Strål
säkerhets
myndigheten
Swedish Radiation Safety Authority

Ageing Management and LTO of NPPs – Swedish perspective

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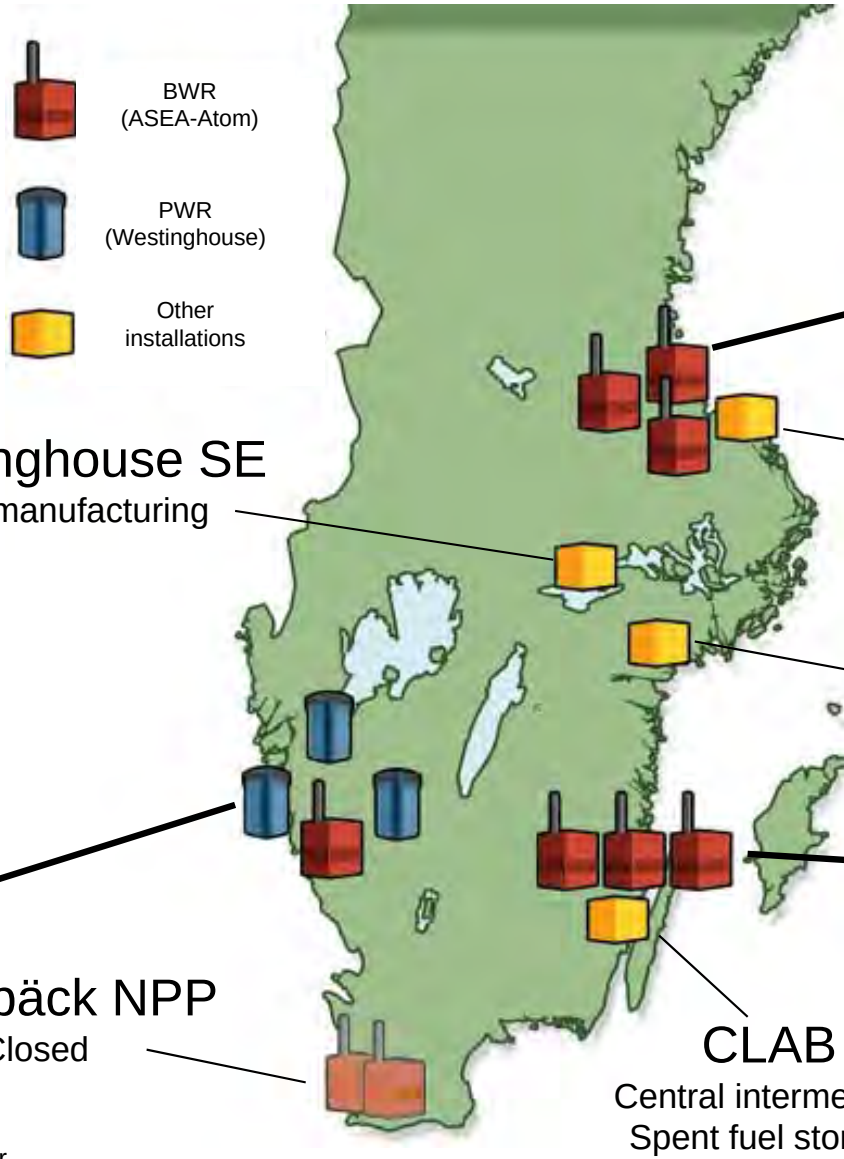
Swedish nuclear facilities

- 7 ASEA-Atom BWRs (5 different designs)
- 3 Westinghouse PWRs (2 different designs)

Forsmark NPP



Westinghouse SE
Fuel manufacturing

SFR
Final storage
Low/interm. waste

Studsvik
Research reactors
closed

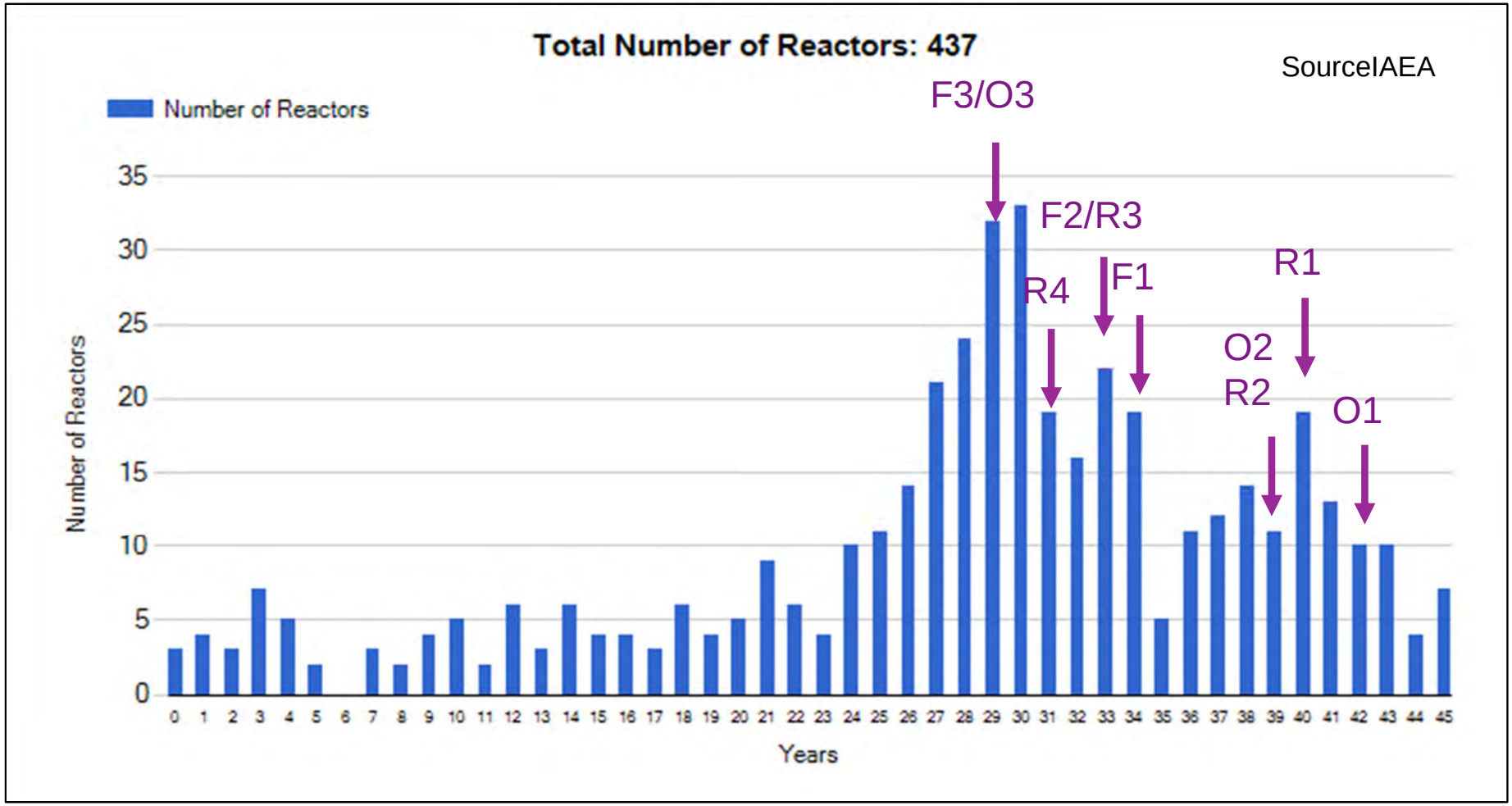
Ringhals NPP

Oskarshamn NPP

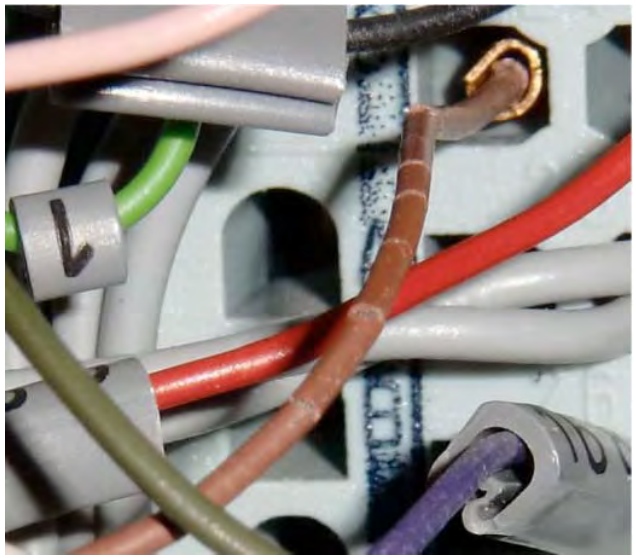
Barsebäck NPP
Closed

CLAB
Central intermediate
Spent fuel storage

Age of Swedish NPPs

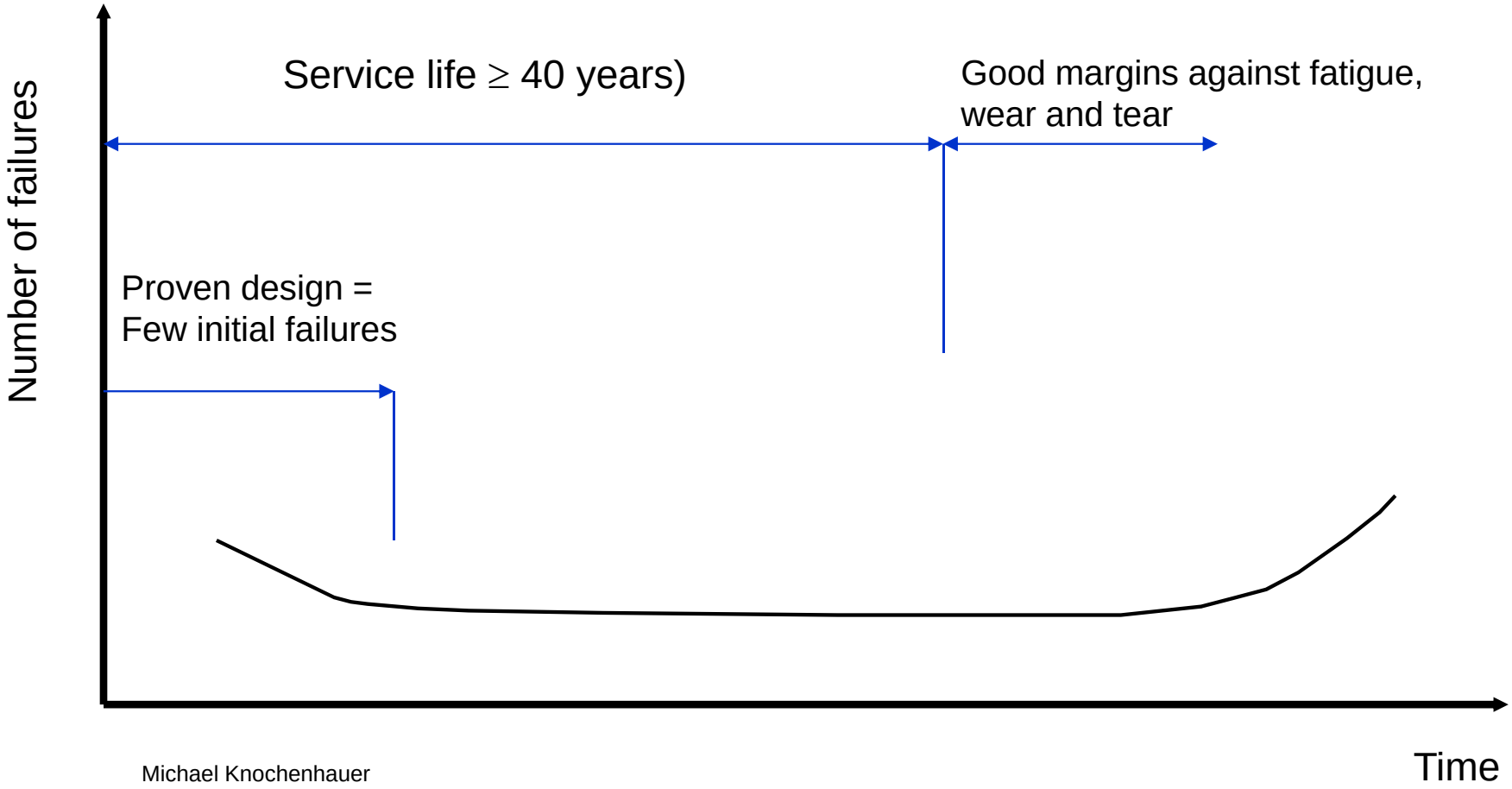


Ageing management

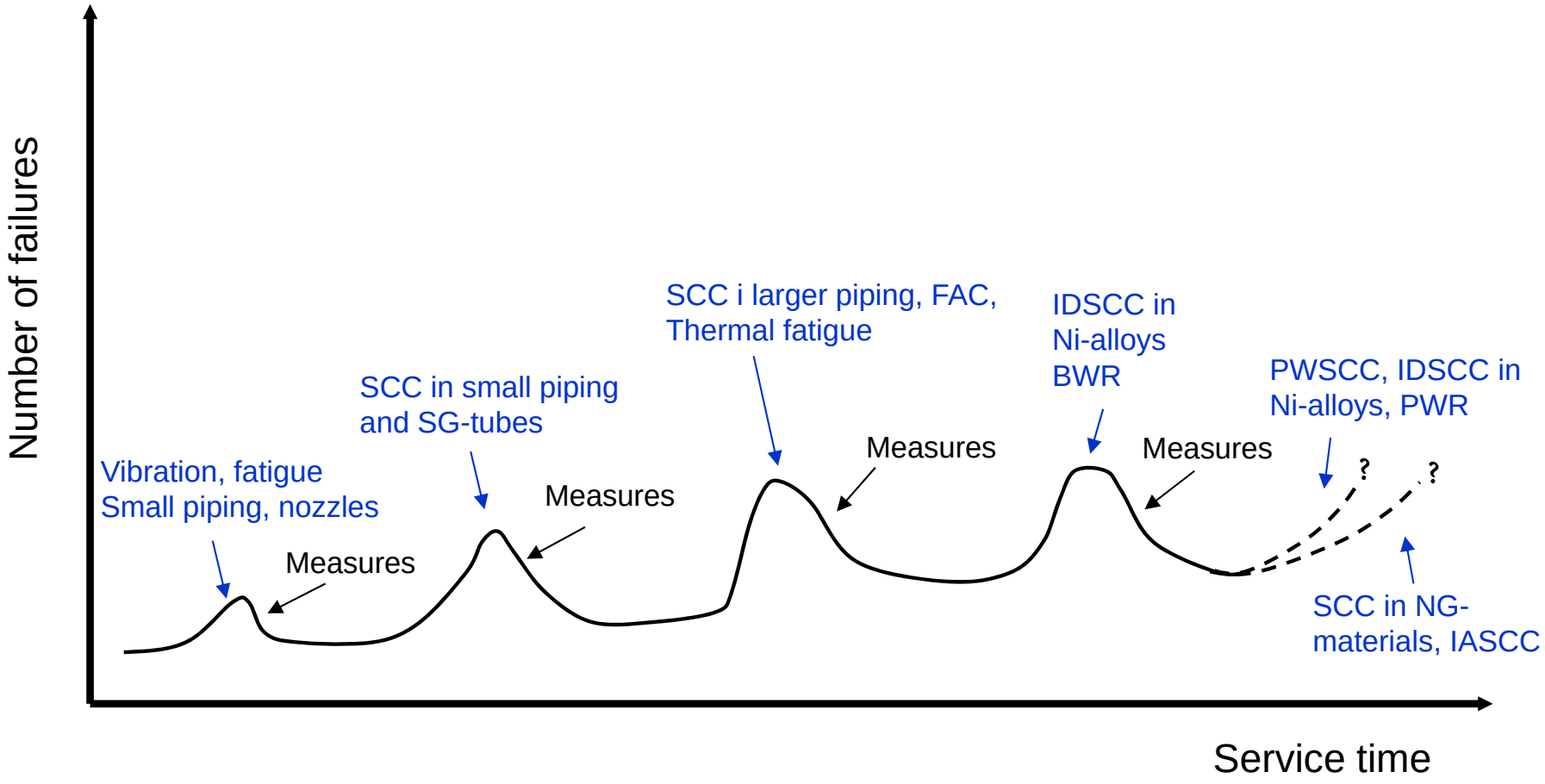


Physical ageing of components and structures

The “bath tube curve” as basis for NPP lifetime



General operating experience so far shows another picture (mechanical components)



Some data from the OECD-NEA OPDE

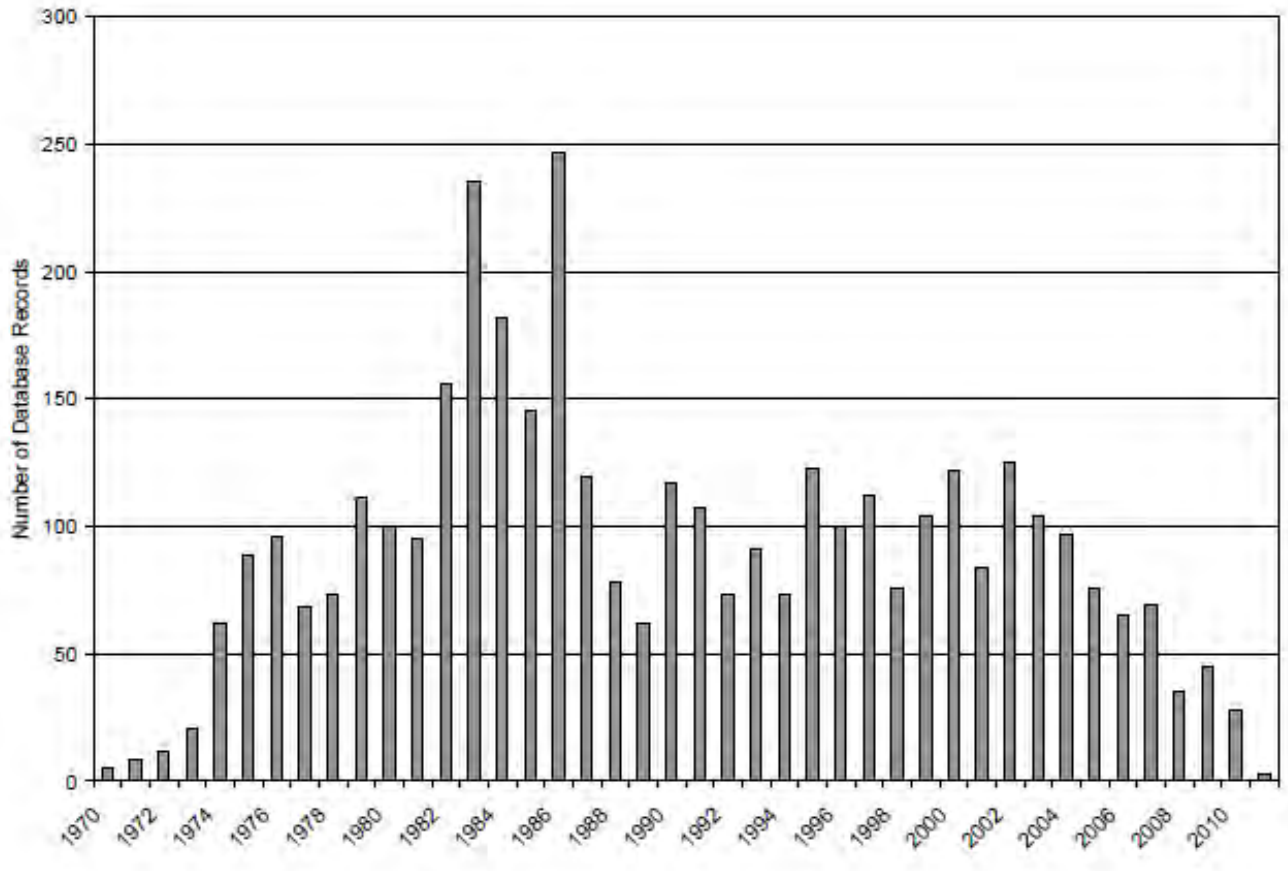
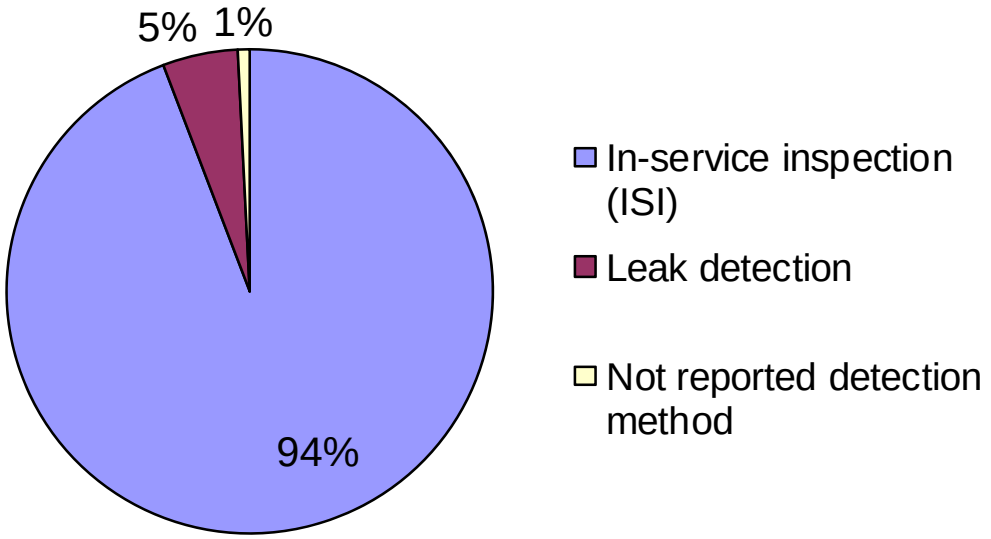


Figure 8: Pipe Degradation & Failure by Calendar Year

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
  - to prevent further failures

Research is important

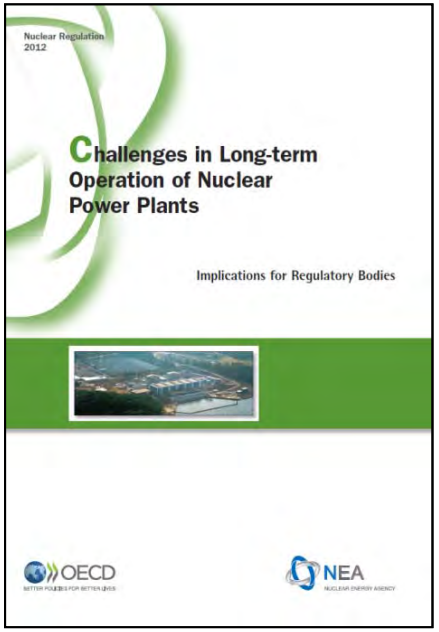
- Research activities and operating experience world wide
  - have led to a situation where substantial knowledge has been accumulated about degradation mechanisms that can affect components and structures in NPPs
- However, degradation history shows clearly that our knowledge base must be continuously 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

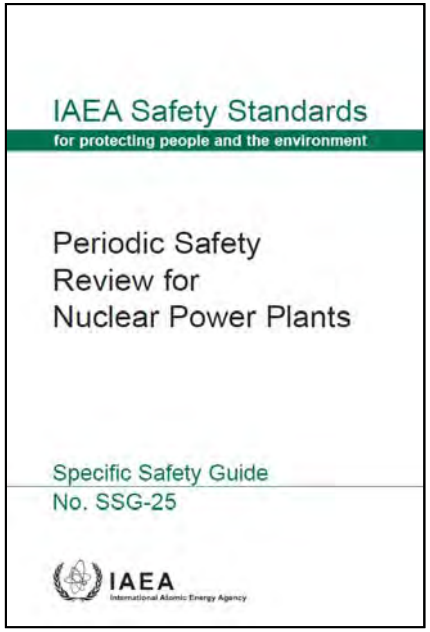
Long-term operation (LTO)

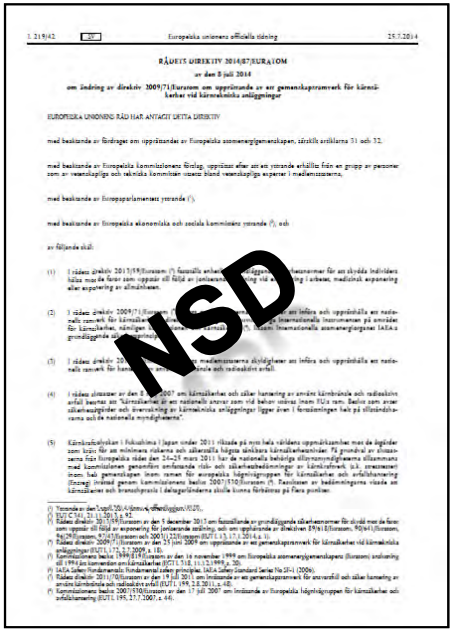
- IAEA definition of LTO is
  “operation beyond an established time frame set forth by, for example, license term, design, standards, license and/or regulations, which has been justified by safety assessment, with consideration given to life limiting processes and features of systems, structures and components”
- This means that both the formal and real conditions for LTO varies between NPPs and countries

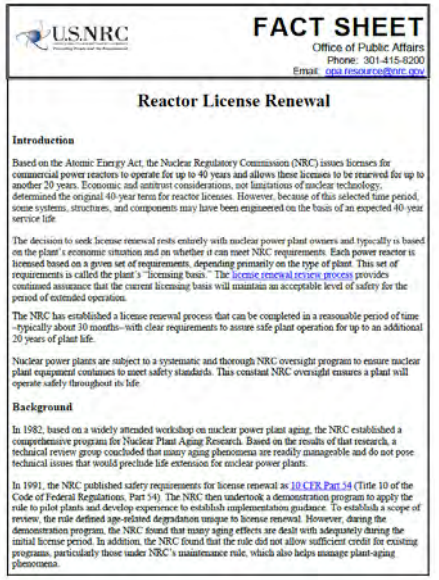
Internationally recommended practice

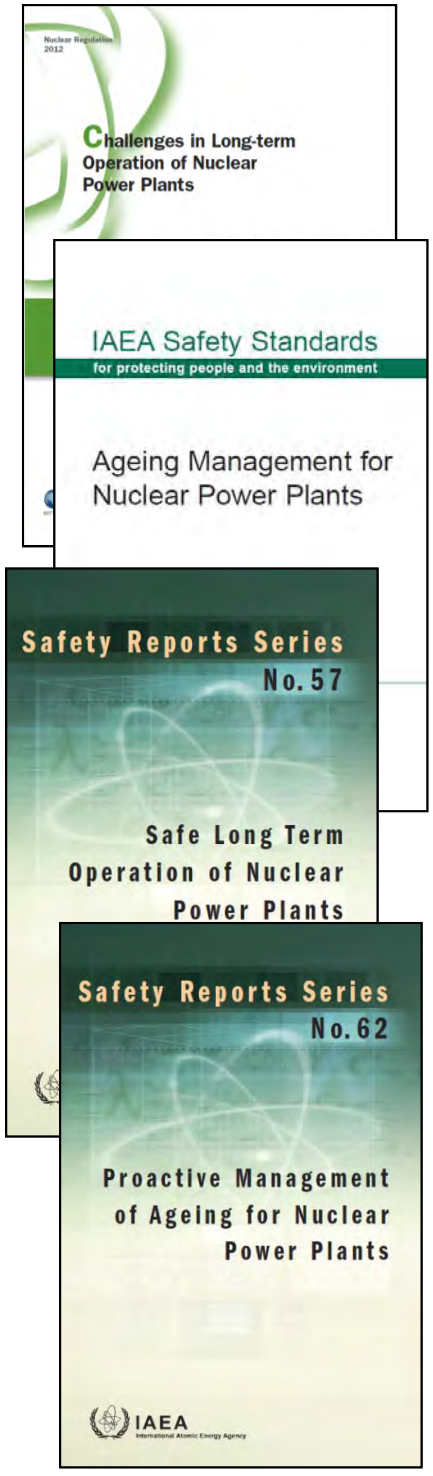
- to have a formal process with the clear position on long-term operation either through
  - a License Renewal process, or
  - by a PSR process focusing on LTO











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

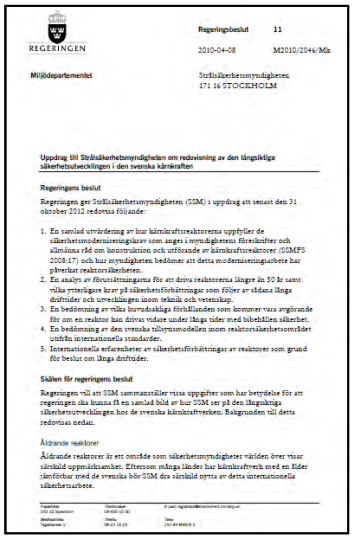
- Technological ageing (obsolete equipment)
  - for example I&C
  - Difficulties in obtaining spare parts, problems with maintenance and repair
- Generation shifts within organizations
  - Important tacit knowledge may disappear from organizations
  - It can relate to specific maintenance practices, 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



REGERINGEN

Regeringsbeslut 11

2010-04-08 M2010/2046/Mk

Miljödepartementet

Strålsäkerhetsmyndigheten
171 16 STOCKHOLM

Uppdrag till Strålsäkerhetsmyndigheten om redovisning av den långsiktiga säkerhetsutvecklingen i den svenska kärnkraften

Regeringens beslut

Regeringen ger Strålsäkerhetsmyndigheten (SSM) i uppdrag att senast den 31 oktober 2012 redovisa följande:

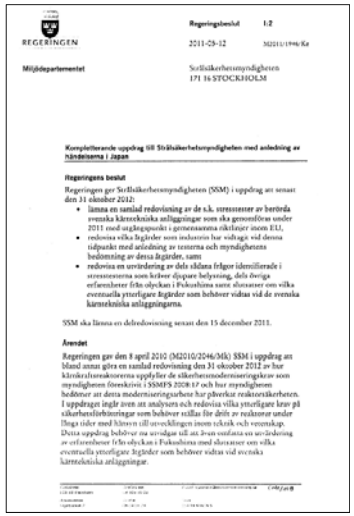
1. En samlad utvärdering av hur kärnkraftsreaktorerna uppfyller de säkerhetsmoderniseringskrav som anges i myndighetens föreskrifter och allmänna råd om konstruktion och utförande av kärnkraftsreaktorer (SSMFS 2008:17) och hur myndigheten bedömer att detta moderniseringsarbete har påverkat reaktorsäkerheten.
2. En analys av förutsättningarna för att driva reaktorerna längre än 50 år samt vilka ytterligare krav på säkerhetsförbättringar som följer av sådana långa driftider och utvecklingen inom teknik och vetenskap.
3. En bedömning av vilka huvudsakliga förhållanden som kommer vara avgörande för om en reaktor kan drivas vidare under långa tider med bibehållen säkerhet.
4. En bedömning av den svenska tillsynsmodellen inom reaktorsäkerhetsområdet utifrån internationella standarder.
5. Internationella erfarenheter av säkerhetsförbättringar av reaktorer som grund för beslut om långa driftider.

Skälen för regeringens beslut

Regeringen vill att SSM sammanställer vissa uppgifter som har betydelse för att regeringen ska kunna få en samlad bild av hur SSM ser på den långsiktiga säkerhetsutvecklingen hos de svenska kärnkraftverken. Bakgrunden till detta redovisas nedan.

Åldrande reaktorer

Åldrande reaktorer är ett område som säkerhetsmyndigheter världen över visar särskild uppmärksamhet. Eftersom många länder har kärnkraftverk med en ålder jämförbar med de svenska bör SSM dra särskild nytta av detta internationella säkerhetsarbete.



REGERINGEN

Regeringsbeslut 1:2

2011-03-17 M2011/1944/Ke

Miljödepartementet

Strålsäkerhetsmyndigheten
171 16 STOCKHOLM

Kompletterande uppdrag till Strålsäkerhetsmyndigheten med anledning av händelserna i Japan

Regeringens beslut

Regeringen ger Strålsäkerhetsmyndigheten (SSM) i uppdrag att senast den 31 oktober 2012:

- lämna en samlad redovisning av de s.k. stresstester av berörda svenska kärntekniska anläggningar som ska genomföras under 2011 med utgångspunkt i gemensamma riktlinjer inom EU,
- redovisa vilka åtgärder som industrin har vidtagit vid denna tidpunkt med anledning av testerna och myndighetens bedömning av dessa åtgärder, samt
- redovisa en utvärdering av dels sådana frågor identifierade i stresstesterna som kräver djupare belysning, dels övriga erfarenheter från olyckan i Fukushima samt slutsatser om vilka eventuella ytterligare åtgärder som behöver vidtas vid de svenska kärntekniska anläggningarna.

SSM ska lämna en delredovisning senast den 15 december 2011.

Ärendet

Regeringen gav den 8 april 2010 (M2010/2046/Mk) SSM i uppdrag att bland annat göra en samlad redovisning den 31 oktober 2012 av hur kärnkraftsreaktorerna uppfyller de säkerhetsmoderniseringskrav som myndigheten föreskrivit i SSMFS 2008:17 och hur myndigheten bedömer att detta moderniseringsarbete har påverkat reaktorsäkerheten. I uppdraget ingår även att analysera och redovisa vilka ytterligare krav på säkerhetsförbättringar som behöver ställas för drift av reaktorer under långa tider med hänsyn till utvecklingen inom teknik och vetenskap. Detta uppdrag behöver nu utvidgas till att även omfatta en utvärdering av erfarenheter från olyckan i Fukushima med slutsatser om vilka eventuella ytterligare åtgärder som behöver vidtas vid svenska kärntekniska anläggningar.

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
- 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

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

Status of SALTO reviews

- 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

Michael Knochenhauer
2015-09-17

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