COMPONENTS INTEGRITY CONCEPT FOR LWRS AND ACTIVITIES OF CEN WORKSHOP 64 PROSPECTIVE GROUP 1

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afnor
NORMALISATION

MISSION OF CEN WS64 PG1 2014 - 2022

CEN-CENELEC Initiative on the further evolution of the AFCEN codes (= French nuclear codes & standards) and thereby harmonisation of nuclear codes & standards (NC&S) at European level.

Scope of Prospective Group 1 (PG1) are mechanical components of Gen II/III LWRs and RCC-M.

Two focus'**:**

- Generation II reactors, the lifetime extension up to 60 years including the large refit
- Generation III reactors, new build

- RCC-M devoted to design and RSE-M code devoted to in-service inspection and surveillance of mechanical components of Gen II and III LWRs,
- PG1 members are familiar with Russian PNAEG code, German KTA code and U.S. ASME BPVC code
- PG1 deliverables (also other PGs) are Code Evolution proposals and Recommendations for R&D projects.

PG1 MEMBERS

AFCEN	AFNOR
CEA - French Research Company	Tractebel Engineering - Belgium nuclear supplier
EDF – French Energy	ENSI - Swiss Nuclear Safety Authority
EC-JRC - European Commission – Joint Research Centre	FENNOVOIMA - Finnish Energy
FRAMATOME – French Nuclear Supplier	STUK - Nuclear Safety Authority of Finland
IRSN - Technical support of French Safety Authority	GRS - Technical support of German Safety Authority
UJV - Nuclear Research Company of Czech Republic	VGB Powertech - German Energy
Nuclear Consultant	

NEW MATERIALS AND NEW CHARACTERISATION TESTS

➲ Additive manufacturing in nuclear safety equipment

- Commonly used in non-nuclear industries and for deployment in nuclear achievement of acceptable mechanical properties with high level of reliability must be demonstrated,
- Demonstrate process stability & reproducibility and assess influence of process parameters,
- Process monitoring and assessment of material properties are challenges (NDT, witness specimens…),
- Assessment of ageing behaviour.

R&D project to answer above is required, which was launched in the meantime (Euratom project NUCOBAM).

➲ Small punch test (SPT)

- SPT may be used as an alternative / complementary test to uniaxial tensile test and to Charpy impact test to determine tensile properties and DBTTs respectively.
- Two possible applications: mechanical properties determination of alloys in design & manufacturing of mechanical components and monitoring of ageing degradation of mechanical components of operating NPPs.

SPT is useful where available quantity of material to be tested is small.

LONG TERM OPERATION OF GEN II & III LWRS

- **Purpose of LTO**
- Safety-related SSCs may be affected by relevant ageing effects and degradation mechanisms in a manner preventing their capability to perform the necessary safety function until end of life reactor shutdown.
- LTO has required significant R&D, mainly, in the fields of thermal and irradiation ageing, corrosion and fatigue damage and numerous projects have been performed in the past.
- Within PG1 a systematic analytical approach was used to identify those ageing phenomena which have an important effect on the LTO capacity of components and whether these phenomena are covered or not by RCC-M and other codes (RSE-M).

- **<u>Some examples</u>**

- ***Denting***
- Denting of steam generator tubes and tube plates has been found to being of higher concern and should avoided by proper design.
    - Share R&D feedback to confirm or not the importance of such phenomena in case of LTO.

LONG TERM OPERATION OF GEN II & III LWRS (2)

- ***Inter Granular Stress Corrosion Cracking (IGSCC) of commonly used alloys and their weld alloys***
- IGSCC was observed in some BWRs and PWRs commissioned in the 1970s / 80s within a few years after starting reactor operation, e.g. Alloy 600 SG tubes and Alloy 182 welds. Solution was to use Alloys 690, 152 and 52 instead that are less susceptibility to IGSCC (but at the expense of being more prone to hot cracking in case of Alloys 152 and 52). Until now no known cases of IGSCC of Alloy 690, 152 and 52 in operating LWRs
    - Recent and currently on-going research and evaluation on IGSCC of Alloys 690, 152 and 52 should be monitored.

- ***Prevention of steam generator tube wear***
- Wear is a damage mechanism where two parts touch each other in a highly dynamic manner, pretty much hitting each other. The area between tube bundle and the anti-vibration bar in the tube bend region may in principle be concerned by this damage mechanism.
    - Share R&D feedback to confirm or not the relevance of this phenomena in case of LTO

LONG TERM OPERATION OF GEN II & III LWRS (3)

- ***Irradiation assisted stress corrosion cracking of reactor internals (IASCC)***
- Reactor internals are exposed to high-energy neutron irradiation and high-temperature reactor coolant. Such an exposure increases the susceptibility of austenitic stainless steels to SCC.

- Two larger R&D projects that covered IASCC were performed, the Horizon 2020 EURATOM funded project SOTERIA in Europe and the Advanced Radiation- Resistant Materials (ARRM) Program of EPRI in the US.

  - Share R&D feedback from these two R&D projects would be an added value.

LONG TERM OPERATION OF GEN II & III LWRS (4)

- ***Fatigue***
- Thermal shock and flow induced vibration induce fatigue degradation mechanism in LWRs. The thermal loads may result from controlled operational conditions such as start-up and shutdowns, load-following, but occur generally where fluids of different temperatures are mixed from stratification of a fluid of different temperatures and a moving free surface.
- Flow-induced vibration of piping can be caused by pressure pulsations, exciting a response in nearby piping due to pumps regime changes by specific multiphase flow regimes and flow frequencies or rapid changes in flow conditions or fluid properties caused by opening valves, cavitation or other large pressure variations.
  - R&D projects on fatigue: Euratom funded projects INCEFA+ (2015-2020) and INCEFA-Scale (2020-2025);
    - A link between the two R&D projects and CEN WS64 could be of added value.

IN-SERVICE INSPECTION

- **Purpose of In-service inspection (ISI)**
- ISI and the associated management (repair, component replacement, service monitoring) are one of the pillars of lifetime extension. There is a direct link between the design and plant life management especially for LTO.

- **Defect geometry for a defect assessment analysis**
- In order to apply the defect assessment method, codes provide methodologies to define the defect geometry, characterization of the shape and the dimensions of the defect. But some information about the interaction between multiple defects seems to be missing.
  - Need studies in order to have some criteria on how to group multiple defects.

IN-SERVICE INSPECTION (2)

- **Fracture assessment**

- Benchmark on fracture assessment (fatigue crack initiation, crack propagation, stability of the surface crack, stability of the through wall crack…) on a pipe line with KTA and RSE-M codes submitted to an internal pressure and bending moment due to thermal expansion. No major differences on the prediction of the fatigue and fracture mechanics.

    - Need going deeper with various examples and experimental results in order to identify more precisely the uncertainties and margins

- **Reactor Pressure Vessel (RPV) integrity assessment**

- A qualitative comparison of approaches and parameters for RPV integrity assessment performed in 2018 by ETSON.

    - Due to the absence of parameters effect quantification, calculation benchmarks in order to better understand the assessment process and margins are needed.

    - However, a quantitative study is an added value for design codes.

IN-SERVICE INSPECTION (3)

Break preclusion

- According to European Utility Requirements for LWR Nuclear Power Plants (Vol 2. Chap 4. Section 5.10 Rev. E) 2016, break preclusion is a concept, implemented during the design phase, to deterministically rule out the catastrophic failure of any important pipe (e.g. LBLOCA in main coolant line) from the list of the design events considered for structures and components.

- Implementation of this concept is based on the following items:

  - Quality in design (material selection, manufacturing, low stresses, good inspectability);

  - Integrity demonstration (limited crack growth of path-through flaw, safety margins to fracture);

  - Surveillance and monitoring of design basis;

  - In-Service Inspection; and

  - Adequate leak detection (with margin)

- For each of these items, quantitative or more precise information would be of added value for NC&S

HARMONISATION OF LICENSING PROCEDURES

- **HORIZON EUROPE EURATOM CALL 2021**
- Contained own topic exclusively on harmonization of licensing procedures and C&S for future fission and fusion plants.
- HARMONISE project proposal (which contains a specific task on C&S) submitted to call and was successful (currently in grant agreement phase).
- Some PG1 members (or their entities) will be involved in the project.
- Important to follow up project work.