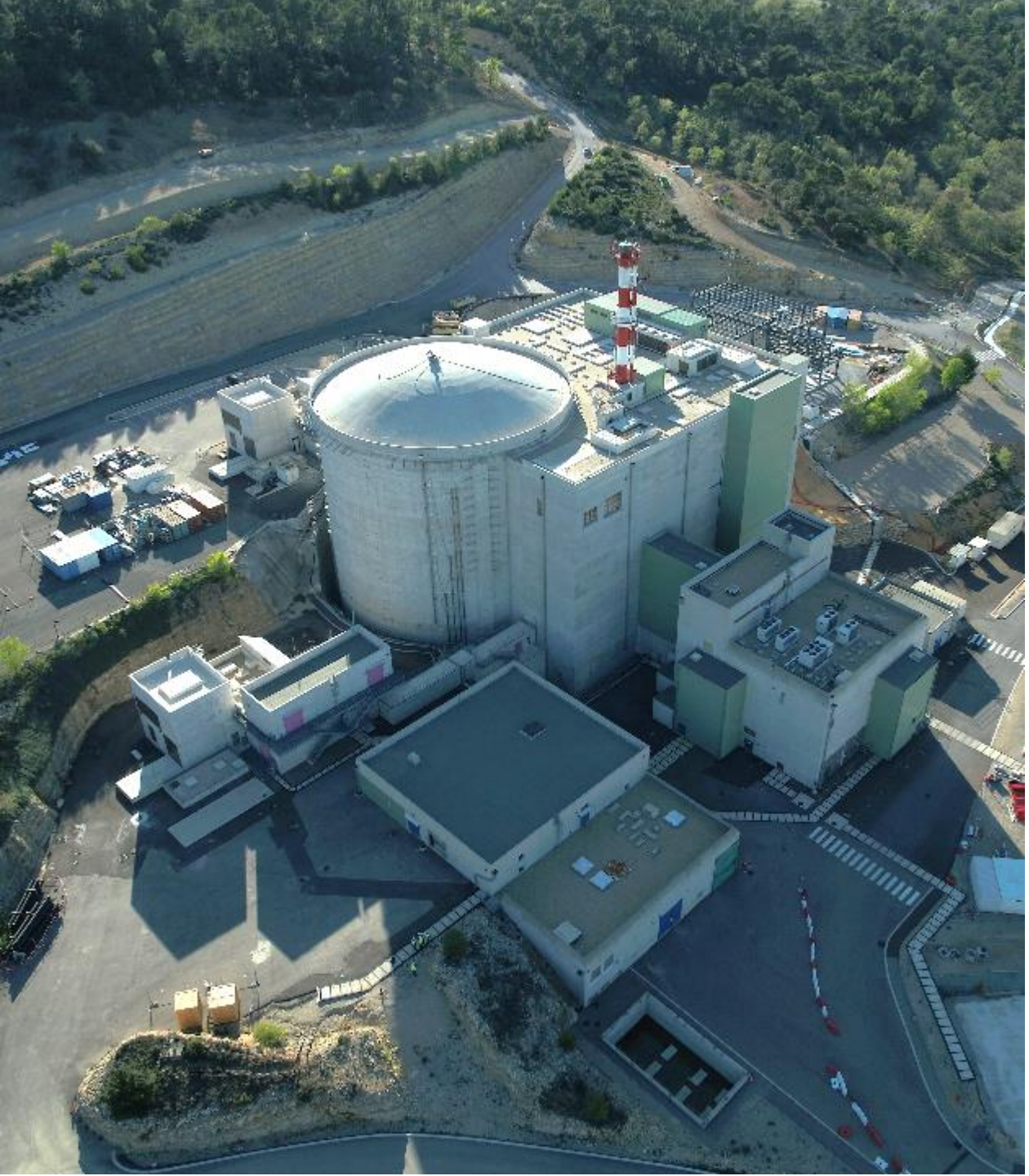

IGORR 2021

AGEING MANAGEMENT OF MATERIALS IN RESEARCH REACTOR

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TechnicAtome (FRANCE)

30/05 – 03/06

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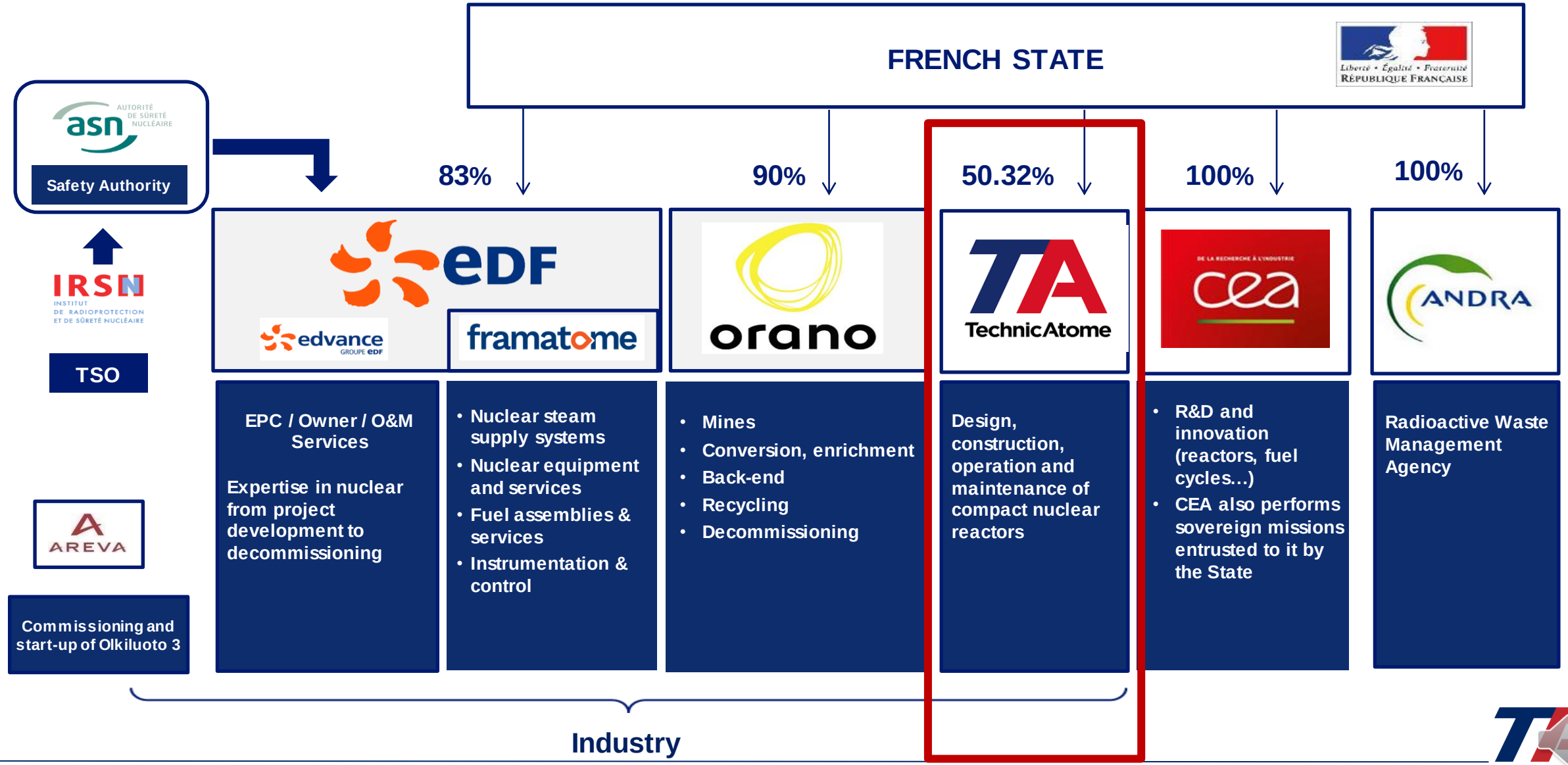
Brief overview of the French Nuclear Landscape



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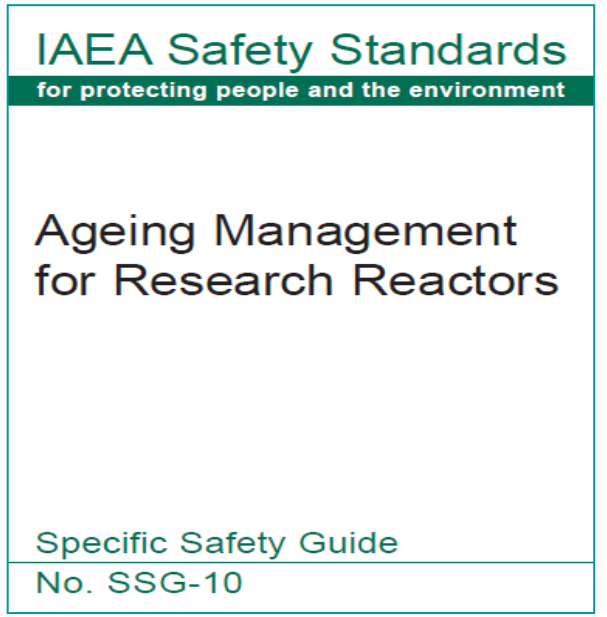
Ageing management for Research Reactors

- **Research Reactors specificities for ageing management:**
  - No serial effects (French case) : Reactor are only one of a kind
  - Ageing/obsolescence has to be managed by reactor operating teams

- **Specific ageing topics in RR due to:**
  - Neutron flux rate exposure;
  - Use of specific materials;
  - Complex design (experimental capabilities)
  - ....

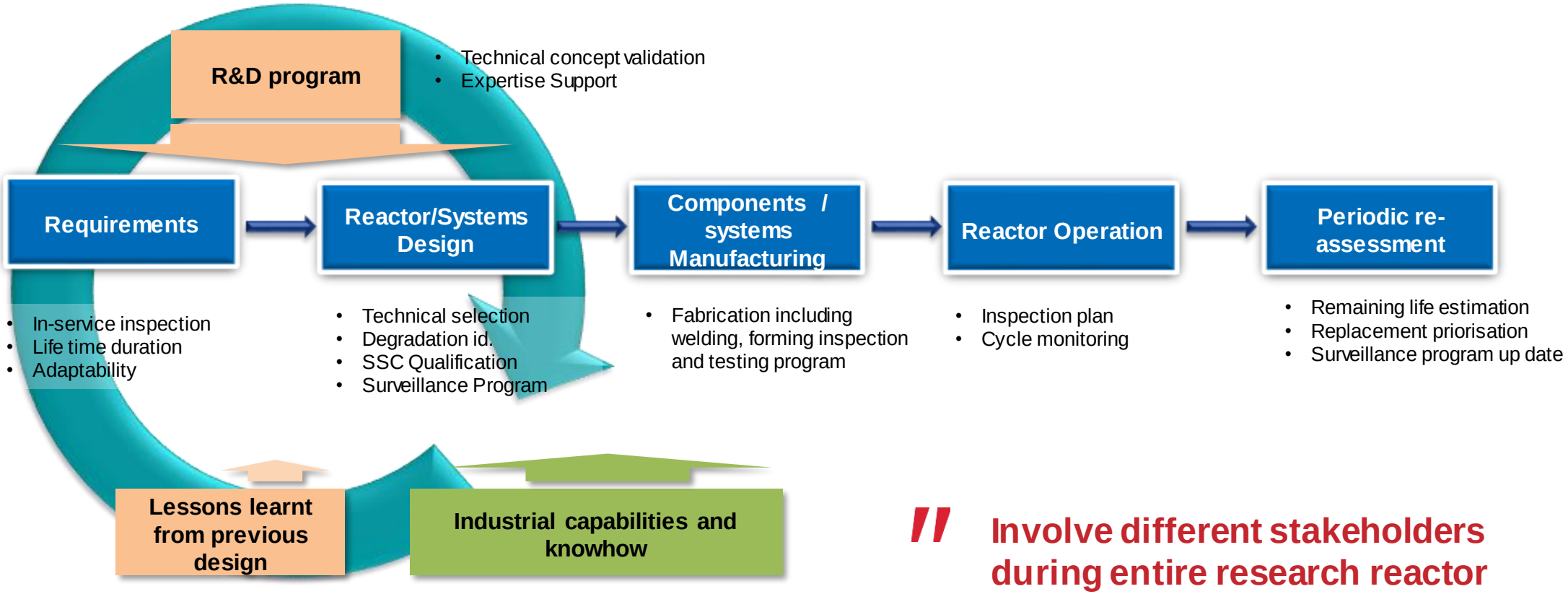


- **IAEA Safety Standards SSG-10, Ageing definition:**
  - Degradation of SSCs (physical ageing), i.e. gradual deterioration in their physical characteristics;
  - Obsolescence of SSCs (non-physical ageing), i.e. their becoming out of date in comparison with current knowledge, standards and technology.

" Ageing management plan implemented from design to operating phase

Ageing Management: an iterative process from design to operation

Ageing management Implementation during reactor life cycle



" **Involve different stakeholders during entire research reactor life cycle**

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Consequences for materials

- **It is expected that the service conditions of a given Research Reactor component can lead to physical ageing of that component. The main effects of this ageing is degradation of materials, including:**

Change in physical properties

Thermal ageing

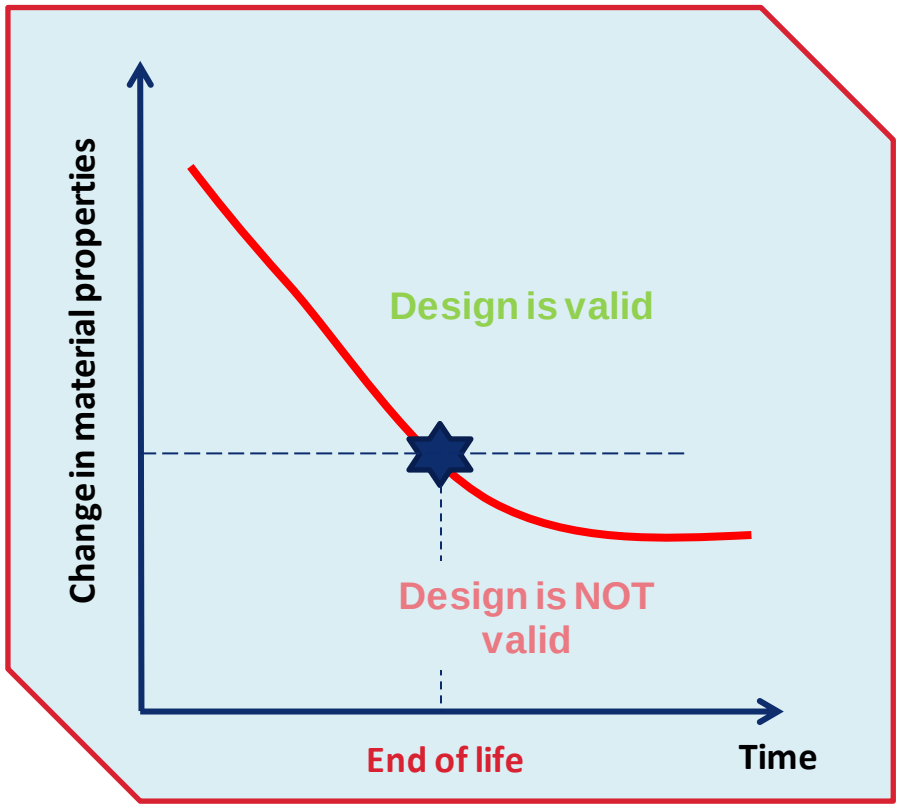
Irradiation ageing

Corrosion

Fatigue

Wear

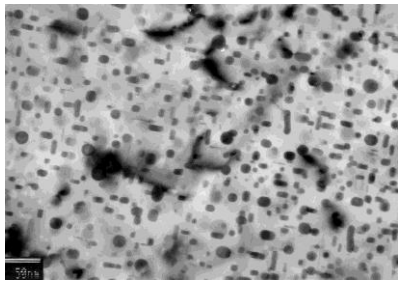
Creep



Design & Construction Code :

- Material properties & evolution
- Calculation rules

R&D activity to assess the material properties and understand ageing mechanisms



Aluminum tubes after irradiation in BR2 Reactor (from CEA)

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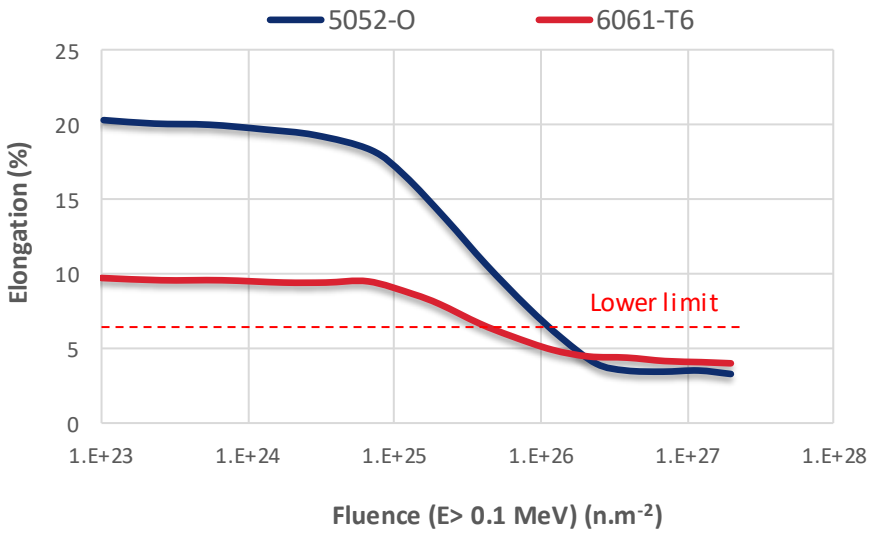
Consequences for materials

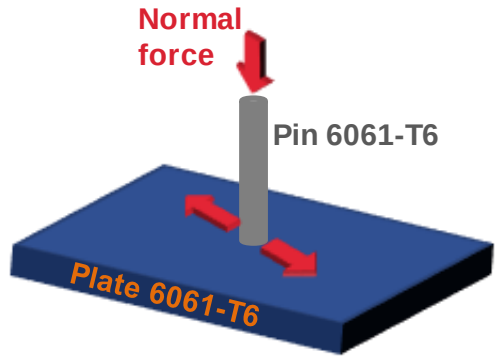
Some examples:

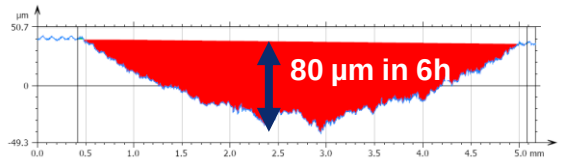
1 Evolution of Elongation (%) with fluence for two Al alloys (neutron energy > 0.1 MeV)

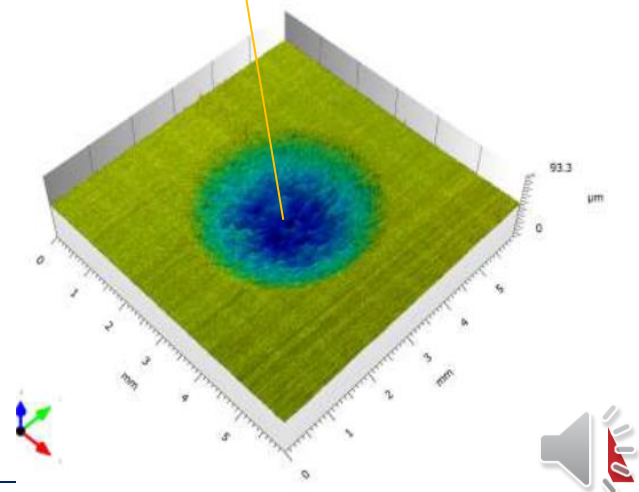


K. Farrell – Response of aluminum and its alloys to exposure in the High Flux Isotope Reactor (CONF-830418--3) in International conference on dimensional stability and mechanical behavior of irradiated metals and alloys, 11-14 Apr 1983

2 Wear observation and topography on an aluminium 6061-T6 plate after vibration in water conditions during a prolonged time (trials according to ASTM G204)







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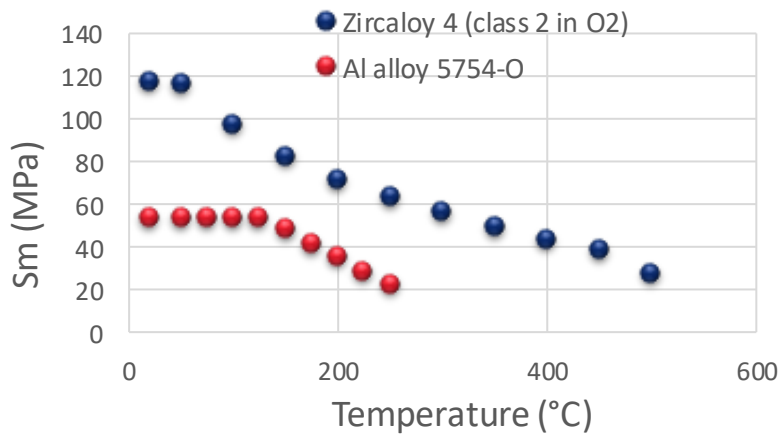
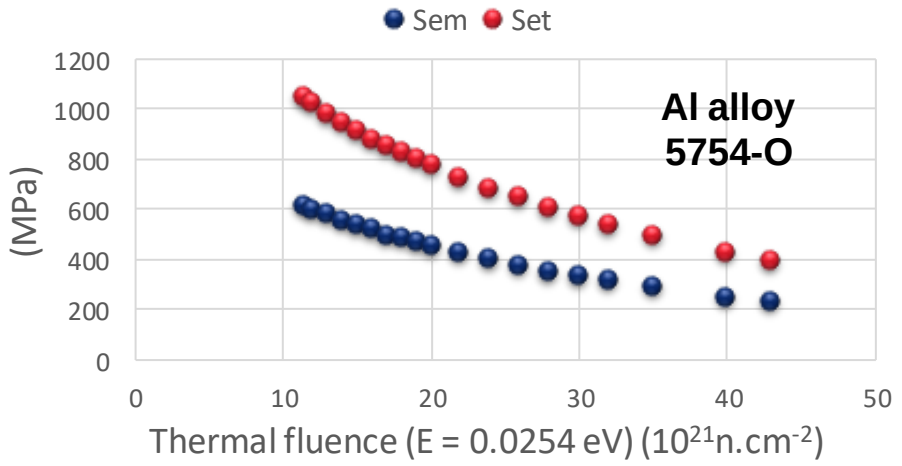
Some technical guidelines for material selection

- **AVAILIBILITY: a standardized material should always be preferred to reduce cost and/or delivery time even if a more specific material could improve the performance.**
- **MANUFACTURING PROPERTIES: depending on the application, weldability and formability are key manufacturing properties to have in mind when selecting the materials to assemble. Qualification of processes is a good way to ensure that material properties are maintained or at least are well characterized after the manufacturing operations.**
- **MECHANICAL CHARACTERISTICS and their evolution with the operating temperature of the selected material should be well documented.**
- **IRRADATION EFFECTS on the mechanical characteristics are to be known.**





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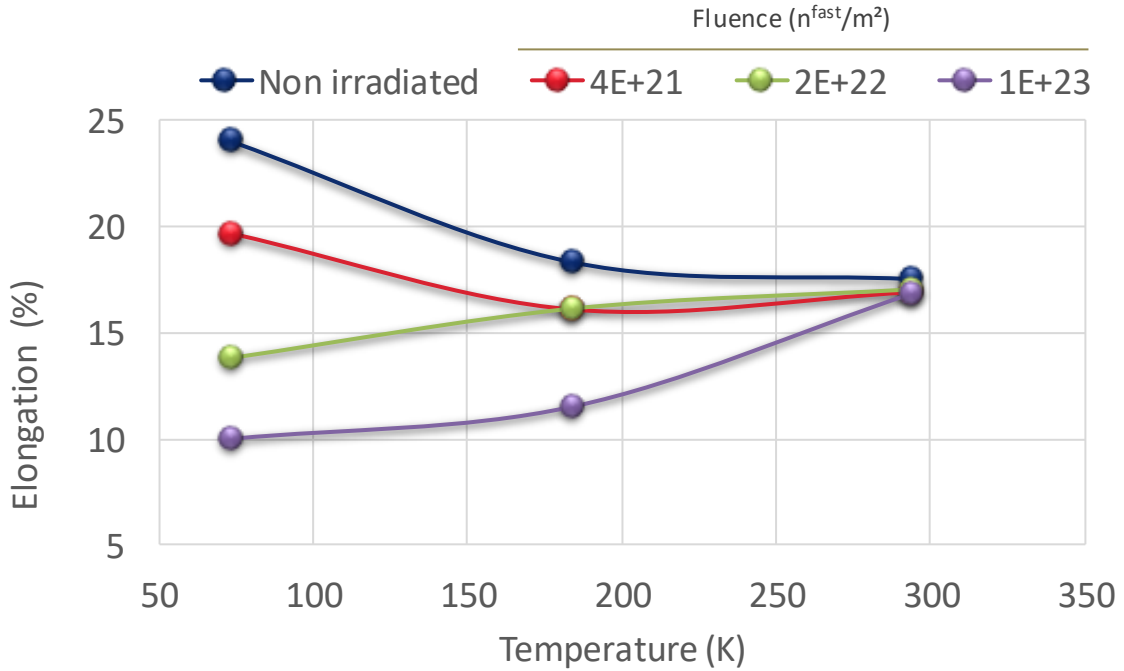
A Cold Neutron Source (CNS) example

- A cold neutron source is subjected to very severe environment during its lifetime.
- Some parts of a CNS are generally cooled down to 19 K during operation and can reach up to 323 K during outreach for maintenance.
- At cryogenic temperatures, the roles of the different irradiation mechanisms are modified. At such a low temperature, the diffusion mechanisms are not operating and the point defects do not recombine with others and hence continuously accumulate within the structure causing further hardening, subsequent embrittlement and increased susceptibility to defects



K. Farrell – Materials selection for the HFIR cold neutron source – ORNL/TM-99-208-Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831 – August 2001

Conclusions

- **Research Reactors usually experience two kinds of time dependent changes: degradation of SSCs (physical ageing) and obsolescence of SSCs (nonphysical ageing). Considering mechanical core components, the changes caused by physical ageing are likely to lead to rapid and severe structural damages with potential safety issues. Thus, they are to be anticipated as early as during the basic design stage of a new Research Reactor project.**

- **TechnicAtome has developed an engineering strategy dedicated to managing the ageing effects on materials. This strategy deals with all the successive stages of a new construction: identification of the technical requirements – design including the selection of materials – operation and ageing monitoring. The application of this strategy allows assessing the design of the most critical components, namely the components close to the nuclear core, with the highest level of safety.**

- **Several examples of actual design situations were presented and some technical recommendation and guidelines were given in order to support the rationale component life. A particular highlight were given on the irradiation effects on aluminium alloys and the combination of multiple ageing effects as well. Finally, the necessity to use design and construction codes, such as RCC-MRx and ASME, was pointed out.**