

Ageing Management and LTO of NPPs – Swedish perspective

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Swedish nuclear facilities





Age of Swedish NPPs









Physical ageing of components and structures

The "bath tube curve" as basis for NPP lifetime



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Service time

Some data from the OECD-NEA OPDE



Figure 8: Pipe Degradation & Failure by Calendar Year

Inspection and control have worked well – so far



- No major safety consequences
- Most degradation events have been detected by ISI
 - but some misses have been reported
- Detection of degradation have often led to extensive replacement measures
 - o to prevent further failures

Research is important

- Research activities and operating experience world wide
 - have led to a situation where substantial knowledge has been accumulated about degradation mechanisms that can affect components and structures in NPPs
- However, degradation history shows clearly that our knowledge base must be continuously updated based on
 - further research, and detailed damage analyses, which often reveal other circumstances than those expected
- Continued international cooperation will be important
 - such as the IAEA IGALL, OECD-NEA OPDE/CODAP

Long-term operation (LTO)

IAEA definition of LTO is

"operation beyond an established time frame set forth by, for example, license term, design, standards, license and/or regulations, which has been justified by safety assessment, with consideration given to life limiting processes and features of systems, structures and components"

This means that both the formal and real conditions for LTO varies between NPPs and countries

Internationally recommended practice

- to have a formal process with the clear position on longterm operation either through
 - a License Renewal process, or
 - by a PSR process focusing on LTO

Nuclear Regulation 2012	IAEA Safety Standards	1.21642 EE Enropalità animene a Biolis tidolog 25.52014 A (AUTE GUERETT VILLA STURIE) ani Saloing se dividei 2007/1/Illurano en apricologiano be divide di Salondo e se pisonalegenore be divide di Salondo e se pisonalegenore be divide di Salondo e di Autori (UTE A DESCIT)	Reactor License Renewal
Challenges in Long-term	for protecting people and the environment	med bestende av fördrager om upprässnder av Foropeista anomenergigemerskapen, särstilt avsklarna 31 och 32.	Introduction
Operation of Nuclear Power Plants		nal balancia yo fungataki kanonizianen diala, appikan dia arian yanaka wikila fato o popo u penene ana u wakalapika diala kanonisa mbaba kanonizaan baba wakalapika pener kanonizaan and balancia ua fingapakanean yanaka() mal katancia ua fingapaka starentaka ada antaka kanonizian yanaka (), udu	Based on the Atenini Emergy Act, the Nuclear Regulatory Commission (NRC) issues Bonases for commortal power reactives to operate for any 160 49 years and dates base base issues to be trearved for any another 20 years. Economic and antitrust considerations, not limitations of nuclear technology, determined the original 164 year term for reactor licenses. However, because of this subset of numerical some systems, structures, and components may have been engineered on the basis of an expected 40 year service life.
	Periodic Safety	ar fillioche dall:	The decision to seek license renewal rests entirely with nuclear power plant owners and typically is based on the plant's economic situation and on whether it can meet NKC requirements. Each power reactor is
Implications for Regulatory Bodies	Review for	(1) Taking abide 201/01(Densen): franzika selasti s	Increased based on a given set of requirements, depending primarily on the type of plant. This set of requirements is called the plant 3 ⁻¹ increasing bases. The setuces (<u>carrent prevent process</u> provides continued assumance that the current licensing basis will maintain an acceptable level of safety for the period of contrade occaration.
	Nuclear Power Plants	(1) Taking 2004, 2004, [Internet II] water and the second seco	The NRC has established a license rensewal process that can be completed in a reasonable period of time -pysically about 30 months-with clear requirements to assure safe plant operation for up to an additional 20 years of plant life.
		 Linear and etc. 20. In section 20. In contrasting on a difference on lefter and separately linear extension of the section of the section 20. In the sec	Nuclear power plants are subject to a systematic and thorough NRC oversight program to ensure nuclear plant equipment commons to meet suffery standards. This constant NRC oversight ensures a plant will operate suffry throughout its Infe
		sillaskauppider och ävervalstörg är kärnalstöka anlägpslogar ligger äver i formänningen halt på villmändska- ransa och är närlenalla myndigkausta".	Background
	Specific Safety Guide	(9) Example (builder) builden) have only 2011 three by much set of the set	In 1982, based on a widely attended weekshop on machen power plana aging, the NRC established a comprehensive program for Nucleur Plana Aging Research. Based on the reveals of that research, a reclaim leview program concluded that musaw gaing phenomena are resultly managerole and do not pore technical issues that would preclude lide extension for miclear power plants.
	No. SSG-25	Landblever och investigansk i kalogenfallener skille konse förbärarg på Fara parlan. 1 Transform den 100 (20 - Former förbärgigen 100 fr.) Transform den 100 (20 - Former förbärgigen 100 fr.) 1 Transform den 100 (20 - Former förbärgigen 100 fr.) Transform den 100 (20 - Former förbärgigen 100 fr.) 1 Transform den 100 (20 - Former förbärgigen 100 fr.) Transform den 100 (20 - Former förbärgigen 100 fr.) 1 Transform den 100 (20 - Former förbärgigen 100 fr.) Transform den 100 (20 - Former förbärgigen 100 former förbärgen 100 (20 - Former förbärgen 100 former förbärgen 100 (20 - Former förbä	In 1991, the NRC published safety requirements for license renewal as 10 CFR 2m1.94 (Title 10 of the Code of Federal Regulations, Part 54). The NRC then undertook a demonstration program to apply the rule to pilot pilots and develop experience to establish unglementation guidance. To establish a scope of review, the rule defined age-related degradation unspace to locnic renewal. However, damg the demonstration program, the NRC found that many spin effects are deal with Adquirely damn the demonstration program.
		 Statisticanov Galificanova do 200 (200 (200 (200 (200 (200 (200 (200	initial forces period. In addition, the NRC found that the rule dot not allow sufficient credit for existing programs, particularly those under NRC's maintenance rule, which also helps manage plant-aging plenomena.



LTO involves some new challenges for both licensees and authorities

- Organisations, resources and expertise must be adaptable to manage new safety issues that might arise
 - e.g. in terms of design bases used, ageing / degradation mechanisms that can affect the long term
- Effective programs for ageing management must be in place
 - Inspection, testing, monitoring, maintenance, replacements
 - Is important before LTO, but even more as NPPs becomes older
- Legal and supervisory framework needs to be reviewed
 - with more focus on ageing issues and ageing management activities

LTO is not only about physical ageing

- Technological ageing (obsolete equipment)
 - for example I&C
 - Difficulties in obtaining spare parts, problems with maintenance and repair
- Generation shifts within organizations
 - Important tacit knowledge may disappear from organizations
 - It can relate to specific maintenance practices, applied but undocumented design bases for certain equipment, etc.
- Plant documentation
 - Poor archiving of detailed design and manufacturing documentation
 - Detailed design and manufacturing documentation has been left with suppliers and manufacturers who have gone out of business

Validity of operating licenses - the formal situation in Sweden

- An operating license for a Swedish nuclear power reactor under both the Nuclear Activities Act and the Environmental Code is a favouring permit without time limitation
- It can not be withdrawn as long as
 - the provisions of laws, government ordinances and SSM's regulations are met, and
 - the conditions and obligations under the license are met

How will the conditions for LTO of Swedish NPPs be examined?

- By a PSR process specifically addressing LTO
- It must be shown that the plant with its SSCs can be used / operated beyond the time originally planned for and with the assumptions which were made when designing the SSCs
 - including revalidation of design analyses, other verifying analyses (TLAA) and environmental qualifications for the extended period
 - and that there are no degradations and deteriorations of various types
- or make the necessary replacements

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Investigation of long-term safety in the Swedish nuclear power industry

- Conclusions in SSM's reporting of the government assignment (2012):
- Safety can be maintained over the long term, provided that
 - additional safety improvements are made
 - the licensees apply effective ageing management,
 - this is examined regularly in the time ahead in the form of in-depth PSR

> Furthermore, it is essential that

- a good safety culture is maintained
- also ensuring that other safety-related conditions pertaining to organisations and human resources are maintained and developed

Recommendation from SSM reporting / Special attention on:

- Irradiation embrittlement of reactor pressure vessels, taking account of effects that can substantially increase the rate of embrittlement
- Fatigue, taking account of impact from the reactor water environment on areas
 sensitive to fatigue
- The condition of tendons and steel liners in reactor containments Michael Knochenhauer

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- Degradation mechanisms that can influence reactor containments' concrete and metal parts
- Possibilities for reliable inspections and testing of reactor containments
 - The validity of environmental qualifications of electrical, instrumentation and control equipment as well as parts with polymer construction materials

More can be read on: www.ssm.se



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Legislation and regulations

- A major review of legislation and regulations for nuclear installations and other activities involving radiation is in progress
- SSM will in this context clarify and define both the regulations and general advice about
 - ageing management
 - safety assessments and TLAA
 - the role and content of PSR
- in the light of the licensees' plans for LTO of the Swedish NPPS



- Ringhals NPPs
 - Pre-SALTO Ringhals 1 and 2 in 2014
 - Follow-up SALTO in 2016
 - Full-scope SALTO for Ringhals 3 and 4 in 2018
- Forsmark NPPs
 - Pre-SALTO planned for 2016
- Oskarshamn NPPs
 - In preparation to request SALTO review

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Conclusions

- Experience shows that effective ageing management must continuously be taken into account
 - from the design phase and throughout the planned period of operation
- In regulatory evaluation of potential for LTO focus on ageing management is necessary but not sufficient
- Other aspects that must be considered are
 - implemented and need for additional safety improvements
 - application of lessons learned from operating experience
 - adequate licensee staff resources and performance
 - security at the plant

Conclusions

- The Swedish licensees have announced that they intend to operate the NPPs longer than originally planned
 - 3 for 50 years and 7 for 60 years (currently under reconsideration!)
- SSM will take position on LTO within the framework of a PSR for each plant
 - Efforts are under way to analyse and evaluate several PSR involving transition to LTO
- Work is also underway to revise and clarify SSM's regulations, including the requirements for
 - ageing management
 - safety assessments and TLAA
 - PSR as a basis for decisions on LTO