RISK OF LIFE TIME EXTENSION OF OLD REACTORS

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Workshop

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Who is INRAG (1)

- International Nuclear Risk Assessment Group
- Interdisciplinary expertise network
- Members are academics, former members and heads of nuclear authorities, members of technical support organizations, independent scientists and experts
- Members are from countries like Austria, Bulgaria, France, Germany, Sweden, the UK and the USA

Goals of INRAG (2)

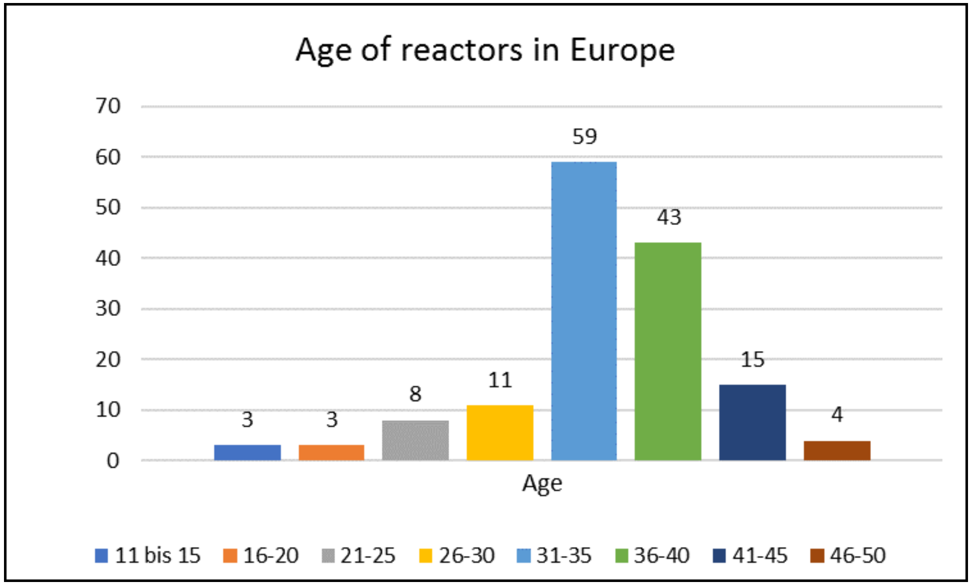
- provide international independent expertise in the nuclear field
- perform analyses, based on scientific and technically sound knowledge and expertise Interdisciplinary expertise network
- make international expert knowledge available to the public and decision-makers

INRAG Study, objective and methods

- Study: Assess problems and risks connected to life time extension (LTE) of nuclear power plants
- Look on examples of LTE utilizing the experience of INRAG members
- Assess consequences of LTE on risk
- Study performed for 'Alliance of Regions for Phasing out Nuclear Power across Europe'

Relevance of the study, age of reactor fleet

- Europe is looking at a fleet of aging reactors, currently planning to continue their operation for a long time



Age of Reactors
Status 01/2019

Age in years	0-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Total
Belgium							2	2	3		7
Bulgaria						1	1				2
Germany						1	6				7
Finland								2	2		4
France					4	6	21	23	4		58
UK					1	1	6	3	4		15
Netherland										1	1
Romania			1		1						2
Sweden							2	4	2		8
Switzerland							1	1		3	5
Slovakia				1	1		2				4
Slowenia								1			1
Spain							4	3			7
Chech Republic				2			4				6
Ukraine			2		1	2	7	3			15
Hungary							3	1			4
Total	0	0	3	3	8	11	59	43	15	4	146

Increased Risk

- Life time extension (LTE) of the aging fleet of nuclear reactors increases the risk for significant radiological releases in Europe.

- Severe accidents can happen in all currently operating European reactors.

- Aging of the reactors increases the risk of severe accidents

- Partial back fitting cannot change the situation significantly

Physical aging (1)

- Physical aging: degradation of structures, systems and components (SSCs) due to variation in temperature, stress, ionizing radiation, chemical processes during operation

- Examples are aging of reactor pressure vessel, primary system components, valves, pumps, concrete structures, electrical systems

- Aging management program (AMP) consists in identifying, monitoring and timely replacement of aging structures

Physical aging (2)

- Aging management only works well with known aging mechanisms and accessible and replaceable SSCs, but
  - Some components cannot be replaced (example: RPV), aging effects reduce the safety margin
  - Some components are hard to access (example: piping in concrete or cable in earth) and monitor
  - Not all aging effects are known
- **Result: Unexpected aging failure**

Technical and conceptual obsolescence

- The plant is out of date compared to current knowledge, standards and technology
- Huge steps forward in technology/standards occurred mostly after major accidents (e. g. Fukushima)
- Changes are often be such that full retrofitting is impossible (concepts like redundancy, diversity, physical separation, protection against external hazards etc.)

Type of Obsolesence

TABLE 1. TYPES OF OBSOLESCENCE

Subject of obsolescence	Manifestation	Consequences	Management
Technology	Lack of spare parts and technical support Lack of suppliers Lack of industrial capabilities	Declining plant performance and safety due to increasing failure rates and decreasing reliability	Systematic identification of useful service life and anticipated obsolescence of SSCs Provision of spare parts for planned service life and timely replacement of parts Long term agreements with suppliers Development of equivalent structures or components
Regulations, codes and standards	Deviations from current regulations, codes and standards for structures, components and software Design weaknesses (e.g. in equipment qualification, separation, diversity or capabilities for severe accident management)	Plant safety level below current regulations, codes and standards (e.g. weaknesses in defence in depth or higher risk of core damage (frequency))	Systematic reassessment of plant safety against current regulations, codes and standards (e.g. through periodic safety review) and appropriate upgrading, back fitting or modernization
Knowledge	Knowledge of current regulations, codes and standards and technology relevant to SSCs not kept current	Opportunities to enhance plant safety missed	Continuous updating of knowledge and improvement of its application

Reference: IAEA (2018): Ageing Management and Development of a Programme for Long Term Operation of Nuclear Power Plants: International Atomic Energy Agency; Specific Safety Guide No SSG-48; Vienna

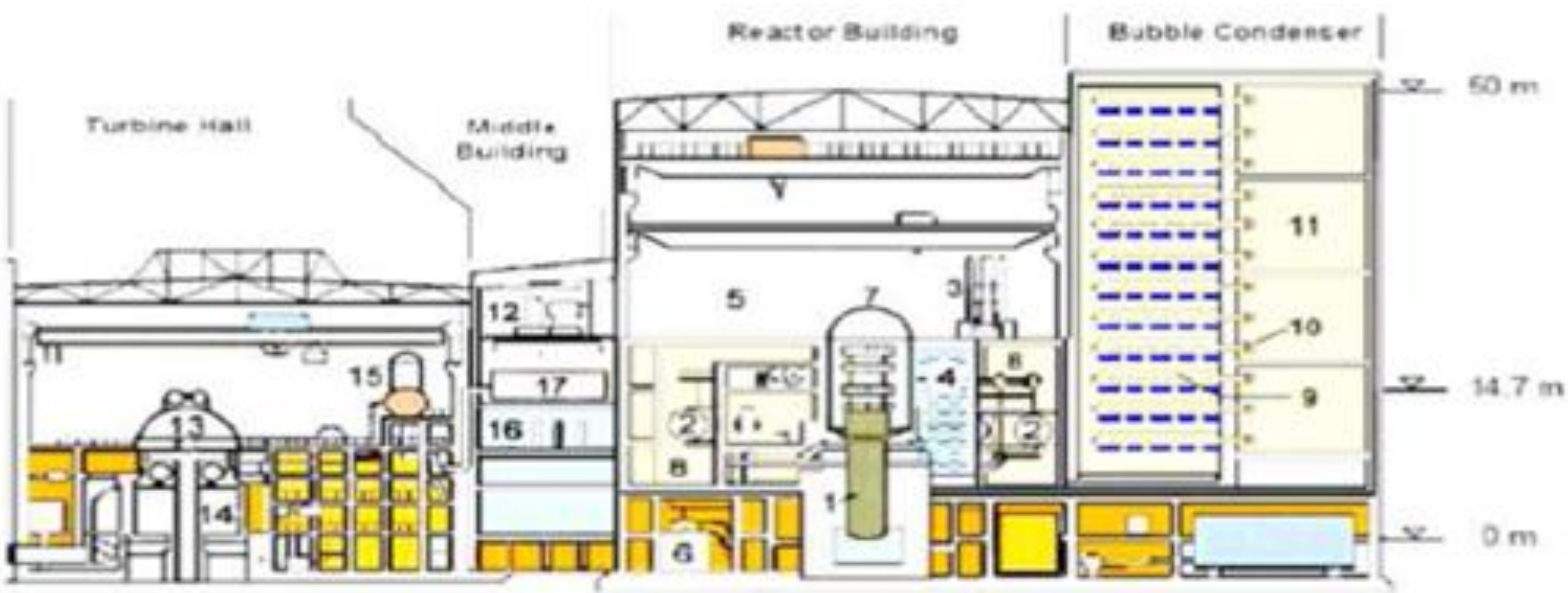
Limits of Back-fittings

- Back-fittings are impossible, because the plants is built
- Back-fittings are postponed for decades
- Back-fittings do not meet the required safety level
- Back-fittings causes failures
- Back-fittings are not always improving the safety: Often shortcomings in the design or materials are not known during construction and licensing of the plant, and only discovered later (even 10-20 years later)

Examples – limits of backfitting

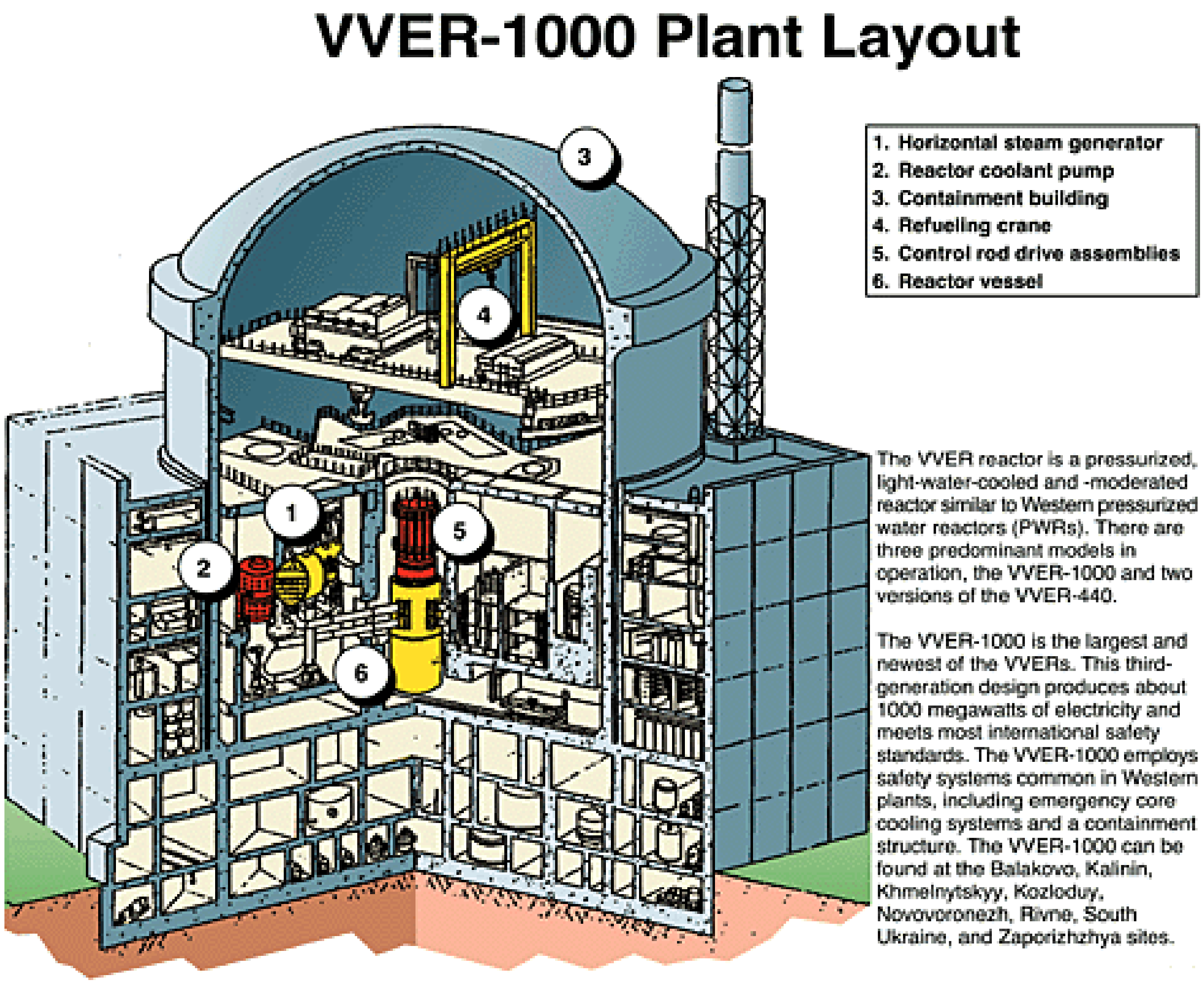
- Higher requirements in redundancy (e.g. n+2 concept instead of n+1)
- Higher requirements in diversity
- Requirement of physical separation of safety systems
- Requirement of safety related systems able to manage a core melt (core catcher, in-vessel retention)
- Protection against airplane crash

VVER 440/V-213



Reference: National Report on the "Stress Tests" for Nuclear Power Plants in Slovakia, Nuclear Regulatory Authority of the Slovak Republic, 30. Dec. 2011

VVER 1000/V-320



Reference: https://insp.pnnl.gov/inspmedia/vver1000.gif

Conclusions
Double Standards

- The design of current reactors (for most of them from 1970/1980) is out of age and would not be accepted today

- Most European countries accept different standards for existing and “new” reactors (Council Directive 2014/87/Euratom has different provisions for reactors with construction license before and after 4 August 2014)

- In many cases, existing reactor designs would not receive a construction license, would the operator apply today. To nowadays standards, their risk is not acceptable.

EU Directive 2014/87/Euratom

The revised Directive Council Directive 2014/87/Euratom defines in Article 8a “Nuclear safety objective for nuclear installations”:

- 1. Member States shall ensure that the national nuclear safety framework requires that nuclear installations are designed, sited, constructed, commissioned, operated and decommissioned with the objective of preventing accidents and, should an accident occur, mitigating its consequences and avoid-ing:
  - (a**) early radioactive releases** that would require off-site emergency measures but with insufficient time to implement them;
  - (b) **large radioactive** releases that would require protective measures that could not be limited in area or time.

More specific with regard to existing nuclear power plants the Directive states:

- 2. Member States shall ensure that the national framework requires that the objective set out in paragraph 1:
  - (a) applies to nuclear installations for which a construction licence is granted for the first time after 14 August 2014
  - (b) is used as a reference for the timely implementation **of reasonably practicable** safety improvements to existing nuclear installations, including in the framework of the periodic safety reviews as defined in Article 8c(b).

Ageing Management program (AMP)

- European Nuclear Safety Regulator's Group ENSREG
- 1st Topical Peer Review Report "Ageing Management“ October 2018

- In 2014, the European Union (EU) Council adopted directive 2014/87/EURATOM amending the 2009 Nuclear Safety Directive to incorporate lessons learned following the accident at the Fukushima Daiichi nuclear power plant in 2011.

Ageing Management program (AMP)

2. Overall Ageing Management Programmes (OAMPs)

Findings	Belgium	Bulgaria	Czech Rep	Finland	France	Germany	Hungary	Italy	NL	Poland	Romania	Slovakia	Slovenia	Spain	Sweden	UK	Norway	Switzerla	Ukraine
Good practice																			
External peer review services: External peer review services (e.g. SALTO, OSART-LTO, INSARR-Ageing) are used to provide independent advice and assessment of licensees' ageing management programmes.	GP (for NPP and RR)	GP	GP	GP	GP (for NPP)		GP		GP			GP	GP	GP	GP		GP	GP	
Expected level of Performance																			
International cooperation: Participation in international projects, experience exchange within groups of common reactor design and the use of existing international databases are used to improve the effectiveness of the OAMP.	GPerf	GPerf	GPerf	GPerf	GPerf	GPerf	GPerf	NC	GPerf	NC	GPerf	GPerf	GPerf	GPerf	GPerf	GPerf	NC	GPerf	GPerf
***Methodology for scoping the SSCs subject to ageing management*:** The scope of the OAMP is reviewed and, if necessary, updated, in line with the new IAEA Safety Standard after its publication.	GPerf	AfI	GPerf	GPerf	GPerf	AfI	GPerf	NC	GPerf	NC	AfI	GPerf	AfI	GPerf	AfI	AfI	NC	AfI	AfI
***Delayed NPP projects and extended shutdown*:** During long construction periods or extended shutdown of NPPs, relevant ageing mechanisms are identified and appropriate measures are implemented to control any incipient ageing or other effects.	GPerf	AfI	AfI	AfI	AfI	AfI	AfI	NC	AfI	NC	AfI	AfI	AfI	GPerf	AfI	AfI	NC	GPerf	AfI
***Overall Ageing Management Programmes of research reactors*:** A systematic and comprehensive OAMP is implemented for research reactors, in accordance with the graded approach to risk, theapplicable national requirements, international safety standards and best practices.	GPerf	NC	AfI	NC	AfI	AfI	GPerf	AfI	AfI	AfI	AfI	NC	NC	NC	NC	NC	AfI	NC	NC

GP: Good practice
GPerf: Good performance
AfI: Area for improvement
NC: Not Concerned

Reference: ENSREG (2018b): 1st Topical Peer Review Report "Ageing Management"; country specific findings European Nuclear Safety Regulator's Group; October 2018; http://ensreg.eu/eu-topical-peer-review

Conclusions
Information on risks

- Operation of nuclear power plants means accepting a residual risk of catastrophic accidents
- To decide whether or not the risk is acceptable, it should be known and transparently communicated to the public
- However, the risk cannot be fully known, since not all processes, state of materials, state of safety systems is fully known
- Even if the risk is known, it is not transparently communicated. Instead, the assessment of the risk is up to the regulatory authority, which then communicates that the plant is “safe”, which means, it adheres to safety regulations.

Conclusions
Public participation

- European countries provide the possibility for public participation for new builds of nuclear power plants (e.g. during environmental impact assessment)
- Life time extensions, even if of greater impact considering the risk, do not necessarily require public consultation process

Conclusions
Transparency

- Operation of nuclear power plants and the decision on life time extension (LTE) is within national authority

- However, the risk of operation of nuclear power plants is affecting also citizens across national borders

- Only view EURATOM directives concern nuclear safety, and international standards like IAEA Safety Standards, WENRA reference levels are not binding.

- There are currently no European regulations on high level requirements for LTE of nuclear power plants

Conclusions

- Nuclear power plants are very complex plants, and aging is a multifaceted process, complex on its own, requiring multiple disciplines for understanding
- While physical aging seems to be manageable in principle with monitoring and replacement, this is not always possible.
- Obsolesce, in many cases, is a fact, back-fittings are not always possible
- The combination of physical aging and obsolesces cause a significant increased risk, which, looking at current plans, will be present in Europe for a long time.