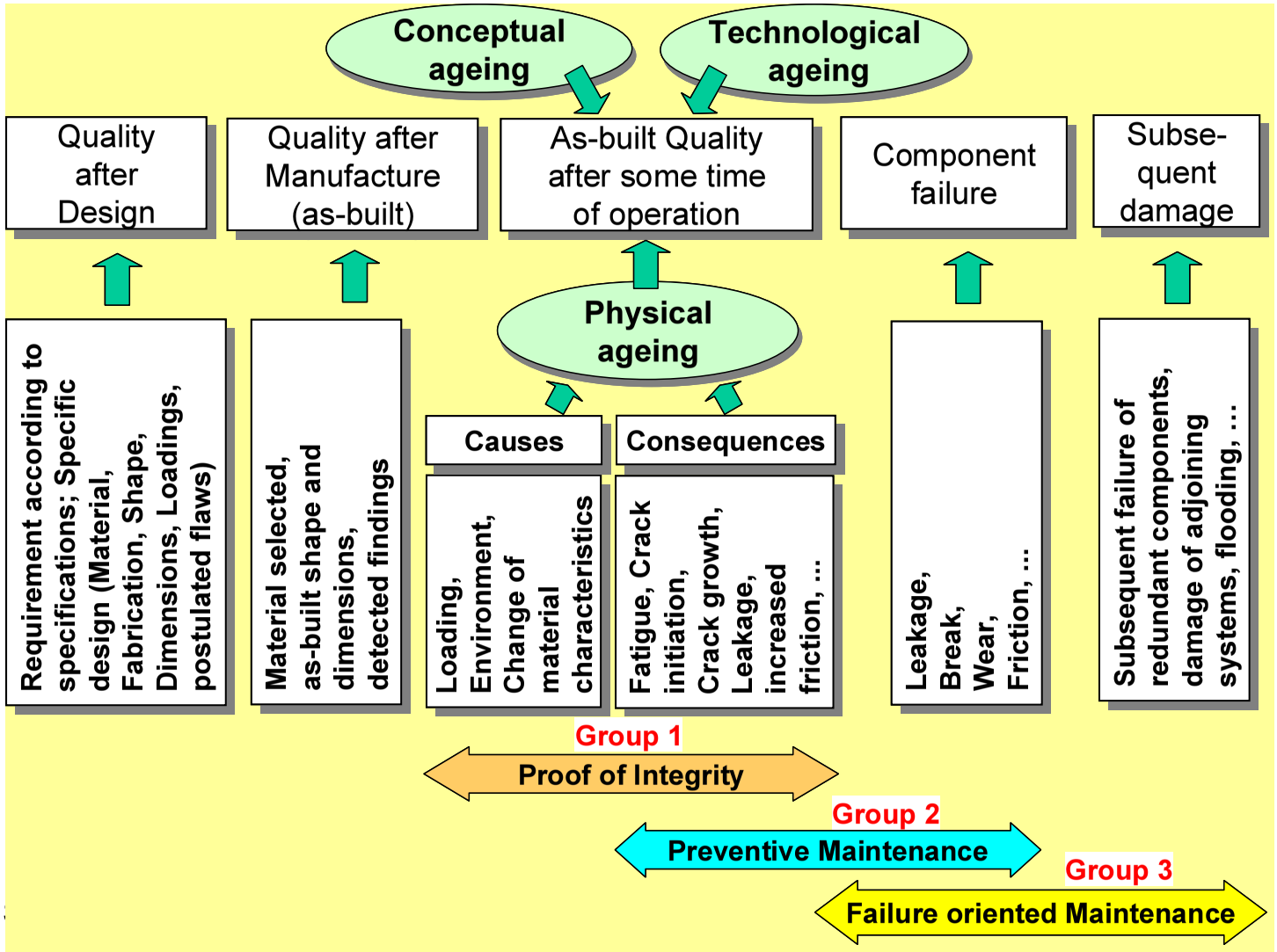
Group 2: For redundant SSC the failure of single part is allowable from the safety relevant point of view. However, common mode failure shall be excluded. In single cases the present quality may fall short of the required quality, for that the required quality shall be restored. The consequences of possible in-service damage mechanisms shall be monitored. (preventive maintenance, time- or condition-oriented).

Group 3: There are no defined standards of the qualityof the SSC concerning the succeeding operation (failure-oriented maintenance).



Procedure for application

Proof of integrity for components of group 1
Preventive maintenance for components of group 2
Failure-oriented maintenance for components of group 3



Procedure for application

Proof of integrity for components of group 1

Demonstrate and guarantee that the load bearing capacity is given for all relevant operational loads as well as accidental loads for the life time taking into account the specified or monitored number of load-cycles.

- **Documentation and assessment of the actual (as-built) state of quality according to the respective requirements (shall be in accordance with the particular requirements in guidelines, codes and standards).**

- **The required quality shall be guaranteed for the total life time by:**

  - **Identification and monitoring of the causes of possible in-service damage mechanisms and assessment of the data recorded.**
  - **Monitoring of the consequences of possible in-service damage mechanisms.**
  - **Follow-up of the state of present knowledge.**

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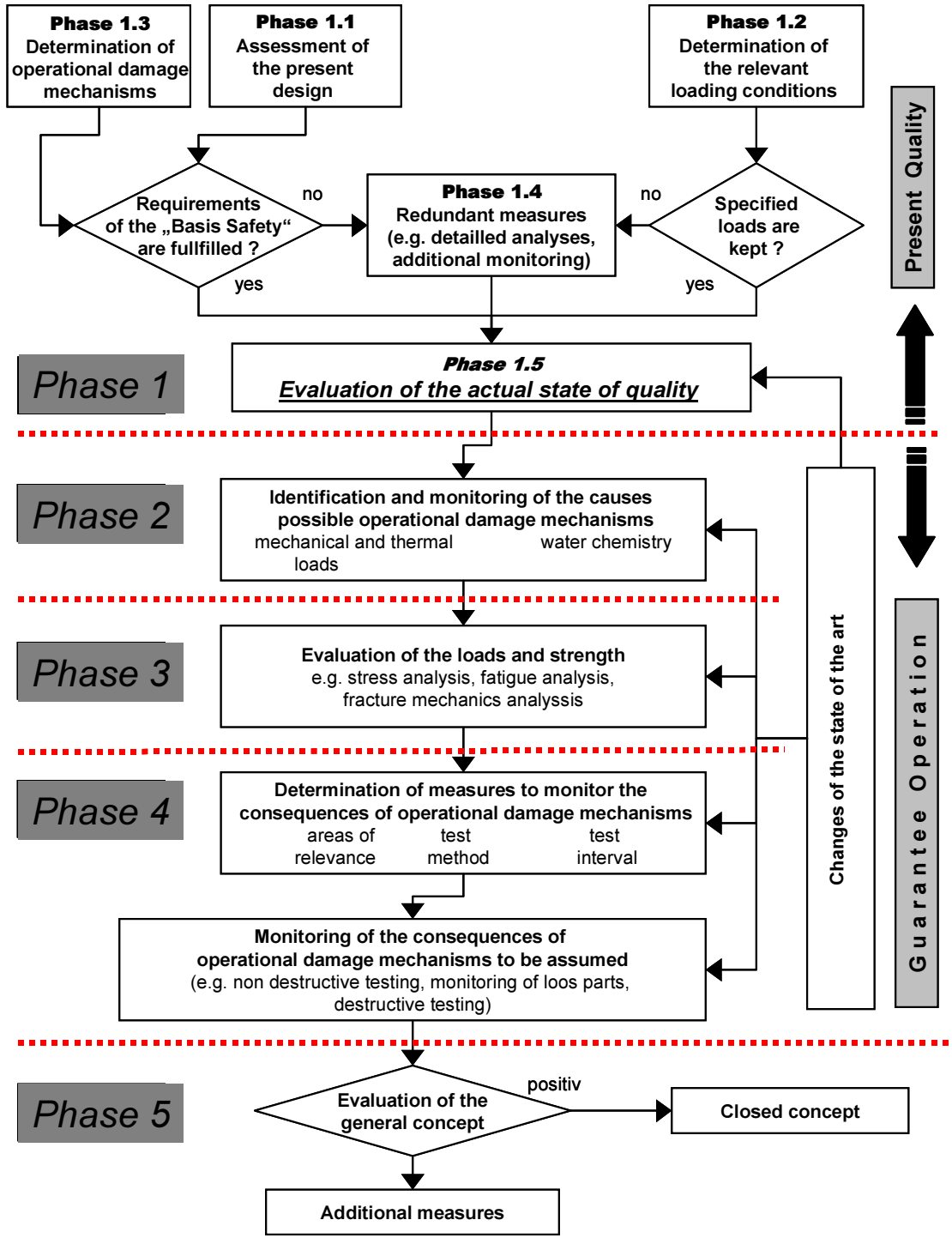
Proof of integrity

for components of group 1 according to KTA safety standard 3201.4



Procedure for application

Preventive maintenance for components of group 2

- The present state of quality shall be kept and guaranteed for the succeeding operation.
- In single cases the present quality may fall short of the required quality, for that the required quality shall be restored.
- Relevant failures have to be checked (monitoring of consequences of operational damage mechanisms).
- Consequential failures are of now effect in view of safety relevance.

Procedure for application

Preventive maintenance for components of group 2

State of quality according to particular requirements:

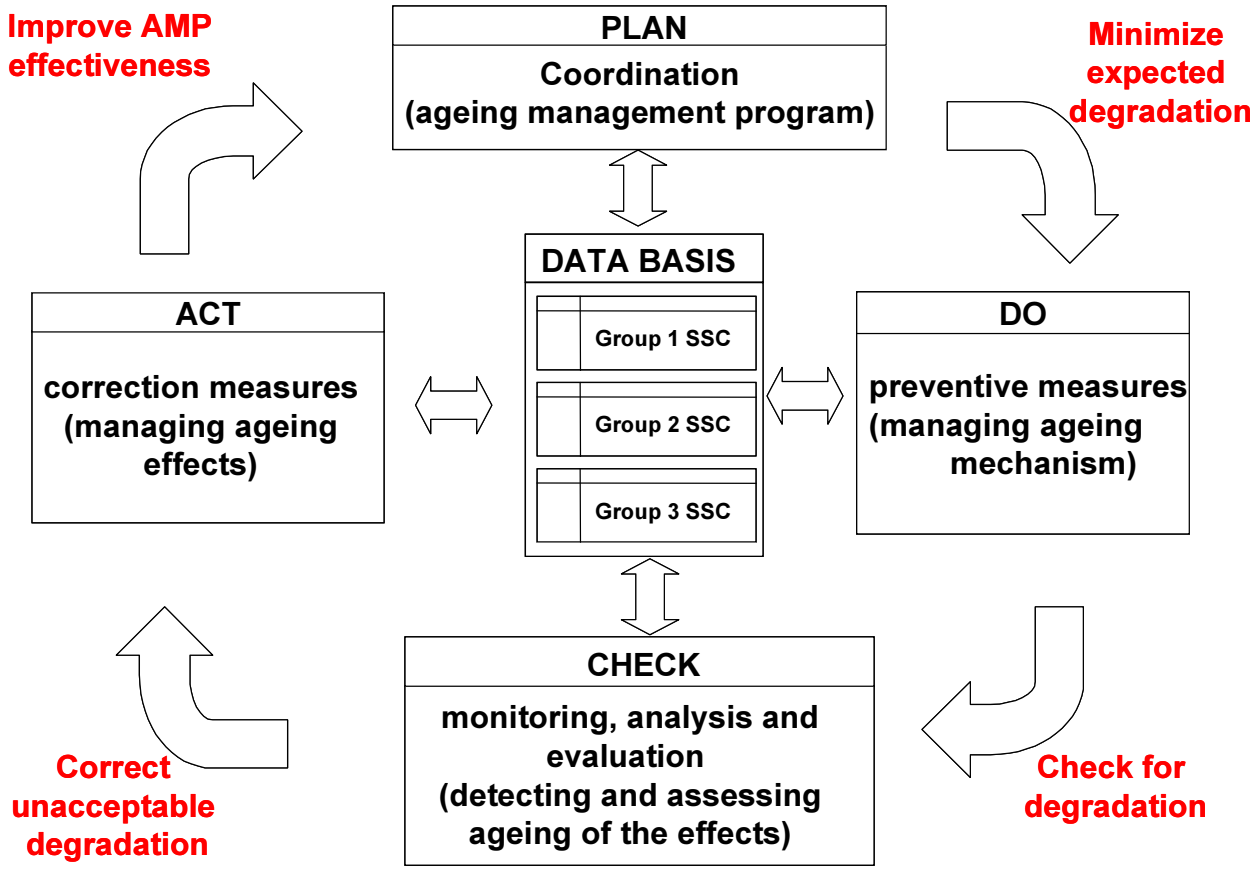
- **Requirements on the material and construction (design and calculation) including manufacture (shall be in accordance with the guidelines, codes and standards)**
- **Results of tests performed (state of findings of manufacture, NDT)**
- **Operational experience (mode of operation, results of operational in-service monitoring, failure investigations, NDT, maintenance measures)**

Operational in-service monitoring and maintenance measures:

- **Maintenance (measures to keep the nominal condition)**
- **Inspection and measurement (measures and actions to determine and asses the actual as-built status)**
- **Repair work (measures to restore the required state of quality)**

Procedure for application

PDCA-Cycle (Deming-Process) Technical and organisational measures



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Summary

- **Guidelines and standards contain the requirements for a safe operation throughout the life time (life time management), for the control of the ageing phenomena (ageing management) for the SSC**
- **Various engineering measures are required depending on the safety relevance (for mechanicl SSC, e.g. proof of integrity for components of group 1, preventive maintenance for components of group 2)**
- **The practical implementation and application is in progress**
- **A new Safety Standard KTA 2301„Ageing Management of NPP“ is under preparation**

End of presentation

Many thanks for your attention

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