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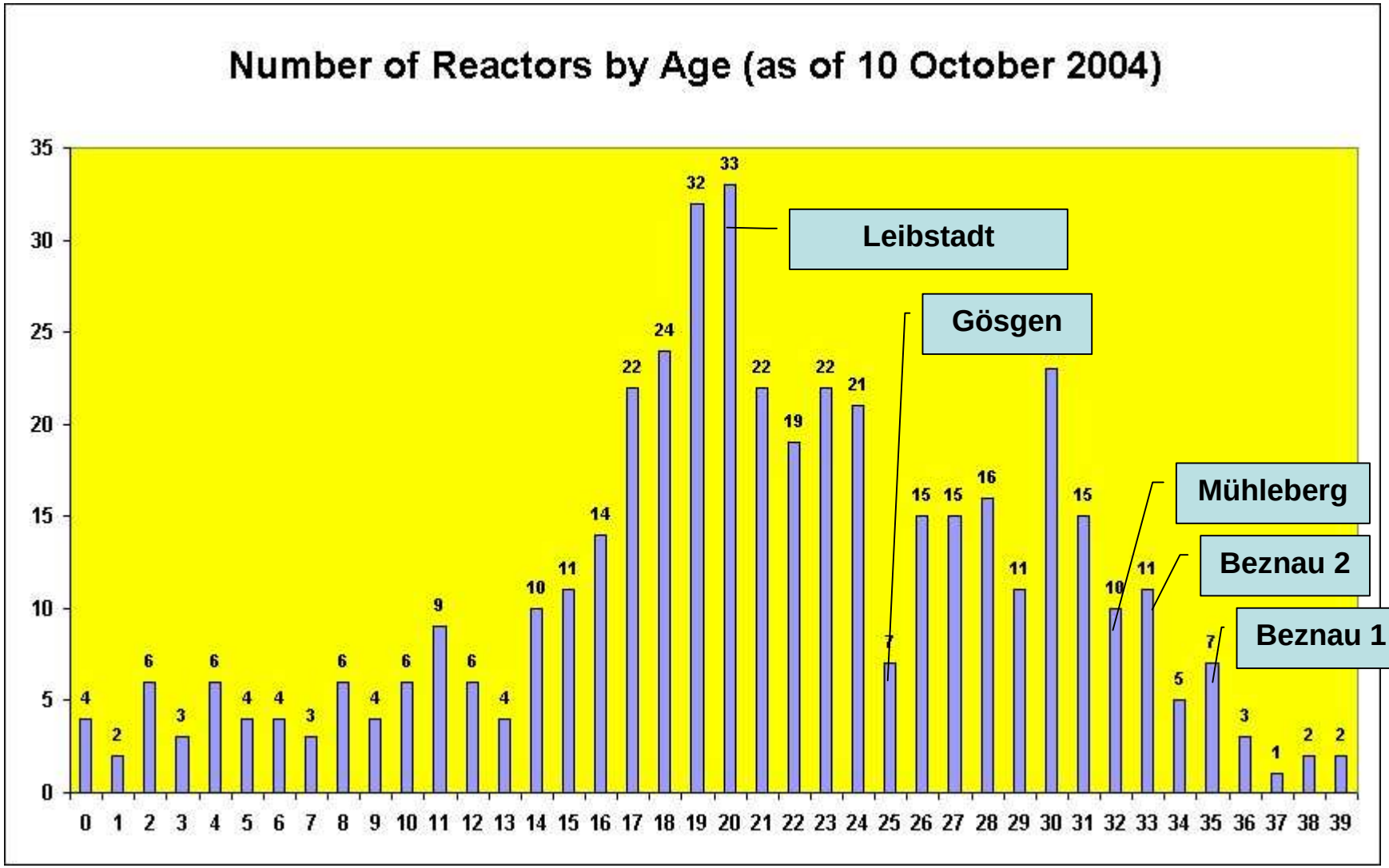
Swiss Federal Nuclear Safety Inspectorate's Guideline for Ageing Surveillance of Mechanical and Electrical Equipment and Civil Structures in Nuclear Installations

Internet: http://www.hsk.ch

Swiss Nuclear Power Plants

Name	Type	Manufacturer	Net Capacity (MWe)	Commercial Operation since	Accumulated operating hours
Beznau-1	PWR (2-Loop)	Westinghouse	365	1969	260267
Beznau-2	PWR (2-Loop)	Westinghouse	365	1971	255926
Mühleberg	BWR	General Electric	355	1972	255742
Gösgen	PWR (3-Loop)	Siemens KWU	970	1979	202029
Leibstadt	BWR-6	General Electric	1145	1984	156546

Status at the end of 2004.


Number of Reactors by Age (as of 10 October 2004)
Leibstadt
Gösgen
Mühleberg
Beznau 2
Beznau 1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
4 2 6 3 6 4 4 3 6 4 6 9 6 4 10 11 14 22 24 32 33 22 19 22 21 7 15 15 16 11 23 15 10 11 5 7 3 1 2 2
0 5 10 15 20 25 30 35

History of Swiss Ageing Surveillance Programmes (ASPs)

1991: Letter to the Swiss NPPs with requirement to establish ageing surveillance programmes

1993: Basic programme of the Swiss Nuclear Power Plant Operators (GSKL)

1995 – today: Elaboration of plant specific ASP procedures and documentation

2004: HSK-Guideline on "Ageing Surveillance of Mechanical and Electrical Equipment and Civil Structures in Nuclear Installations" HSK-R-51/d

2005: Federal Ordinance on Nuclear Energy (OENu), 732.11, Art. 35

Ordonnance sur l'énergie nucléaire (OENu)

732.11

du 10 décembre 2004 (Etat le 1er février 2005)

Art. 35 Surveillance du vieillissement

1 Le détenteur de l'autorisation doit assurer au moyen du programme approprié, la surveillance systématique du vieillissement de tous les équipements et de toutes les constructions dont la fonction et l'intégrité comptent pour la sécurité et la sûreté.

2 Il doit analyser les résultats obtenus, en déduire les mesures à prendre et les prendre.

3 Il doit, toujours à l'aide du programme approprié, consigner les résultats de la surveillance du vieillissement de l'installation et mettre périodiquement à jour ce programme, selon l'état de l'installation.

4 Les autorités de surveillance sont chargées de régler dans des directives les méthodes de la surveillance du vieillissement et jusqu'où cette surveillance doit aller.

Recent ageing issues in Swiss NPPs

Core shroud cracking (NPP Mühleberg):

- Cracks detected since 1990, no replacement but reinforcement with tie rods 1997
- Efforts to slow down crack growth by modification of primary BWR water chemistry (NMCA-HWC) have not been successful so far

SCC susceptibility of Inconel 600 penetrations:

- No cracks found until today
- Recalculation of RPV head temperature in NPP Beznau 1 & 2 leads to higher values (2004)
- Reassessment of SCC susceptibility of RPV head penetrations leads to an enhanced ISI programme in NPP Beznau 1 & 2

Steel containment corrosion resulting from temporary leakages:

- Corrosion occures mostly in inaccessible areas of containment, local loss of wall thickness > 10%
- Additional inspections and examinations, measures to stop leakages...

Cracks in safe end of RPV nozzle of CRD return line (NPP Mühleberg):

- Leakage < ¼ TS-limit, repaired by temporary overlay welding, nozzle capped 2005
- Thermal fatigue damage - stratification
- The ageing mechanism was unexpected and misjudged by the plant specific ASP, because wrong values of flow were used in a temperature calculation

Definitions in HSK-R-51

Ageing:

- Cumulative, time-dependent change in physical and/or chemical properties (material conditions) of NPP systems, structures and components (SSCs) that has been caused by one or more ageing mechanisms.

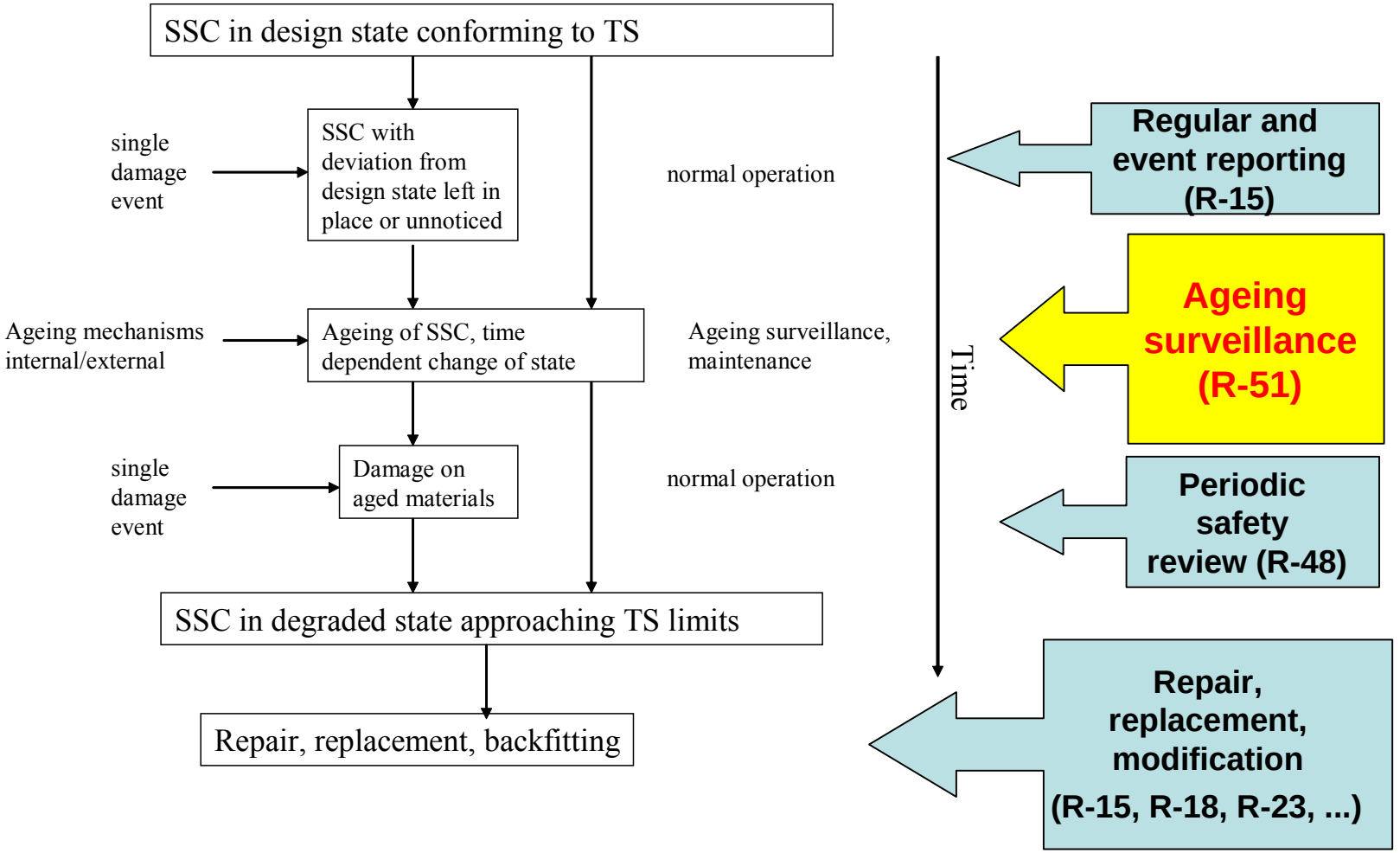
Ageing Surveillance:

- All time effective measures of timely recognition, evaluation and mitigation of the condition of ageing of a SSC.

Ageing Surveillance Programme (ASP):

- Systematic procedure to check the influence of ageing on NPP installations, to evaluate the state of ageing and to check exsisting measures of ageing surveillance with respect to completeness and efficiency. It aims at the recognition of gaps in ageing surveillance and at measures to close these gaps.

Service life of nuclear equipment and HSK guidelines



Requirements of ageing surveillance

- Identification of ageing mechanisms; catalogs of ageing mechanisms
- Component specific identification of possible ageing mechanisms, documentation in plant specific component files
- Inventory of the existing ageing surveillance. Evaluation of inspection methods and techniques. List of supplementary actions.
- Interface regulation between different technical departments.

Requirements for the systematic procedure

- consider all known and possible ageing mechanisms
- check qualification and application of ageing surveillance methods
- identify and treat possible deficiencies and open questions
- evaluate trends from maintenance and operating experience
- evaluate knowledge from research and technical and industrial experience
- determine values of risk relevance for components from PSA
- document the results and proofs of ageing surveillance

Example for mechanical equipment

Generic ageing information (catalogue and other)
- corrosion
- SCC, E-C
- fatigue
- embrittlement
- other mechanical
- combination

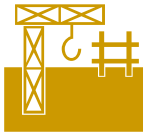
Detailed evaluation

Relevant mechanism?

no

Specific data of system or component
- all parts
- material information
- water chemistry
- environment
- transients
- maintenance history
- calculations...

ASP-result:	**mechanism**	**NDE/ISI**	**reference**
nozzle xyz	fatigue	UT	✔, transient book-keeping
weld x001	(no)	UT	
weld x002	IGSCC	UT	✔
elbow xab	Erosion-Corr.	(no)	further action 1!
pipe xcd	deformation	VT	✔



Civil Structures

The ageing surveillance of civil structures addresses the following materials:

- Concrete and Reinforced Concrete
- Iron and Steel, Reinforced Steel, Tensioning Steels
- Anchors
- Fire Bulkheads
- Joint Tapes, Seals
- Paints and Coatings

Criteria for condition monitoring in the civil structure's ASP-guideline.

Inspection plan on the basis of a 10-year inspection interval.

Mainly visual inspections.

Electric Equipment

- About 30 types of active and passive electrical components
- List of recommended diagnosis methods
- Ongoing qualification programmes: pre-aged samples of electrical components tested for fitness to operate under normal and upset conditions.
- Ageing of cables monitored by samples that are placed at locations with high radiation levels and high temperatures
- Regular testing of the samples e. g. elasticity of the insulation of the cables

Mechanical equipment

Mechanical equipment to be included in the ASP documentation:

- pressure retaining boundary of the primary coolant system (safety class 1)
- reactor pressure vessel internals (safety class 2 and 4)
- primary containment system (safety class 2)
- essential parts of safety systems (safety class 2 and 3)
- ISI-regulation requirements (NE-14): components of safety systems where the susceptibility to ageing damage has to be evaluated
- risk relevant components, selection based on results of probabilistic safety assessment (PSA) – independent of safety class
- other components which are important for reasons like operation and radiation protection and which are selected by an expert panel of the NPP

36 types of ageing mechanisms:
corrosion – fatigue – embrittlement - wear - mechanical damage

Mechanical equipment

Elements of ageing surveillance of mechanical equipment:

- maintenance programmes, operational surveillance and walk downs
- testing programmes according to technical specifications
- in-service inspection programmes (NDE) according to the Swiss regulation NE-14
- transient book-keeping for fatigue monitoring
- testing of surveillance samples for the assessment of neutron embrittlement of reactor pressure vessel steel
- control and surveillance of water chemistry
- various types of global condition monitoring, such as leakage detection

Additional activities:

- Instrumentation and temperature recordings, recalculation of fatigue usage factors
- Single examinations and special examination programmes
- destructive ageing examinations and other ageing studies

HSK-supervision of ageing surveillance

- Assessment of ASP-documents, catalogues, technical reports...
- Review of regular and event reporting of the plant operators
- Inspections, plant walk-downs
- technical and regulatory meetings
- requirement of further assessments or actions if neccessary
- assessment of ageing surveillance activities as a part of the periodic safety review (PSR)

Conclusions

•Systematic procedures are established in order to determine the current state of ageing of all important parts of the Swiss NPPs and to support the planning of maintenance and ISI-programmes for mechanical and electrical components and for civil structures.

•Useful side effects: Historical information is made available from the archives (document ageing), young personnel learns about the history and operating experience of old components and systems that are still in use (personnel ageing).

•14 years of successful experience with ASPs:

- required since 1991
- PSR NPP Gösgen (November 1999)
- PSR NPP Mühleberg (December 2002)
- PSR NPP Beznau II (March 2004)
- PSR NPP Beznau I (November 2004)

"Ageing under control...*!?*"