FRANCE

SAFETY ASSESSMENT OF NUCLEAR FACILITIES IN FRANCE

AGEING MANAGEMENT

NATIONAL ACTION PLAN

PRODUCED PURSUANT TO ARTICLE 8e OF COUNCIL DIRECTIVE 2014/87/EURATOM DATED 8 JULY 2014

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List of content

1. INTRODUCTION

In 2014, the European Union (EU) Council adopted directive 2014/87/EURATOM and, recognizing the importance of peer review in delivering continuous improvement to nuclear safety, introduced a European system of Topical Peer Review (TPR) commencing in 2017 and every six years thereafter.

The 30th Meeting of the European Nuclear Safety Regulators Group (ENSREG) in July 2015 identified ageing management of nuclear power plants as the topic for the first Topical Peer Review.

This peer review, according to the Terms of Reference[1] and WENRA Technical Specification[2], focused on the Ageing Management Programmes (AMPs) at Nuclear Power Plants (NPPs) and Research Reactors (RRs) above 1 MWth. In addition to reviewing the programmatic part of ageing management, the peer review process examined the application of the AMPs to the selected systems, structures and components (SSCs) in four thematic areas, namely; electrical cables, concealed piping, reactor pressure vessels, or equivalent structures, and concrete containment structures.

The peer review process was overseen by a Board and consisted of three phases:

1. the national self-assessments, conducted against the Technical Specification and documented in the National Assessment Reports (NARs) published at the end of 2017;
2. a question/answer period on the NARs and a one-week workshop to discuss the results of the self-assessments, the questions and comments on the NARs with a goal to identify and discuss both generic and country-specific findings on Ageing Management Programmes (1st semester of 2018);
3. the completion of the Topical Peer Review report and country specific findings report.

Topical Peer Review Report and country specific findings were endorsed at the 37th ENSREG meeting in October, 2018. It was recalled that according to the Directive "*Member States should establish national action plans for addressing any relevant findings and their own national assessment".*

In accordance with the agreed format at the 38th ENSREG meeting in March 2019, France has elaborated the present national action plans (NaCP):

- **Sections 2 and 3** of this report address the results of the self-assessment and respond to the country specific findings allocated to France for reaching the Topical Peer Review expected level of performance;
- As the findings related to the cables were not allocated to the countries, **Section 4** presents France's position with regard to these findings, and if relevant the planned actions;
- **Section 5** is dedicated to the generic findings for which France was allocated a good practice or a good performance. Information is provided to ensure dissemination of good practice or performance to other countries;
- As the scope of this peer review focusses on NPPs and RRs, the Board recommended that countries explore the regulation and implementation of Ageing Management Programmes of other risk significant nuclear installations. This is the object of **Section 6** for which France reports on a voluntary basis for the nuclear installations, out of the TPR scope, which present the greatest risks or adverse effects;
- **Section 7** summarizes the planned actions, the associated deadlines and the regulator monitoring process.

[1] http://www.ensreg.eu/sites/default/files/attachments/ensreg_tpr_terms_of_reference_-_january_2017.pdf
[2] http://www.ensreg.eu/sites/default/files/attachments/wenra_tpr_technical_specification_-_january_2017_1.pdf

2. FINDINGS RESULTING FROM THE SELF-ASSESSMENT

This section is dedicated to the findings from the self-assessment as expressed in the National Report[3] (NAR). France position for each finding is presented through a summary of the actions that are planned to address them.

2.1. Overall Ageing Management Programmes (OAMPs)

2.1.1. OAMP for research reactors (see NAR §9.5)

"This review highlights the fact that the monitoring of research reactor ageing is currently based on maintenance programmes, inspections and periodic tests. ASN considers that the research reactor licensees need to adopt a more formalised approach to ageing management. More specifically, ASN considers that the research reactor licensees must apply an approach that allows the adequacy of the inspections and tests implemented to be ascertained. They must also define additional verifications to ascertain their fitness to fulfil their functions with regard to the ageing mechanisms that could affect the EIPs (elements important for protection)."

Country position and action

- BNI No. 101 (Orphée) operated by the CEA

On account of its final shutdown at the end of 2019, no specific action is required for the Orphée reactor.

- BNI No. 24 (CABRI) operated by the CEA

As indicated in the NAR, the CEA manages the ageing of each installation individually through periodic inspections and tests (PIT), the periodic safety reviews and preventive maintenance. There is no formalised ageing management programme. There is, however, a harmonised process for the issues associated with obsolescence.

The measures to take into account the effects of ageing on the CABRI reactor during the various life cycle phases are:

- the design, dimensioning and qualification of the EIPs[4] to fulfil their defined requirements over their service life,
- the performance of inspections and periodic tests,
- monitoring of the potential consequences of the ageing mechanisms on these equipment items (integrated in the PITs),
- implementation of preventive maintenance and treatment of obsolescence by the early replacement of items of equipment, which contributes to the control of ageing.

The following table provides a non-exhaustive list of the main EIPs concerned, the identified ageing mechanisms and the corresponding periodic inspection activities.

[3] Safety assessment of nuclear facilities in France ageing management, national report produced pursuant to article 8e of Council Directive 2014/87/EURATOM dated 8 July 2014, December 2017 : http://www.french-nuclear-safety.fr/International/Multilateral-relations-in-Europe/The-European-Union/ENSREG

[4] EIP : Element Important for the protection of Interests

Table 1: Management of the ageing of the main Cabri EIPs concerned by ageing-related degradation

Name of EIP	Specified requirement	Ageing mechanisms	Inspections	Inspection frequency
Reactor block	Seismic resistance	Corrosion, irradiation, fatigue, erosion	Visual inspection of the corrosion indicator (corrosion of the aluminium and stainless steel parts of reactor block)	10 years
Cooling system	Water-tightness Seismic resistance	Corrosion, chemical attack, fatigue, erosion	Visual inspection of core water system supporting structure, (situated outdoors) for corrosion of the carbon steel	10 years
Water storage tanks	Water-tightness Seismic resistance	Corrosion, chemical attack, climatic constraints	Visual inspection of the condition of the tanks and associated retention structures	10 years
Reactor building	Compliance with leakage rate limits	Corrosion, erosion, fatigue, climatic constraints	Check of reactor building leakage rates	1 year
			Visual inspection of the condition of the inter-building gap seal cover	5 years
Nuclear pressure equipment (pressurised water (PW) loop in particular)	Compliance with regulations	Pressure, temperature, irradiation	Regulatory inspections and in accordance with the POES[5] (e.g. direct or indirect visual inspections, ultrasound, requalification by pressure tests, etc.)	According to regulations (e.g. periodic inspections at 40 months; 10-yearly re-qualifications; etc.)
Primary pumps	Water-tightness Seismic resistance	Fatigue, erosion	Vibration measurement (and analysis of development)	3 years

[5] POES: Maintenance and monitoring operations programme

			Replacement of seals of the 2 primary pumps	Every 3500 hours of operation or every 10 years
Flywheel of pump POEC01	Availability (cannot become a projectile)	Corrosion, fatigue	Ultrasound inspections	10 years

In the context of the periodic safety review, the conclusions of which were submitted in 2017, a new approach to ageing comprising the following four phases is being implemented:

- determination of the EIPs concerned,
- identification of the ageing mechanisms to which these EIPs can be subjected in the different operating conditions of the BNI, and the impact of these phenomena on compliance with their defined requirements (assessed in terms of consequences and time of inoperability),
- determination of the ageing monitoring programme: the results of the abovementioned analysis will be used to define and justify the nature and frequency of the inspection, maintenance and monitoring measures implemented,
- the periodic reassessment of the ageing monitoring programme: objective and measurable criteria (frequency, non-compliant inspection results, etc.) shall be defined to reassess this ageing management programme.

This approach which is based on the methodology presented in IAEA guide SSG-10 has been implemented in the last periodic safety review for certain EIPs. The CEA plans to extend it to all EIPs in the first half of 2020. This approach will be formalised in specific notes.

ASN notes that within the framework of the periodic safety review, the CEA has reinforced and extended its methodology, which is satisfactory on the principle. ASN will examine the application of the new methodology based on IAEA guide SSG-10 to certain systems, structures and components (SSC), such as the reactor block and the reactor containment. ASN conducts also a particular review of the *in situ* inspections carried out and the adequacy of the identified inspections. On completion of examination of the periodic safety review (2021), ASN will, if necessary, ask the CEA to supplement its approach and to formalise its ageing management programme in the baseline requirements.

- BNI No. 172 (RJH) operated by the CEA

The RJH reactor is under construction on the Cadarache site; it does not have an ageing management programme. The issues relating to ageing are taken into account in the design, manufacturing and construction stages.

The structures, systems and components (SSC) concerned by ageing are identified among the EIPs that are important to safety and have a safety classification. For each of these EIPs, the ageing mechanisms have been identified at the design stage and integrated in the dimensioning of the SSCs. They are also taken into account in the qualification programmes, which were presented to ASN as part of the CEA's response to a commitment made in the examination of the creation authorisation application.

The following table presents the ageing mechanisms and the qualification methods implemented for the various classes of equipment.

Table 2: Ageing mechanisms and methods of EIP qualification for RJH

AGEING MECHANISMS					
EIP family (grey) Sub-family	**HEAT**	**IRRADIATION**	**HYGROMETRY**	**VIBRATION**	**Prolonged operation**
CLASSIFIED VALVES					
- Valves	Analysis or test	Analysis	Analysis	OEF [6]or standardised test	Test and Analogy / Analysis
- Actuators	Test or Analogy / Analysis	Test or Analogy / Analysis	Test or Analogy / Analysis	OEF or standardised test	Test
MOTOR-PUMP ASSEMBLIES					
- Reactor coolant pump set	Analysis	Analysis	Analysis		Test Vibration monitoring
- Auxiliary motor-pump assemblies	Analysis and Analogy	Analysis and OEF	Analysis		Test Vibration monitoring
ELECTRICAL EQUIPMENT					
- Distribution cabinets	Analysis	Analysis	Analysis	Analysis	Analysis
- Transformers	Analysis or test	Analysis or test	Analysis or test	Analysis or test	Analysis or test
- Cables	Analysis	Analogy or test	Analysis	Analysis	
INSTRUMENTATION AND CONTROL EQUIPMENT	Analysis	Analysis	Analysis	Analysis	Analysis
INSTRUMENTATION	OEF	OEF	OEF	OEF	OEF
BACKUP DIESEL GENERATOR SET	Analysis	Analysis	Analysis		Test Vibration monitoring
MECHANISMS					
- Detection of FCB and FCH ASA and FCB APAC[7]	Test	Test	Test	Test	Test
-Electromagnet (disconnection)	Test	Test	Test	Test	Test

[6] OEF : operating experience feedback

[7] FCB: low end of travel - FCH : high end of travel – ASA: emergency shutdown absorbers – APAC: neutron flow monitoring absorbers

In addition, with regard to the civil engineering, the paraseismic supports and the prestressing cables of the reactor containment are subject to special monitoring before commissioning and during operation. This makes it possible to detect any drops in performance and take action to restore the required level of performance.

As RJH commissioning has been pushed back beyond 2019 (the date initially planned in the Creation Authorisation Decree), the question of ageing management is posed from a specific angle associated with the equipment storage durations during prolonged construction period before start-up.

It is to be noted that the equipment items will be installed in the RJH progressively as construction work proceeds. The majority of them will be installed later after completion of the studies and the manufacturing processes. However, some of these supplies are already on the site and are dealt with the following actions:

- equipment having undergone partial acceptance:
    - functional equipment: these items have satisfied the test process and are managed by the CEA which maintains them in operational condition. Examples include the site high-voltage substation, the tertiary cooling system water intake and discharge structure, and the polar crane in the reactor building.

      A programme of required maintenance and inspections is put in place on the basis of the manufacturer's specifications and regulations. These items of equipment are therefore operated and maintained in operational condition in exactly the same way as if the RJH was functioning. There are no specific ageing phenomena due to prolonged construction to be considered in such a situation.
    - non-functional equipment: these items have satisfied the construction test process. They must undergo additional operations performed by other work task to make them fully functional. This is the case for example with the airlock doors: the mechanical part has undergone acceptance and the interlocking instrumentation and control work will be carried out later.

      These items of equipment can be subject to special conservation or protection measures. Thus, the airlock doors mentioned above have been fitted with protective panels. Generally speaking, the question of conservation of equipment pending entry into operation is addressed with the manufacturers and the prime contractor who recommend specific measures and checks which are implemented by the CEA.

      When the equipment becomes functional, it is attached to the preceding category.
- equipment installed pending acceptance:

    Installed equipment items which have not yet undergone acceptance are under the responsibility of the contractors who must protect their supply against damage. Depending on the time between the installation and acceptance of these items, special conservation conditions may be required. This could be the case with pipes which, after undergoing the hydrostatic test, shall be dried and if necessary inerted, or rotary equipment which will require periodic manoeuvring. These measures shall be defined jointly with the contractor. Their implementation shall be the responsibility of the contractor or be performed by the CEA after clarifying the limits of responsibility.

ASN recalls that the RJH installation under construction does not yet have operational baseline requirements. Nevertheless, the issues associated with ageing have been integrated in the design, qualification and construction stages. The EIP qualification method deployed by the CEA, which includes specific qualifications to take ageing into account, is currently being examined by ASN. With regard to the issues associated with equipment preservation due to the extension of the construction time frame, ASN has noted that the CEA has implemented a procedure to ensure that equipment already installed or awaiting assembly and commissioning on site is properly conserved. Lastly, within the framework of the commissioning application (2028), ASN will examine the elements relative to the implementation of prescriptions[8] with regard to the monitoring and management of ageing of certain SSCs (reactor containment and paraseismic supports, core vessel) and if necessary will ask the CEA to supplement the ageing management programme of its installation.

- BNI No. 67 HFR operated by the ILL

As indicated in the NAR, the ILL's ageing management is integrated in the periodic inspections and test (PIT) process and the maintenance process. There is no specific process relative to the installation ageing management procedure.

The methodology for taking ageing into account comprises the following elements:

- determination of the SSCs which must be subject to ageing monitoring: the safety analysis presented in the BNI safety analysis report allows the identification of the EIPs to which the ageing management procedure primarily applies. This procedure is partially presented in the safety analysis report,
- as exhaustive as possible identification of the damage deterioration mechanisms to which these EIPs are subjected in operation (for example: corrosion, fatigue, abrasion, thermal and climatic constraints),
- identification of the associated inspection activities (nature, extent and frequency) and the maintenance activities associated with these inspections and checks,
- regular reassessment of this programme in the light of the new information available.

This methodology was applied to the reactor block and the reactor containment during the periodic safety review, the conclusions of which were submitted in 2017.

ASN notes that during the periodic safety review, complementary in situ investigations were carried out on several EIPs enabling the development of their ageing to be monitored. ASN examines the result of these investigations, particularly with regard to the adequacy of these inspections. Furthermore, an in-depth examination of the methodology shall be carried out for and the reactor block containment EIPs. On completion of the examination of the methodology in the framework of the periodic safety review (2021), ASN will, if necessary, ask ILL to supplement its methodology and formalise its ageing management programme.

2.1.2. Implementation of AMP on NPP sites (see NAR §9.4)

"The specific aspects of the site and of each reactor could be better taken into account in the local ageing management programme (PLMV) and the unit ageing analysis report (UAAR)."

Country position and action

According to the EDF national instructions for drafting the Unit Ageing Analysis Reports (UAARs), the specific features of the site and of each reactor have to be taken into account in the drafting of the UAAR and the corresponding local ageing management plan (PLMV). However, the experience from the recent years shows some heterogeneity in the production of these documents among the different sites.

[8] ASN resolution 2011-DC-00226 of 27 May 2011 setting the technical requirements for the design and construction of BNI No. 172

Therefore, in 2018, EDF set up an action plan to improve their quality and usability. This action plan includes an upgrade of the format of the UAAR (by updating the EDF national drafting guide), so that greater account is given to the specific aspects of the site.

The work to optimise the UAAR production process is currently in progress, via the pre-release by EDF national service of a new drafting guide and support to the plants for this new guide, which should come into force in late 2019/early 2020.

ASN considers that the evolutions proposed by EDF in the action plan should answer its expectations. ASN will assess their effectiveness, especially for the fourth periodic safety review of the 900 MWe reactors, by carrying out inspections on site.

2.2. Concealed pipework

2.2.1. Definition of a generic program of verification of concealed pipework (see NAR §9.4)

"*With a view to continued reactor operation beyond 40 years, EDF has undertaken an ageing management programme for buried or poorly accessible pipes in addition to its monitoring provisions. Under this programme EDF has performed inspections on the Tricastin, Fessenheim and Bugey sites, with the aim of defining a generic programme of verifications and being able to decide during the fourth ten-yearly outage inspections (VD4) whether the buried pipes are fit for continued service or need to be renovated. The examination is in progress and the conclusions are expected in 2018.*"

Country position and action

Maintenance of the NPP fleet buried pipework is covered by various doctrines or programmes:

- the maintenance doctrines for the pipework carrying "toxic, radioactive, inflammable, corrosive, explosive" (TRICE) fluids and buried gravity networks on nuclear sites are implemented through the regular local preventive maintenance programme on all the NPPs.
- for the extension of the service life of the plant units, a particular programme is put into place on pipework that is buried or in ducts difficult to access. This programme, called "buried pipework" leads to additional inspections supplementing the regular local programmes.

The monitoring of TRICE pipework, the monitoring of gravity networks and the "buried pipework" programme, are able to cover the surveillance of all pipework buried or in ducts difficult to access.

The purpose of the "buried pipework" programme is to inspect the pipework with a risk of failure at VD4[9]+20 years, as assessed by using the BPWorks software, and to rule on its ability to perform its function until this time, using the "fitness for service" (FFS) method. The BP Works software and the FFS method used are derived directly from the methods employed by the American NPPs licensees.

In addition to taking account of known OEF from the various pipes concerned, the BPWorks software analyses each pipework section according to various parameters (type of soil, type of fluid, consequences of any failure, etc.) and classifies them according to their potential consequences (low, medium or high). The TRICE pipes which have not been classified "high risk" by the BPWorks software, are systematically upgraded manually by EDF as a precautionary measure. This methodology enables the sections of a given pipe assessed as being highest risk to be identified and inspected, using methods appropriate to the degradation being investigated (external visual inspection, thickness measurements or internal TV inspection). Then, the approach to demonstrate the resistance of the pipes for the

[9] VD4 : fourth ten-yearly outage

VD4+20 years time-frame is based on application of the FFS method. If the application of the FFS method concludes that these inspected sections are fit for service at VD4+20 years, then the sections of lower risk are also fit, thus confirming that all the concerned pipework is able to perform its functions for the time-frame in question.

Thus, under the “Buried pipework” programme, the sections of the pipework that are considered to be most sensitive with regard to environmental risks (risk of groundwater contamination) or safety risks (firefighting function) are inspected.

The “buried pipework” programme concerns the entire 900 and 1300 MWe NPP fleet. To date, the complete approach (risk assessment, expert analysis programme, inspections and summary reports) has already been deployed on the 3 sites of Fessenheim, Bugey and Tricastin. It concluded that the pipework included within the scope is able to perform its function up until VD4+20 years, except for the JPU network at Tricastin. For this network, interim inspection will be required after VD5[10].

Moreover, in order to reinforce the demonstration of the robustness of the approach, supplementary inspections will be performed on the Tricastin site for pipework with environmental implications, to cover the risk of groundwater contamination. Depending on the results and their analysis, EDF will decide on the possible extension of the inspections of these pipes. These additional inspection results will be transmitted post VD4 start-up of Tricastin unit 1.

In order to build on its operating experience feedback, EDF will upgrade the summary report specific to each site before each VD5 of the 900 MWe plant series, considering any new OEF aspects that would have occurred between two ten-yearly outages and reintroducing them into these specific analyses, as necessary.

Additionally, in order to integrate the approach conducted for the “buried pipework” programme into a long-term process for analysing the ageing of this equipment and thus re-examining its behaviour, EDF set up a new Ageing Analysis Sheet (FAV), available in the 2019 update of the FAV database.

Based on the current results of the “buried pipework” programme and on the complements adopted by EDF, ASN considers the approach implemented by EDF as acceptable for managing the ageing of concealed pipework in a generic manner. ASN considers as acceptable the scope of the supplementary inspections, established according to the operating constraints (lock-out of systems on units in operation, processing of zones with high dosimetry), the geometry of the system (accessibility and length for performing internal televisual inspection, specific equipment required) and technical pertinence. However, ASN will examine the results to come in order to ensure that no further action is needed, especially for renovation or replacement of piping for operation beyond 40 years.

[10] VD5 : fifth ten-yearly outage

3. Country specific findings resulting from the TPR

This section is dedicated to the country specific findings [11]resulting from the Topical Peer Review for which an area for improvement was allocated.

3.1. Overall Ageing Management Programmes (OAMPs)

3.1.1. TPR expected level of performance: 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, the applicable national requirements, international safety standards and best practices. A systematic and comprehensive OAMP is implemented for research reactors, in accordance with the graded approach to risk, the applicable national requirements, international safety standards and best practices.

3.1.2. Country position and action

This finding is already addressed in Section §2.1.1.

3.1.3. TPR expected level of performance: 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.

3.1.4. Country position and action

Concerning facilities under construction, the Flamanville 3 EPR project defined organisational measures for the preservation of equipment, notably during the extension period between the end of equipment assembly and fuel loading. For equipment subject to safety or regulatory criteria, the project organisation takes account of the ambient conditions and the generic risks assessment (corrosion, cleanness, temperature, light, etc.) including the corresponding countermeasures (individual or collective protection with different types of preservation). Proportionate means are implemented to ensure that these preservation conditions are controlled (walkdowns in buildings with recording of temperature or relative humidity parameters, use of heaters or dehumidifiers, etc.).

For outages with a significantly extended duration, the recent situations in Paluel 2 and Bugey 5 led EDF to draw up regulatory dossiers in 2016 and 2017 relative to the extension of the duration of an outage beyond 2 years. These dossiers included a part describing the special measures taken during the extended outage and concluding about the fitness of the equipment that could have been submitted to ageing with a view to the restart of these units.

French and international operating experience feedback confirmed that the following equipment - civil engineering structures, automation and I&C equipment, automation electrical cables, equipment in operation or undergoing periodic testing, main primary system - requires no preservation measures in addition to those stipulated in the standard preservation baseline requirements. However, preservation measures were put into place for valves (restart patrol and certain equipment operations), rotating machines (operating tests), electrical equipment (checks before and during re-energisation of electrical cubicles), lifting gear (checks prior to commissioning) and, more specifically,

[11] http://www.ensreg.eu/sites/default/files/attachments/hlg_p2018-37_161_1st_tpr_country_findings.pdf

replacement steam generators (hermetic closure, chemical driers for the enclosed air volume, external protection, leaktight and controlled hygrometry storage).

An update, for the end of 2020, of the EDF national doctrine for the preservation of equipment during outages and the corresponding implementing documents is planned to take account of the long-duration outage periods.

ASN will examine the future EDF updated doctrine with regard to the future IAEA guidance on this topic, being developed in the IGALL project, and with regard to ageing operating experience feedback (OEF). For Flamanville 3 EPR project, due to negative OEF, ASN will examine the effectiveness of EDF preservation organization and provisions in the frame of its review of EDF request for extending the delay of the reactor commissioning. Depending on the conclusions of its review, ASN will require additional actions, as necessary.

3.2. Concealed pipework

3.2.1. TPR expected level of performance: Opportunistic inspection

Opportunistic inspection of concealed pipework is undertaken whenever the pipework becomes accessible for other purposes.

3.2.2. Country position and action

As part of the “Buried pipework” programme (see 2.2.1), the choice of systems and sections of highest risk, thus to be inspected, is determined by the BPWorks software. EDF considers that it is not essential to inspect the lower risk sections which would be exposed opportunistically by other work in progress. In addition to the “buried pipework” programme and the routine monitoring provisions (groundwater inspections and contamination), EDF intends to set up an organisation to inform the national level of the scheduling of local activities, including the excavation of buried pipework, and thus analyse whether or not the inspection of these uncovered pipes is opportune.

ASN considers that the evolutions proposed by EDF in the action plan are acceptable. ASN will assess their effectiveness, especially in the frame of the fourth periodic safety review of the 900 MWe reactors, by carrying out inspections on site, in order to ensure that no further action is needed, particularly for renovation or replacement of piping for operation beyond 40 years.

4. GENERIC FINDINGS RELATED TO ELECTRICAL CABLES

In the subsections below, France position for each finding related to electrical cables as well as planned action if relevant are detailed.

4.1. Good practice: characterize the state of the degradation of cables aged at the plant

Cables are aged within the actual power plant environment and tested to assess cable condition and determine residual lifetime.

4.1.1. Country implementation

As mentioned in NAR §3.1.1.2.3, EDF has for the past few years chosen to sample cables from the site for assessment. Since 2011, cable sampling programs have been defined, to cover all the ranges of LV and MV cables installed. The cables sampled are chosen from among those operated in the most demanding conditions, so that they encompass all the cables installed.

To date, a total of:

- 14 K3/NC MV cables and 2 K1 MV cables (RHRS) have been sampled and assessed;
- 3 K1 LV cables have been sampled from inside the reactor building (on the CVCS and RHRS systems) and assessed;
- 3 K2 coaxial cables have been sampled and assessed, including two taken from inside the reactor building;
- 3 K3/NC LV power cables from outside the reactor building have been sampled and assessed.

The characterisations carried out systematically for each sample enable the state of ageing of the cables to be precisely identified:

- Electrical measurements over the entire length of the cables prior to each cable sample;
- Mechanical properties of the polymer materials (elongation and ultimate tensile strength);
- Characterisation of whether or not stabilising species protecting against oxidation (EPR and PRC insulation) and dehydrochlorination (PVC insulation) are present;
- Infrared measurement to reveal incipient consumption of these stabilising species, or even the presence of degradation products.

These characterisations and the R&D studies carried out for many years by EDF R&D, provide detailed knowledge of the electrical cables ageing mechanisms and enable their residual lifetime to be estimated.

4.1.2. Country planned action if relevant

EDF is continuing to sample and assess LV and MV cables on-site in accordance with the predetermined programs, which enables to cover all ranges of installed MV and LV cables. No additional action is planned.

ASN considers that no further action is required.

4.2. TPR expected level of performance: documentation of the cable ageing management program

The AMP is sufficiently well-documented to support any internal or external reviews in a fully traceable manner.

4.2.1. Country implementation

As mentioned in the NAR (§2.3.1), the documentation of ageing management is based on Ageing Analysis Sheets and Detailed Ageing Analysis Report (DAAR).

The cable ageing management programme is mainly based on Ageing Analysis Sheets updated annually, which aim at identifying ageing mechanisms and implementing means of monitoring cables on site. In addition, a periodic Detailed Ageing Analysis Report (DAAR) is updated every 5 years, collecting EDF operating experience feedback on cables, the results of the R&D studies, and the results of the characterization of cable samples removed from site. This periodicity of 5 years seems adapted with regard to positive feedback on cables.

Database for MV and LV cables have been established, gathering the type and formulation (specific to each manufacturer) of the polymer materials constituting the insulation and the outer sheaths, and the conditions of operation (mainly temperature, irradiation and humidity).

4.2.2. Country planned action if relevant

EDF has a complete documentation on the cable ageing management programme, in accordance with the scope of IAEA TECDOC 1402. As a consequence, no additional actions is planned.

ASN considers that no further action is required.

4.3. TPR expected level of performance: methods for monitoring and directing all AMP-activities

Methods to collect NPP cable ageing and performance data are established and used effectively to support the AMP for cables.

4.3.1. Country implementation

As mentioned in §4.1.1, EDF has set up a methodology to collect samples which cover all ranges of installed MV and LV cables provide measurements.

Since 2011, EDF has been implementing national databases for monitoring all the electrical cables directly assigned to production (MV, LV, classified and non-classified) on the 900 and 1300 MWe plant series.

These databases are regularly updated, at least annually, as required by the preventive maintenance programmes for the MV and LV cables. Therefore, each site forwards the results of the measurements taken on the cables (such as the tangent delta (dissipation Factor) and partial discharge measurements periodically made on samples of the MV cables) and all observations related to cable ageing (results of visual inspections, operating conditions, etc.).

4.3.2. Country planned action if relevant

A methodology is defined to assess the cable conditions and get characterizations. The databases are regularly updated, enabling EDF to collect information related to the ageing of the cables and closely monitor the ageing of the various types of cables operated on the sites. No additional action is planned.

ASN considers that no further action is required.

4.4. TPR expected level of performance: Systematic identification of ageing degradation mechanisms considering cable characteristics and stressors

Degradation mechanisms and stressors are systematically identified and reviewed to ensure that any missed or newly occurring stressors are revealed before challenging the operability of cables.

4.4.1. Country implementation

The R&D studies carried out by EDF in recent years on the polymer materials making up the electrical cables, notably for development of the multi-scale model (NAR §3.1.1.2.2), have given EDF a detailed understanding of the ageing mechanisms which could affect the electrical cables.

The sampling programmes for on-site assessment of the MV and LV cables supplement these studies and are a means of ensuring that the mechanisms affecting the cables on the site are indeed those identified during the R&D studies. All the physico-chemical characterisations performed on the cables sampled allow characterisation of the state of ageing of the cables at several scales (macroscopic and microscopic analyses) and can, where applicable, detect any mechanism not previously identified.

The activities implemented as part of the in-service monitoring of the MV and LV cables (visual inspection, isolation measurement for the LV cables, dissipation factor and partial discharge measurements for MV cables) are also able to detect any new degradation mechanisms and stressful operating conditions that could compromise the functionality of the cables.

EDF also carries out a regular international watch on the ageing of electrical cables by taking part in conferences and international exchanges (JICABLE conference, exchanges with the EPRI within the framework of the MAI and the European TEAM cables project).

4.4.2. Country planned action if relevant

The various actions taken in recent years (R&D studies, operating experience feedback, on-site cables monitoring, appraisal of cables sampled on the sites, international watch) enable to identify the mechanisms that can affect electrical cables and the most stressed cables. No additional action is planned.

ASN considers that no further action is required.

4.5. TPR expected level of performance: prevention and detection of water treeing

Approaches are used to ensure that water treeing in cables with polymeric insulation is minimised, either by removing stressors contributing to its growth or by detecting degradation by applying appropriate methods and related criteria.

4.5.1. Country implementation

Treeing phenomena affect MV cables with a polyethylene based insulation operating in humid conditions. The humidity/electric field combination causes electrochemical reactions that lead first to the appearance of micro-cracking, then gradually to the formation of water trees in the insulants.

As mentioned in NAR § 3.1.2.1.2, EDF has decided not to bury the cables, thereby preserving them from water. Nevertheless, MV cables passing through galleries or trenches can occasionally be subjected to humid conditions.

Between 2012 and 2015, all the MV cables for the NPP fleet in operation were inspected. The in-situ recordings identified cables potentially subjected to humidity. Since then, the cables have been subject to close monitoring as part of the ageing management programme implemented by EDF. Dissipation factor and partial discharge measurements are periodically taken on these cables, as these electrical diagnostic methods are appropriate for detecting treeing phenomena.

4.5.2. Country planned action if relevant

The steps put in place by the ageing management programmes enable cables operated in humid conditions to be detected and the monitoring of the cables concerned to be reinforced with periodic measurement of the dissipation factor and partial discharges. No additional action is planned.

ASN considers that no further action is required.

4.6. TPR expected level of performance: consideration of uncertainties in the initial EQ

The accuracy of the representation of the stressors used in the initial Environmental Qualification is assessed with regard to the expected stressors during normal operation and Design Basis Accidents.

4.6.1. Country implementation

To ensure that the ambient conditions considered at initial qualification are representative, EDF relies on the inspections stipulated by the Basic Preventive Maintenance Programmes (PBMP) for the MV and LV cables.

For the MV cables, the PBMP requires an initial visual inspection of all the MV cables, to detect the routing zones presenting a risk and in particular the stressful operating conditions (high ambient temperature, proximity of a high-temperature pipe, humidity, high dosimetry, etc.). These inspections were performed between 2012 and 2015 on all the EDF sites (more than 14,500 MV cables inspected). On the basis of these inspections, the "stressed cables" are sampled and diagnostic measurements are periodically taken on each cable in the sample, in order to check their ageing status.

For the LV cables, the PBMP requires a visual inspection of all the premises with the aim of identifying the stressor zones and the condition of the cables and cable raceways. A periodic visual inspection (every 10 years) of the stressor zones identified by the initial inspection is then carried out.

The inspections thus performed ensure that the cables are operated in conditions compliant with the Design and construction rules for electrical equipment of PWR nuclear islands (RCC-E[12]) and, as applicable, can detect the most stressful operating conditions liable to speed up cable ageing. The cables subject to these most stressful operating conditions are the subject of close monitoring.

It should be noted that on-site cable sampling for assessment is a means of verifying the good behaviour of the cables operated in stressful conditions. The sampled cables are selected from among those most heavily stressed such that they are representative of the entire targeted population. For example, for the MV cables, the cables sampled are those passing through the turbine hall and/or outdoors, with a high duty cycle and, if possible, subject to a significant load.

4.6.2. Country planned action if relevant

The steps put in place by the ageing management programmes enable cables used in stressful conditions and not considered at initial qualification to be detected and the monitoring of the cables concerned to be reinforced. The assessments of the cables sampled from the site, chosen from among the most stressed cables, supplement this approach. No additional action is planned.

ASN considers that no further action is required.

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[12] AFCEN code: RCC-E describes the rules for designing and building electrical assemblies and I&C systems for pressurised water reactors.

4.7. TPR expected level of performance: determining cables' performance under highest stressors

Cables necessary for accident mitigation are tested to determine their capabilities to fulfil their functions under Design Extension Conditions and throughout their expected lifetime.

4.7.1. Country implementation

The EDF approach to demonstrate that the cables needed in accident situations are able to fulfil their function throughout their qualified lifetime is based on two main points:

- R&D studies allowing an in-depth understanding of the ageing phenomena that could affect the cables and of their kinetics as well as predictive modelling of the behaviour of the cables over time.
- On-site sampling of the cables, designed to validate this predictive approach: when assessing the cables sampled on-site, EDF uses advanced physico-chemical ageing indicators (mechanical characterisations, infrared analyses, oxidative induction time, etc.). All the results obtained are able to precisely characterise the state of degradation of the polymers, input data to the predictive models and ensure the ability of the cables to withstand accident conditions.

  To date, the various samples taken show that, after more than 30 years of operation, all the K1 cables sampled are still in the first phase of ageing with respect to oxidation: consumption of the antioxidants. No impact on the macroscopic properties of the polymer materials (rupture elongation) or the electrical properties has been evidenced.

EDF also occasionally performed tests on the ability of the K1 cables sampled on the site to withstand accident conditions, with application of thermal ageing representative of an additional 20 years of operation and an irradiation dose of 500 kGy (covering 60 years of operation and accident irradiation of 250 kGy). These tests demonstrated that these K1 cables retain their functionality during and after a thermodynamic accident.

4.7.2. Country planned action if relevant

EDF will continue to assess the K1 cables sampled on-site and thus improve its understanding of the ageing phenomena affecting these cables and the prediction models, in order to guarantee their performance in accident conditions. No additional action is planned.

ASN considers that no further action is required.

4.8. TPR expected level of performance: techniques to detect the degradation of inaccessible cables

Based on international experience, appropriate techniques are used to detect degradation of inaccessible cables.

4.8.1. Country implementation

Under the preventive maintenance programmes for the LV and MV electrical cables, EDF uses the various internationally available diagnostic techniques for on-site monitoring of cable ageing (see NAR §3.1.3). Some of these techniques are usable for monitoring the ageing status of inaccessible cables:

- The dissipation factor and partial discharge measurements for the MV cables.
- For the LV cables, the reflectometry measurements (used to check the condition of the coaxial cables making up the neutron flux measurement links – see NAR §3.1.3.3), the isolation resistance measurements and the electrical continuity measurements.

At the same time, EDF is continuing with its R&D work in order to identify new diagnostic methods and take part in works (NAR § 3.1.3.2) and experience sharing internationally, with the aim of discussing the use of diagnostic techniques and the associated criteria.

4.8.2. Country planned action if relevant

EDF will continue its studies to identify new techniques for inspecting cables in operation, including those usable on inaccessible cables. EDF will as well continue conducting an international watch on these subjects. No additional action is planned.

ASN considers that no further action is required.

5. ALL OTHER GENERIC FINDINGS

This section is dedicated to the generic findings made by the Topical Peer Review for which France was allocated a good practice or a good performance. Information is provided to ensure dissemination of good practice or performance to other countries.

Besides, when no good practice was allocated, France position related to the implementation of the generic good practice is stated.

5.1. Overall Ageing Management Programmes (OAMPs)

5.1.1. 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.

5.1.1.1. Allocation by the TPR

A good practice has been allocated to France by the TPR board for this finding.

5.1.1.2. Country position

In recent years, EDF has used external peer reviews, in order to get independent advice and assessment of its management programmes:

- Corporate OSART in 2014,
- OSART-LTO at GOLFECH in 2016 and BUGEY in 2017,

EDF's position is to continue this audit approach, including an LTO module in the next IAEA OSART reviews (scheduled for PALUEL in 2020 and BELLEVILLE in 2021).

Besides, EDF recently carried out benchmarking with several American NPPs licensees (Duke and Dominion) concerning the identification and selection of the SSCs to be considered for ageing management, as well as benchmarking between its ageing management process and the elements (AMR, TLAA, AMP) identified in the IAEA IGALL.

5.1.2. TPR expected level of performance: Data collection, record keeping and international cooperation

Participation in international R&D projects, experience exchange within groups of common reactor design and the use of existing international databases are used to improve the effectiveness of the NPPs OAMP.

5.1.2.1. Allocation by the TPR

A good performance has been allocated to France by the TPR board for this finding.

5.1.2.2. Country position and action

EDF is involved as different roles (expert, observer, contributor, coordinator, etc.) in various international working groups, whether for mechanical components or for civil engineering structures, I&C, or for electrical components.

The strategy adopted by EDF is as follows:

- to stay abreast of the recommendations, guides or documents issued by the international safety regulators;
- to take part in topics that are important for EDF (ageing, integrity, safety margins and consequences),

- to ensure that the conclusions and recommendations issued by the key working groups are consistent with the positions adopted by EDF,
- to compare the approaches adopted by the main nuclear countries for management of ageing of plant units and the corresponding justifications,
- to utilise international frameworks to share R&D measures in support of ageing management,
- to consolidate French approaches to topics concerning process methodology, operating duration, integrity analysis practices, margins evaluation, break preclusion, codes and standards (RCCM, RSEM), etc.

In this respect, EDF takes part in the work of the various international working groups and international bodies of the IAEA, ASME, AFCEN, OECD-NEA, EPRI, NUGENIA, MAI, ENIQ, EPERC, FITNET, PWROG or FROG.

ASN is also involved in different working groups of the IAEA IGALL project (mechanical components and regulatory guidance) and contributes to SALTO missions as reviewer for mechanical SSCs. It also participates to the NEA working group on integrity and ageing of components and structures (WGIAGE).

5.1.3. TPR expected level of performance: Methodology for scoping the SSCs subject to ageing management

The scope of the OAMP for NPPs is reviewed and, if necessary, updated, in line with the new IAEA Safety Standard after its publication.

5.1.3.1. Allocation by the TPR

A good performance has been allocated to France by the TPR board for this finding.

5.1.3.2. Country position and action

As indicated in the NAR (§2.4.3), the new IAEA Safety Standard on Ageing Management (SSG-48) is integrated into the EDF ageing management programme since the end of 2016 (through the methodological guide).

From 2017, the approach initiated by EDF provides actions in order to extend the scope of the SSCs to be considered for the 4th PSR of the 900 MWe NPPs (VD4-900), in connection with this new IAEA Safety Standard. This point has been described in the NAR §2.3.1.4 :

> *"The purpose of sub-process SP1 is, from among all the SSCs of a reactor, to identify those components for which an ageing phenomenon or time-dependent degradation mode can lead to difficulty with carrying out a safety function:*
>
> - *SSCs important for safety (EIPS),*
> - *non-EIPS SSCs, for which ageing could lead to failures liable to compromise the design hypotheses adopted in the safety case;*
> - *non-EIPS SSCs which, with respect to the PSA (Probabilistic Safety Assessments) make a significant contribution to limiting the core melt risk.*
>
> *With regard to preparation for VD4-900 and the subsequent VDs, the scope of the SSCs is extended:*
>
> - *to all the SSC which are elements important for the protection of interests (EIP);*
> - *to the other SSCs considered for the seismic, fire and internal flooding hazard PSAs. "*

It should also be noted that the OSART-LTO audit of the BUGEY NPPs in October 2017 was conducted on the basis of this IAEA new standard.

EDF has already taken into account the new IAEA safety standard on ageing management since 2016 from its draft version, notably on SSC scoping. Actions to adapt to this new standard have already been identified and undertaken in the ageing management process.

5.2. Concealed pipework

5.2.1. Good practice: use of results from regular monitoring of the condition of civil structures

In addition to providing information on soil and building settlement, the results from regular monitoring of the condition of civil structures are used as input to the ageing management programme for concealed pipework.

5.2.1.1. Allocation by the TPR

A good practice has been allocated to France by the TPR board for this finding.

5.2.1.2. Country position

The "settlement" parameter is systematically taken into account as an input data to the BPWorks software (see §4.1.2.3.1 of the NAR):

> "*The software evaluates a probability of failure for each pipe section according to the characteristics of each pipe (fluid transported, operating conditions, surrounding soil data, level of the water table, etc.).*"

For that reason, an identification of areas with a risk of potential settling is conducted.

In practical terms, the following approach is applied for each site:

- First, an inventory of geotechnical disorders affecting the nuclear site is carried out. It is based on the elements known and listed to date. It is not limited to the buried linear structures (pipes or galleries), but covers all the civil structures on the site. Most of the disorders inventoried are related to problems due to excessive differential settlements.
- This inventory is compared with the known or assumed foundation conditions of buried pipelines, by integrating the specificities of these types of civil structures (in general their shallow burial depth) and the geotechnical specificities of the sites (e.g. : geo-mechanical quality of the embankments or of soil in place).
- Then, a general opinion on the "geotechnical" risks that might affect the buried pipes is proposed. It allows to identify the worst generic configurations, which must then be analyzed network-by-network in order to map specifically sensitive areas.

In the end, the approach defines for each site a zoning, which specifies its areas at risk of settlement.

Thus, the settlement data derived from the monitoring of civil structures and used as an input to the BPWorks software are well integrated into the AMP for concealed pipework.

5.2.2. Good practice: performance checks for new or novel materials

In order to establish the integrity of new or novel materials, sections of pipework are removed after a period of operation and inspected to confirm the properties are as expected.

5.2.2.1. Allocation by the TPR

A good practice hasn't been allocated to France by the TPR board for this finding.

5.2.2.2. Country position

In order to establish the integrity of new or novel materials, sections of pipework are removed after a period of operation and inspected to confirm the properties are as expected.

There are no buried high density polyethylene (HDPE) classified networks on the NPP fleet currently in operation in France. The first use of this type of pipework is for the post-Fukushima work (networks connecting the ultimate heat sink and the nuclear island users). This work is scheduled for between 2018 and 2021, the first-off plant units are Bugey and Tricastin.

For these recently installed networks, preventive maintenance is as follows:

- Performance of a hydrostatic test every 10 years in order to confirm the flow/pressure pairs,
- Ten-yearly sampling of a HDPE pipe for tests to verify that the chemical-mechanical parameters remain within the estimates made by R&D (normal ageing of the pipe).

The installation of buried sections of HDPE pipe by EDF makes provision for periodic sampling and the corresponding testing, to check the condition of the properties of a section after operation.

5.2.3. TPR expected level of performance: inspection of safety-related pipework penetrations

Inspection of safety-related pipework penetrations through concrete structures are part of ageing management programmes, unless it can be demonstrated that there is no active degradation mechanism.

5.2.3.1. Allocation by the TPR

A good performance has been allocated to France by the TPR board for this finding.

5.2.3.2. Country position and action

The containment penetrations are singular points of the containment, constituting the third barrier. In this respect, they must take part in the strength and leaktightness of the containment.

Several safety-related containment penetrations are to be considered:

- The electrical cable penetrations, which are permanently pressurised with nitrogen or dry air (monitored by annual recording of internal pressure on manometer). Monitoring in the preventive maintenance programme requires periodic verification of the pressure gauges and a periodic inspection of the penetrations (no loosening and condition of electrical connections). The electrical busbars are submitted, as the K1 electrical cables, to a R&D programme. The objective of this R&D programme is to apprehend the ageing of their isolation material (PEEK or KAPTON). It is also the case for the gaskets in polymeric material of electrical penetrations;
- The piping penetrations (known as “mechanical penetrations"), the access openings (equipment/personnel hatches), and the penetrations equipped with a blind flange.

The leak tightness of the containment is checked by:

- periodic pressure tests every 10 years on the complete containment (“containment test”) which correspond to the type A (see NAR § 7.1.3.4.2) overall test confirming the tightness of the containment and its penetrations,
- more frequent partial tests concerning the isolation devices:
    - mechanical penetrations (other than those of the main primary system and the SIS and CSS pipes on the sumps side): this is a type C test (see NAR § 7.1.3.4.2).
    - penetrations equipped with blind flanges, including equipment/personnel hatches: this is a type B test (see NAR § 7.1.3.4.2).

The systems are tested with air or water, depending on whether they would be filled with air or water in an accident situation.

With regard to the penetration sleeves for single-wall containments (with metal liner), a maintenance note requires a visual examination of the skin welds, before and after testing, by the main penetrations (equipment/personnel hatch, steam and main water piping) and the penetrations included in blistering, in order to detect any corrosion type degradation or visible cracking.

The programme of complementary investigations for VD3 900 and VD3 1300 also makes provision for visual examination of other welds connecting with the accessible penetration sleeves, by means of sampling from among several plant units:

- 900 MWe plant series (Fessenheim 1, Bugey 2, Gravelines 1, Tricastin 1): no prejudicial flaw on the connecting welds between the penetration sleeves and the liner was found, apart from slight flaking of paintwork and traces of corrosion,
- 1300 MWe plant series (Paluel 3, Saint-Alban 1, Cattenom 2): harmless corrosion was observed on a few containment penetrations on Paluel 3 and Saint-Alban 1; an inspection and possible paint rework programme is planned for the medium-term.

Concerning a few reserve penetrations ("capped” penetrations) of the 900 MWe plant series, another maintenance document requires (in addition to the applicable preventive maintenance programme) inspection via the outer surface of the interior of the penetration in order to assess the condition and the presence of any traces of corrosion.

Concerning the penetrations for the steam and main water piping, the applicable preventive maintenance programme requires:

- the inspection of certain welds connecting the flange to the steam and main water pipes, by means of an ultrasound process used in the space between the pipe and the penetration sleeve;
- the inspection of the inner wall of the main water pipes for the 900 MWe plant series, at the penetration, by means of TV inspection and ultrasound thickness measurement from the interior of the pipe (zones considered to be inaccessible to an inspector), to search for corrosion-erosion degradation.

The ageing management process thus led to the identification of 2 specific Ageing Analysis Sheets (FAV) per plant series for electrical penetrations (ageing of MV penetration tightness seals – ageing of busbars and electrical conductors for LV penetrations).

The inspection and preventive maintenance actions planned or already carried out for containment penetrations are sufficient to ensure that there is no active degradation mechanism for safety-related pipework penetrations through concrete structures. ASN underlines the importance to take into account all the available inspection data in order to manage ageing of pipework located in inaccessible zones.

5.2.4. TPR expected level of performance: scope of concealed pipework included in AMPs

The scope of concealed pipework included in ageing management includes those performing safety functions, and also non-safety-related pipework whose failure may impact SSCs performing safety functions.

5.2.4.1. Allocation by the TPR

A good performance has been allocated to France by the TPR board for this finding.

5.2.4.2. Country position and action

The safety classification of the pipes and their proximity to safety classified SSCs are among the parameters incorporated into the BPWorks software, which is used for the "buried pipework" programme, and contributing to the risk ranking given to each pipework section, which is then used to define the assessment programme.

The scope of the "buried pipework" programme includes all the pipes belonging to the following configurations, regardless of their safety classification:

- buried
- in a duct that is difficult to access (under sand, under road, etc.).

Based on this approach, non-safety related concealed pipework, whose failure may impact SSCs performing safety functions, is included in the scope for the ageing management programme of concealed pipework.

5.3. Reactor pressure vessel

5.3.1. Good practice: Hydrogen water chemistry

H*ydrogen Water Chemistry (HWC) is used in BWRs which may be sensitive to Intergranular Stress Corrosion Cracking.*

5.3.1.1. Allocation by the TPR

The TPR board acknowledged that France is not concerned by this finding.

5.3.1.2. Country position

France has only PWR power plants and therefore is not concerned.

5.3.2. Good practice: Implementation of a shield

Shielding in the core of PWRs with relatively high fluence is implemented to preventively reduce neutron flux on the RPV wall.

5.3.2.1. Allocation by the TPR

A good practice has been allocated to France by the TPR board for this finding.

5.3.2.2. Country position

In light of the possible extension of the operating life of the nuclear reactors, EDF has initiated an approach designed to reduce the neutron flux at the most heavily irradiated points on the 900 MWe series reactor vessels (hot spots), and thus limit irradiation ageing of these areas.

The principle consists in introducing absorbent hafnium rods into the twelve fuel assemblies facing the hot spots of the reactor vessel. The aim is to achieve a neutron flux reduction of about 45% at the hot spots in the vessel.

The deployment of this measure is programmed for all the 900 MWe reactors on the occasion of their 4th ten-yearly outage inspection, independently of the margins specific to each pressure vessel with regard to the fast fracture risk in the irradiated zone.

This modification was implemented early, in 2018, on the Tricastin 3 unit, ahead of its 4th ten-yearly outage inspection, in order to prepare for its general deployment to the entire 900 MWe plant series.

5.3.3. TPR expected level of performance: Volumetric inspection for nickel base alloy penetration

Periodic volumetric inspection is performed for nickel base alloy penetrations which are susceptible to Primary Water Stress Corrosion Cracking for PWRs to detect cracking at as early a stage as possible.

5.3.3.1. Allocation by the TPR

A good performance has been allocated to France by the TPR board for this finding.

5.3.3.2. Country position and action

Since 2012, for all the reactor pressure vessels of the EDF NPP fleet, the nickel based alloy reactor vessel bottom head penetrations, sensitive to stress corrosion in the primary medium (600 or equivalent alloy) undergo volume examination by ultrasounds every ten years. This examination is a means of detecting incipient cracking from the inner or outer wall.

5.3.4. TPR expected level of performance: Non-destructive examination in the base material of beltline region

Comprehensive NDE is performed in the base material of the beltline region in order to detect defects.

5.3.4.1. Allocation by the TPR

A good performance has been allocated to France by the TPR board for this finding.

5.3.4.2. Country position and action

The base metal of the core zone undergoes an automated ultrasonic inspection during each ten-yearly outage. The zone examined concerns the first twenty-five millimetres of the vessel wall, to look for an underclad cracking type manufacturing defect. This periodic examination is carried out on all the vessels of the EDF NPP fleet, regardless of their manufacturing conditions.

In addition, for the examination of specific problems, occasional examinations can also be performed. For example, examinations were carried out on several vessels, representative of EDF NPP fleet vessels to look for hydrogen induced cracking defects. These examinations have revealed no defects of this type.

5.3.5. TPR expected level of performance: Environmental effect of the coolant

Fatigue analyses have to take into account the environmental effect of the coolant.

5.3.5.1. Allocation by the TPR

A good performance has been allocated to France by the TPR board for this finding.

5.3.5.2. Country position and action

The general approach adopted to take the environmental effects on fatigue into account consists in selecting precursor, or “sentinel” zones for each type of component, depending on the loadings to which they are subjected and taking account of the potential impact of the primary environment on the susceptibility of the zone to fatigue.

This approach was applied to the pressure-resistant parts of the reactor vessel in contact with the primary coolant and led to the peripheral adapters of the reactor vessel closure head, as the only zone eligible for this approach, being identified as the sentinel zone to be the subject of a specific fatigue study taking account of the environment effects in the frame of the periodic safety review.

5.3.6. TPR expected level of performance: Suitable and sufficient irradiation specimens

For new reactors, suitable and sufficient irradiation specimens and archive materials are provided to support the reactor through its full operational life.

5.3.6.1. Allocation by the TPR

A good performance has been allocated to France by the TPR board for this finding.

5.3.6.2. Country position and action

As indicated in the NAR (§5.1.3.1.1 – Programmes for monitoring the effects of irradiation)

> *"the principles of this monitoring programme are similar for all the plant series in the EDF fleet, from 900 MWe series to the EPR. Each RPV starts out with at least six capsules, four being introduced at reactor start-up and the following ones being introduced in service (reserve capsules). The capsules are withdrawn at regular intervals in order to encompass the irradiation of the RPVs when the ten-yearly outages are reached."*

For Flamanville 3 (FA3 EPR), Irradiation Surveillance Programme (ISP) insertion and withdrawal calendar originally considers six irradiation capsules, each corresponding to an equivalent ten year additional operation. These six capsules are sufficient to support material surveillance through FA3 EPR RPV design operational life (60 years).

Each irradiation capsule includes the following material specimens:

Material	**Specimens (type / number) per irradiation capsule**		
	Charpy V (impact energy tests)	**Compact Tension (fracture toughness tests)**	**Tensile**
Upper core shell	18	10	6
Lower core shell	18	10	6
Weld metal	18	10	6
Heat Affected Zone of selected shell	18	/	/

In addition to these six already manufactured ISP capsules, the following archive material is stored by the licensee for future use. This archive material is capable of two additional capsules, identical to the first six:

- Archive material of lower and upper core shells, allowing machining of additional specimens (Charpy, Compact Tension and Tensile),
- Weld metal specimens manufactured from ISP weld coupon (Charpy, Compact Tension and Tensile),
- Heat-affected zone (HAZ) specimens manufactured from ISP weld coupon (Charpy).

Specimens of base metal, weld metal and HAZ and almost equivalent to the content of a complete capsule, are also stored at the manufacturer's workshops. These specimens remain the property of the licensee.

In addition, all the specimens (tested or not) are stored by the licensee during the plant life time. This archive material remains available for Charpy samples reconstruction, if needed, to complete irradiation surveillance programme. This represents a significant amount of archive material as it also includes the specimens machined for initial ISP tests on un-irradiated material:

Material	Specimens (type / number) machined for ISP tests on un-irradiated material		
	Charpy V (impact energy tests)	**Compact Tension (fracture toughness tests)**	**Tensile**
Upper core shell	6 x 18	12	10
Lower core shell	6 x 18	12	10
Weld metal	24	12	10
Heat Affected Zone of selected shell	24	/	/

This archive material can be used for Charpy samples reconstruction for:

- Base metal (from base metal Charpy specimens)
- Weld metal (from Heat Affected Zone Charpy specimens)

R&D programmes are also in progress to develop the use of miniature specimens (mini-Charpy, mini-CT) in order to optimize the use of archive material for further investigations on material behavior.

The available material for FA3 EPR Irradiation Surveillance Programme is considered sufficient to support material surveillance through the full operational plant life, with significant margin:

- The standard ISP includes six irradiation capsules, in accordance with the design operational life (60 years),
- Archive material equivalent to two complete irradiation capsules is stored by the licensee (plus additional remaining material stored by the manufacturer) for possible future use in the ISP,
- The material specimens are stored during the plant life time, thus allowing to increase the content of ISP through specimen reconstruction if needed.

5.4. Concrete containment structure and pre-stressed concrete pressure vessel

5.4.1. Good practice: Monitoring of concrete structures

Complementary instrumentation is used to better predict the mechanical behaviour of the containment and to compensate for loss of sensors throughout the life of the plant.

5.4.1.1. Allocation by the TPR

A good practice has been allocated to France by the TPR board for this finding.

5.4.1.2. Country position

As mentioned in the NAR (§7.1.3.2.1.1), the mechanical behaviour of the containment is regularly monitored in operation and during pressure testing by means of surveillance which measures overall deformation and displacement. As of the construction stage, the containment is equipped with instrumentation, distributed around the basemat, the gusset, the cylindrical part and the dome. Additional test instrumentation may be temporarily added for the performance of a pressure test.

When the fleet was designed, the containment surveillance system was the response to a significant need for surveillance to verify the design hypotheses and ensure satisfactory construction. Today, there is less need for this surveillance, as the displacement kinetics diminish consistently with the phenomena of deferred deformation of pre-stressed concrete. This system produces significant feedback (more than 3 tests per unit) feeding an extensive base (58 units and 25 years of use) and which can prove invaluable: in particular, the data provided by the vibrating wire strain gauge (acoustic strain gauge) embedded in the structure are likely to highlight phenomena, such as concrete swelling pathologies, even in structures that are difficult or impossible to access, particularly the containment basemats.

The current need is aimed more at ensuring the management of ageing by taking account of confirmed failures and the risks of future failure of the instrumentation. The Optimal Instrumentation System is a response to this requirement. The principles of the optimum instrumentation system comply with the definition of containment prestressed wall instrumentation means that are necessary and sufficient for:

- monitoring the structure,
- being able to carry out the required demonstration studies throughout the forthcoming industrial operation period,
- guaranteeing compliance with the functional requirements applicable to the containment instrumentation system.

As mentioned in the NAR §7.2.3, the optimum instrumentation system thus comprises:

- the original instrumentation with replacements if faulty (topographical references, pendulums and invar wires, thermocouples, some strain gauges),
- additional instrumentation (new vertical invar wires, facing strain gauges)

and is installed gradually, as and when unit outages take place and according to the identified needs.

Finally, EDF is also experimenting with new surface sensor technologies on the VeRCoRs mock-up, notably to acquire measurements distributed by optical fibre. If their reliability is proven, these technologies could offer an alternative to the surface sensors currently installed on the containments.

5.4.2. Good practice: Assessment of inaccessible and/or limited access structures

A proactive and comprehensive methodology is implemented to inspect, monitor and assess inaccessible structures or structures with limited access.

5.4.2.1. Allocation by the TPR

A good practice has been allocated to France by the TPR board for this finding.

5.4.2.2. Country position

The various parts (basemat, cylindrical part and dome) of the French nuclear power plant containment are equipped with instrumentation systems. These systems can be of help to identify certain phenomena, such as concrete swelling pathologies, even in structures with little or no access, such as the containment basemats. The use of these measures provided by these systems partly compensates for the current lack of NDE methods applicable to these structures.

As mentioned in the NAR, EDF is heavily committed to the development of NDE for inspection of inaccessible areas and is notably a participant in the French research project called ENDE (for non-destructive assessment of containments, 2014-2018 extended until 2020), focusing on the exploration of non-destructive techniques for characterising the state of stressing and cracking of the concrete, as related to the tightness of a containment. This project, which comprises 6 academic laboratories, enables the possible measurement techniques to be extensively investigated.

For EDF, the aim is to develop non-destructive examination solutions for assessing parameters of interest, such as the water content, the evolution of the pre-stressing in the concrete, damage to the concrete, the dimensions and opening of a crack under evolving loading, in order to supplement the visual inspections of the structures and be able to fine-tune the prediction models for the mechanical behaviour and tightness of the containments.

This partly intersects with the goals of the VeRCoRs project, so the mock-up was made available to the ENDE project partners for measurement campaigns during and outside pressure testing. At this stage, the following points of interest have been identified:

- The analyses of these measurement campaigns confirmed the benefits of non-linear ultrasound techniques crossed with electromagnetic techniques for assessment of stress in the concrete. A thesis targeting these techniques will be started at the end of 2019.
- The large-scale experiments carried out on VeRCoRs have led to significant advances in the characterisation of closed cracks by linear ultrasound measurements (surface waves). The industrialisation of the technique is in progress.
- The spatial variability of the properties of the concrete was also investigated during a multi-technique campaign carried out in 2019 on the VeRCoRs mock-up. The results are currently being analysed.
- A measurement of the water content by embedded sensors has been obtained. As this parameter is the main marker of concrete ageing, the investigations are continuing to measure it with other NDE type methods.

These approaches should enable the most appropriate techniques to be selected for accessing the characteristics of interest. These actions eventually aim to produce validated and reliable industrial NDE techniques liable to be deployed in a targeted manner on the containments, in addition to visual inspections and monitoring with surveillance instrumentation.

5.4.3. TPR expected level of performance: Monitoring of pre-stressing forces

Pre-stressing forces are monitored on a periodic basis to ensure the containment fulfils its safety function.

5.4.3.1. Allocation by the TPR

A good performance has been allocated to France by the TPR board for this finding.

5.4.3.2. Country position and action

On the 58 EDF plant units, the containments are pre-stressed with pre-stressing tendons injected with cement grout. The consequence of this is not being able to retension or replace the pre-stressing tendons during the lifetime of the containment.

The phenomena of concrete shrinkage and creep and pre-stressing tendon relaxation lead to a drop in the pre-stressing of the containment over time. Concrete creep under a sustained load, when coupled with concrete shrinkage, depends on the composition of the concrete and cannot therefore be delayed or neutralised. Relaxation of the pre-stressing tendons cannot be delayed or neutralised either, as these tendons are injected into a cement grout.

There is no means of counteracting the loss of tendon pre-stressing. Monitoring is therefore necessary. In operation, this is achieved by periodically measuring the deformation of the concrete at a frequency appropriate to the kinetics of the phenomenon. Readings are taken from the surveillance system by EDF at least every 3 months. Most of the sites have telemetry and the readings can be more frequent if necessary. The pre-stressing force is also monitored during the full-pressure containment tests by measuring the instantaneous deformation of the concrete.

In addition, on the first unit of each site, 4 vertical pre-stressing tendons were injected with grease such that they are free to deform (extend or shorten) and transmit the effect of this deformation to a dynamometer placed at the end of the tendon. The tension in the pre-stressing tendons can thus be monitored by means of dynamometers installed on the vertical pre-stressing tendons injected with grease. However, these measurements are not used in the predictive studies of containment behaviour.

On certain plant units, the loss of tension is measured by weighing of the tendons (lift-off) injected with grease. This method, which can compensate for any malfunction of the dynamometers, nonetheless remains hard to implement on a plant unit in operation. The experience also indicates that such an operation can lead to a significant and lasting disruption of the series of measurements (hysteresis type discontinuity linked to the operation). Given that these measurements are not used in the containment's long-term mechanical behaviour evaluation studies, lift-off measurements are not deployed.

6. STATUS OF THE REGULATION AND IMPLEMENTATION OF AMP TO OTHER RISK SIGNIFICANT NUCLEAR INSTALLATIONS

ENSREG asked participating countries to complete this section on AMP for other significant nuclear installations on a voluntary basis[13].

To answer this request, ASN has decided to address the AMP of the category-1 installations in operation (nuclear power reactors and research reactors with a power exceeds 1 MWth lie already within the scope of the TPR), the 1st category corresponding to the installations presenting the greatest risks or adverse effects.

6.1. Board recommendation[14]

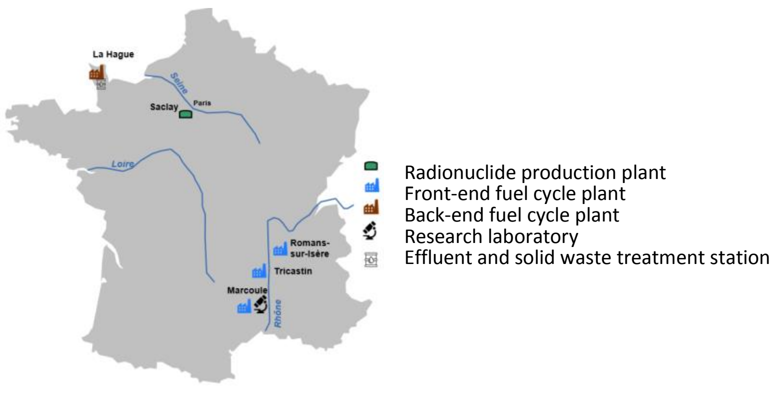
The Board recommends that countries explore the regulation and implementation of Ageing Management Programmes of other risk significant nuclear installations while developing and implementing National Action Plans to ensure they exist and are effective.

6.2. Country position and action (fuel cycle facilities, installations under decommissioning, waste facilities, etc.)

6.2.1. Nuclear installations perimeter

France counts more than one hundred highly diverse basic nuclear installations (BNI), with extremely varied implications for nuclear safety, radiation protection and protection of the environment. These include research nuclear reactors, nuclear power reactors, radioactive waste storage and disposal, fuel fabrication or reprocessing plants, laboratories, industrial irradiators, etc. To reinforce the efficiency of its control while ensuring that it is proportionate to the issues and significance of the risks or adverse effects presented by the facilities, ASN adopted in September 2015[15] an approach that classifies the nuclear installations in 3 categories, where the 1st category corresponds to the installations presenting the greatest risks or adverse effects[16]. The list of BNIs indicating their category is updated annually by an ASN resolution.

The installations with significant risk in category-1, not included in the TPR scope, are the following:



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[13] Minutes of ENSREG plenary meeting – 25 March 2019

[14] http://www.ensreg.eu/sites/default/files/attachments/hlg_p2018-37_160_1st_topical_peer_review_report_2.pdf

[15] ASN resolution 2015-DC-0523 of 29 September 2015 establishing a classification of BNIs according to the risks and drawbacks they present for the interests mentioned in article L. 593-1 of the Environment Code

[16] All the nuclear power reactors in operation are classified as category-1 BNIs.

Table 3: Category-1 BNIs (Sept. 2019, excluding installations lying within the scope of the TPR)

BNI No.	Name	Licensee	Activities sector	Activities	Location
29	UPRA	CIS bio international	Production plant	Production of artificial radionuclides	Saclay site
151	MELOX	Orano	Front end of fuel cycle	Fabrication of fuel based on reprocessed plutonium (MOX) for power reactors	Marcoule site
148	ATALANTE	CEA	Research	Research laboratory	Marcoule site
63	Romans	Framatome	Front end of fuel cycle	Fabrication of fuel for research reactors	Romans-sur Isère site
98	Romans	Framatome	Front end of fuel cycle	Fabrication of fuel for power reactors	Romans-sur Isère site
105	COMURHEX	Orano	Front end of fuel cycle	Transformation of radioactive substances	Tricastin site
155	TU5	Orano	Front end of fuel cycle	Transformation of radioactive substances	Tricastin site
168	George Besse II	Orano	Front end of fuel cycle	Transformation of radioactive substances	Tricastin site
116	UP3-A	Orano	Back end of fuel cycle	Reprocessing spent fuel	La Hague site
117	UP2-800	Orano	Back end of fuel cycle	Reprocessing spent fuel	La Hague site
118	STE3	Orano	Back end of fuel cycle	Effluent and solid waste treatment	La Hague site

6.2.2. Category-1 BNI ageing management (excluding initial scope of TPR)

6.2.2.1. BNI No. 29 (UPRA) – CIS bio international, Saclay site

The implementation of an ageing management procedure for the EIPs was initiated in the periodic safety review for which the conclusions were submitted in 2018. This procedure concerns the equipment items classified as EIPs and the site's retention systems. It consists in identifying for each type of EIP:

- the ageing mechanisms to which they can be subjected,
- the consequences of a failure,
- the measures taken by the installation to manage the ageing mechanisms.

Identifying the consequences of a failure enables the measures taken to control equipment deterioration to be made proportionate to the risks.

The EIPs are classified first by family (25 families), then by type (about 85 types). For each type of EIP, the following aspects are analysed (general analysis):

- is there a risk of obsolescence ? (yes/no),
- is there a risk of ageing? (yes/no).

  If the answer to the second question is yes, an analysis is conducted to determine the origin of this ageing for each type of EIP (chemical products, irradiation, contamination, mechanical constraints, electrical constraints, thermal constraints, others).

Further to this general analysis and when necessary (identification of a risk of ageing), a detailed analysis of the monitoring and maintenance programme and of obsolescence is carried out. Through these detailed ageing analyses, CIS bio international adopts a position on:

- the adequacy of the PITs performed,
- the adequacy of the periodic preventive maintenance operations,

CIS bio international position regarding the sufficiency of the PITs and preventive maintenance are bases on:

- the existence of a continuously monitoring program that enables to detect EIP ageing, and it's adequacy,
- the ease of EIP replacement in case of a failure detection.

On completion of this detailed analysis performed in the framework of the periodic safety review, CIS bio international decides whether or not it is necessary to perform additional *in situ* investigations to take stock of the situation.

In the context of the periodic safety review, CIS bio international deemed it necessary to perform additional investigations (mainly visual inspections) of about twenty types of EIP, in order to determine the ageing situation of these EIPs. A summary document tracking the ageing analysis is drawn up for each type of EIP. Alongside this, to meet an ASN requirement formulated at the end of the last periodic safety review, a civil engineering monitoring and maintenance programme has been put in place since the conformity review performed during the last periodic safety review had revealed the presence of more significant cracking that expected.

ASN underlines the work initiated and the methodology developed with regard to ageing management in order to establish a situation assessment for the types of EIP for which the PITs and the preventive maintenance work did not allow the development of ageing-related deterioration to be monitored. This methodology is being examined by ASN. ASN will also be attentive to CIS bio international's position regarding the results of the additional investigations and the need to set up new programs in order to monitor ageing degradation. On completion of the examination of the periodic safety review ASN will, if necessary, ask CIS bio international to supplement its methodology and formalise its ageing management programme. ASN considers that this programme should be implemented on an ongoing basis, and not only during periodic reviews and should not be limited to monitoring and maintenance programmes.

6.2.2.2. BNI No. 151 (MELOX) – Orano, Marcoule site

Ageing management concerns the SSCs fulfilling a function that is important for protection (EIP), along with the equipment necessary for operation of the installation.

The ageing analysis methodology defined as part of the last periodic safety review (submitted in 2011) consists in identifying the SSCs in operation which can be subject to phenomena that reduce their performance. This selection is made in particular on the basis of the lessons learned from the last periodic safety review and from operation as well as the periodic inspections and tests.

For these SSCs, ageing detection and monitoring are achieved by:

- monitoring the development of the operating parameters monitoring measures,
- monitoring the recurrence of operating faults and/or failures,
- specific investigations based on the expert assessment,
- visual inspections for assessing the general condition,
- resistance and endurance calculations for determining the service limits of mechanical components.

The choice of detection parameters is adapted to the particularities of each SSC studied: active or passive component, damage mechanisms, measurement possibilities, representativeness of an investigation technique, etc. If ageing of an SSC is detected, the following procedure is applied: either the existing SSC is maintained in operational condition (MCO) or it is replaced (identically or with improvements). MCO is the preferred option for addressing ageing problems.

A prior diagnosis phase serves, after analysing the feasibility (integrating the availability of spare parts and the work constraints), to decide whether to perform a simple adjustment or, in the case of defective components or sub-assemblies, to repair or replace with identical parts complying with the original specifications. Two concrete application examples are provided:

- Neutron screens: neutron (absorbing) screens are EIPs which control the criticality risks by solid poisoning. The proof of the sub-criticality of storages facilities that use these screens is demonstrated provided that the thicknesses of the screens and the concentrations of boron atoms (neutron capture) and hydrogen atoms (neutron thermalisation), are greater than the values used in the design calculation notes.
    - An analysis of the degradation and ageing mechanisms was carried out during the first periodic safety review (submitted in 2011)). This analysis concluded that ageing over time could call into question the homogeneity of the screens, thereby deteriorating the expected performance.
    - A verification of control parts representative of the screens of the installation, consisting in measuring the attenuation of a flux of neutrons at different points of the sample, has been put in place. This verification serves to guarantee that the uniformity of the material, and therefore the expected performance of the screens, is maintained. This verification is repeated periodically (at each periodic safety review).
- Sintering furnaces: the sintering furnaces are installed on the process line for fabricating MOX fuel. These furnaces are also EIPs with respect to static containment, control of the criticality risk and the explosion risk.
  Some of the furnace components are sensitive to ageing, notably the internal brickwork which isolates the outer metal wall from the high temperature reigning inside the furnace. Part of this brickwork, the hearth, also permits the circulation of the products inside the furnace. Deterioration of this brickwork leads to malfunctions which put the equipment out of service. The preventive replacement of the brickwork is a factor that is known to furnace manufacturers and users. The plant operating experience feedback has allowed the consolidation of a monitoring programme based on the following detection means:
    - monitoring changes in the operating parameters: the total duration of use is one of the targets for triggering replacement of the brickwork of a furnace,
    - monitoring the failure recurrence rates: the frequency of malfunctions linked to the circulation of products is monitored and can be a trigger for furnace refurbishment,
    - visual inspections (using a camera) performed during cleaning of the material circulation channel.

  The assessment of the gaskets after replacing sections of shaft furnaces has led to clearance this equipment with regard to ageing.

  The handling of brickwork ageing is based on 2 areas:
    - maintaining in operational condition by local repairs of the brickwork carried out after visual inspections or the remedying of a malfunction,
    - complete replacement of furnace sections (metal wall equipped with its brickwork) by new sections. Replacing sections is a complex job that takes several weeks and involves

specific procedures and tools, and a specified requalification process for the safety and quality of the manufactured products.

This ageing analysis methodology will be deployed again within the framework of the next periodic safety review (2021). The actions identified to take account of ageing shall be set out in the procedures at the end of this safety review.

ASN notes that at present, ageing management is based on a variety of operational processes (periodic inspections and tests, OEF analysis) and does not cover all the EIPs. ASN will analyse the EIP inspections and ageing management programme proposed by Orano under the next periodic safety review (2021). On completion of its examination ASN will, if necessary, ask the licensee to supplement its ageing management programme. This programme must not be confined solely to the periodic safety reviews and it must include the identification and analysis of the ageing mechanisms encountered.

6.2.2.3. BNI No. 148 (ATALANTE) – CEA, Marcoule site

Ageing management concerns the products and equipment that can jeopardise the safety of the installation (i.e. EIP on account of safety). The procedure implemented, initiated at the end of the last periodic safety review (2007) for the management of ageing, is organised around three themes:

- equipment monitoring by performing regulatory inspections and tests (RITs) and periodic inspections and tests on the EIPs: these checks therefore serve to monitor equipment ageing, detect a failure requiring repair of the equipment and possibly schedule renovation work,
- anticipation of failures or obsolescence by applying preventive maintenance: the licensee defines the preventive maintenance operations organised in parallel with the regulatory inspections and tests and periodic inspections and tests, taking into account the manufacturer's maintenance recommendations and the OEF on the equipment concerned. Thanks to the monitoring of these operations and the analysis of the work reports, the maintaining of product and equipment performance has improved and their ageing is better detected, thereby allowing anticipation of their upgrading or replacement by new-generation products or equipment.
- utilisation of the OEF of the installation or of other CEA installations to anticipate the renovation work to perform on the products or equipment. The OEF is based essentially on:
    - the analysis of the malfunctions specific to the installation,
    - the analysis of indicators such as consumption or level of availability,
    - the observation of an operating improvement such as a change in a practice or an item of equipment,
    - the information from another CEA installation,
    - the data identified and provided by the product or equipment manufacturer.

  These OEF elements are communicated then taken into account by the person(s) in charge of the product(s) and equipment concerned in order to adapt the preventive failure management and optimise their nominal functioning. The most significant actions are recorded in a summary which is integrated in the annual safety assessment.

To carry out large-scale equipment replacement or upgrading operations, a multi-year medium/long-term plan has been put in place to schedule the necessary actions to maintain or improve the performance of the installation and anticipate the costs associated with their performance.

Complementary ageing management actions have recently been carried out and concern:

- a review of the EIPs (based on the list updated during the periodic safety review) aiming to identify the EIPs which are not subject to ageing management by applying the procedure describing how ageing is taken into account,
- for the EIPs concerned, identification of additional inspection activities to put in place according to the ageing mechanisms affecting the equipment.

This has resulted in the identification of about ten EIPs for which ageing could be better taken into account. The additional inspection activities envisaged hinge mainly on regular monitoring of the installation, focusing in particular on:

- the condition of the third static containment barrier (internal structures of reinforced concrete shells, inter-building seals, roofs, flat roofs and external facades that are subject to climatic stresses),
- the condition of closed-off openings within the second static containment barriers,
- the condition of the pipes and tanks constituting the first static containment barrier, which can be affected by possible corrosion phenomena,
- the condition of the walls of shielded housings and shielded boxes subjected to chemical and irradiating environments,
- the condition of the ventilation ducts,
- the condition of the fire dampers.

These diagnoses have made it possible to identify the ageing mechanisms involved and determine the ageing situation of these EIPs. All the recommended actions resulting from these diagnoses have been taken up in an action plan that prioritises the curative, corrective and preventive measures to be implemented according to their impact on the control of the risks. In the light of the conclusions of these diagnoses, the CEA has defined a programme for regular monitoring when it’s necessary.

ASN observes that the general procedure described by the CEA aims first and foremost to ensure that the EIPS are functioning correctly through the regulatory inspections and tests as well as periodic inspections and tests and to take into account the risks associated with obsolescence. It must be supplemented by identifying and defining the ageing mechanisms involved, consistently with the monitoring programme, to consolidate the current ageing management programme.

ASN does however consider that the additional actions carried out recently by the CEA for those EIPs whose ageing development cannot be checked by normal monitoring, constitutes an initial approach to the management of installation ageing. In the context of the periodic safety review, ASN will ask the CEA to supplement its ageing management procedure in order to check the exhaustiveness of the identified deterioration mechanisms and the adequacy of the planned inspections. The programmes for regular monitoring of the installation defined by the CEA, which allow monitoring of the development of ageing of the EIPs concerned, must be formalised in an operational document.

6.2.2.4. BNI No. 63 and 98 – Framatome, Romans-sur-Isère site

The setting up of an ageing management programme with the performance of extensive and specific investigations was initiated during and at the end of the last periodic safety reviews (the conclusions of which were submitted in 2015 and 2013 for BNIs No. 63 and 98 respectively and on which ASN adopted a position on completion of their examination). The scope comprises the EIPs identified as being potentially subject to ageing in the safety analysis report (SAR) (see methodology described below). In addition, a specific procedure relative to civil engineering is currently being deployed. It should be noted that there is a technical guide describing the EIP ageing management procedure which is referenced in the integrated management system (IMS). The ageing mechanisms are described in the SAR, the monitoring measures (periodic inspections and tests) are called out in the RGEs [17]and the scope of these tests and the preventive maintenance measures are specified in the operating procedures.

Generally speaking, ageing phenomena are detected and monitored through:

- tracking the operating parameter monitoring measures intended to reveal the appearance of deterioration phenomena,
- monitoring the recurrence of abnormal events of operating faults or failures signifying a loss of reliability,
- specific investigations based on the expert assessment from a cross-cutting analysis focusing on the various ageing phenomena.

The methodology applied by Framatome is:

1. identification of the ageing phenomena that can affect the equipment and installations (study and description in the SAR),
2. identification of the equipment and structures that can be affected by these ageing phenomena (identification in the SAR),
3. definition of monitoring measures to check the progress of the ageing phenomena and definition of prevention measures. These measures are usually integrated in the periodic inspections and tests and in the maintenance operations. It should be noted that the periodic inspections and tests do not only check the operation of an item of equipment but also its wear.

The procedure described above is applied as follows:

1. Identification of the ageing phenomena:
   Framatome has identified 5 ageing phenomena that can affect the equipment of its installations:
   - corrosion: the equipment where on service conditions (manufacturing process) involves the use of corrosive chemical products (e.g. hydrofluoric acid) can be subject to the phenomenon of ageing by corrosion,
   - fatigue: equipment submitted to vibrations can be subject to the phenomenon of ageing by fatigue,
   - abrasion: the equipment involved in the pneumatic transfer system to convey uranium dioxide powder can be subject to the phenomenon of ageing by abrasion,
   - thermal constraints: equipment operating with heating process and/or large significant thermal variations can be subject to thermal induced ageing (e.g. conversion furnaces),
   - climatic stresses: EIPs located outdoors can be subject to ageing associated with climatic stresses, such as extreme temperatures, rainfall or snow. This is the case with civil engineering works.
2. Identification of the room (or workstation) and equipment concerned:
   The equipment and room (or workstation) concerned by each of the ageing mechanisms are:
   - for corrosion: mainly the hydrofluoric acid condensation station and the recycling workshop which use chemical reagents such as nitric acid,
   - for fatigue: mainly in the fuel element workshop, in the gloves boxes containing crushing, grinding or screening equipment,
   - for abrasion: mainly the pneumatic transfer systems and the uranium oxide powder reception hoppers between the conversion and pelletizing workshops, especially in the curved sections of the pneumatic transfer system,

[17] general operating rules

- for thermal constraints: mainly the conversion furnaces of conversion workshop, and the sintering and oxidation furnaces of the pelletizing workshop,
- for climatic stresses: mainly the civil engineering structures.

3. Definition of monitoring, prevention and maintenance measures.
   - for corrosion:
     - prevention measure: choice of special materials and coatings and installation of a processing unit on the ventilation system to trap the nitrogen oxides that could damage the filters,
     - monitoring measure: periodic (annual) visual inspection.
   - for fatigue:
     - monitoring measure: periodic leak-tightness check (pressure test).
   - for abrasion:
     - prevention measure: choice of materials and double encapsulation at the curved sections,
     - monitoring measure: periodic leak-tightness check (pressure test), periodic inspection and/or replacement of the straight and curved sections of the pneumatic transfer systems, periodic visual inspection of the condition of the striking plate of the outlet hoppers.
   - for the thermal constraints:
     - prevention measure: choice of materials and equipment,
     - monitoring measure: periodic check of the state of wear.
   - for climatic stresses:
     - prevention measure: reinforcement of equipment and buildings against climatic stresses,
     - Monitoring measure: deployment of monitoring plans following the periodic safety reviews of BNIs Nos. 63 and 98, they are based on the potential pathologies of the different parts of civil engineering structures.

The replacement criteria and preventive maintenance actions are described in the periodic inspections and tests procedures.

ASN considers that the ageing management methodology deployed by Framatome for its installation is satisfactory. The ageing management programme is formalised in the integrated management system.

6.2.2.5. BNI Nos. 105, 155 and 168 (COMURHEX, TU5, George Besse II) – Orano, Tricastin site

The Tricastin site accommodates several BNIs which until 2018 belonged to different licensees, and were not subject to a single EIP ageing management monitoring system. Consequently, work is in progress to harmonise the practices. The periodic safety reviews of the installations have made it possible to reinforce the methodology and conduct specific investigations and actions on the installations with regard to ageing monitoring and management.

Ageing management concerns all the EIPs. It is ensured by controlling the conformity of the installations with their safety baseline requirements and the requirements defined for them throughout the life of the installation. This procedure is regulated by a specific directive (directive on the verification of installation conformity). The objectives are:

- to define a process for verifying the conformity of the EIPs, in correlation with the initial conformity and the environment of the EIP,

- to define a conformity verification strategy (defining the inspections).

Consequently, ageing management is currently integrated in the periodic inspections and tests which form part of the installations maintenance process of the IMS.

The procedure currently being deployed by Orano is based on the development of a formalised verification strategy and keeping it up to date. This strategy is adapted to the significance of the risks and issues associated with each EIP and to their ageing kinetics. The methodology is based in particular on the processes of regulatory watch and document management, preventive and corrective maintenance, and modification management.

The process for developing the conformity verification strategy is as follows (in progress):
- study of the file describing the installation/equipment concerned (qualification file, etc.),
- formalisation of a verification sheet bringing together all the operational criteria associated with the equipment conformity verification operations. This sheet can be specific to an EIP or applicable to a family of EIPs. It sets out all the specified inspections and tests,
- the verification strategy is revised when necessary and in particular in the context of the periodic safety reviews.

For certain targeted installations, a monitoring and periodic inspection and test programme to check ageing shall be put in place as part of the maintenance procedures.

The conformity reviews carried out during the periodic safety reviews are an important step in the ageing management of EIPs. These conformity reviews concern all the EIPs. However, the analysis can concern each EIP or a representative sample of the EIP constituents, depending on the equipment and the reproducibility of the installations.
The conformity review comprises four main steps:
- Step 1: identification of the initial design requirements and operational criteria relative to the defined requirements (DRs). The DRs are specified by the operational criteria (explicit requirements with verifiable acceptance criteria).
- Step 2: analysis of documents. This step consists in finding and analysing the design and production documents on the one hand, and the operating documents used for operational management, maintenance operations, periodic inspections and tests, and procurement of the EIPs on the other. The updating of the preventive maintenance plans according to OEF and to take account in particular of early warning signs (adjust frequencies, introduce new inspections, etc.) is analysed at this stage. This step serves to create the conformity review plan (inspections or checks to carry out, production of on-site visit sheets).
- Step 3: Performance of *in situ* inspections and visits and ageing analysis. The aim of the *in situ* visits and inspections is to detect and locate any deterioration to structures and equipment arising during their operation. Equipment ageing is analysed primarily through visual assessments, non-destructive tests, specific *in situ* investigations, OEF and installation maintenance.
- Step 4: synthesis and defining of conformity action plans. At the end of the review, the conformity of each EIP constituent is determined on the basis of the analysis of the demonstrations of conformity with the DRs and the *in situ* visits and inspections if applicable. Deviations identified during the conformity review are dealt with as soon as possible and in priority. The conformity action plan for the installation and the corresponding schedule are presented in the periodic safety review file.

  Furthermore, in the light of the lessons learned from the periodic safety review of TU5, Orano Tricastin is integrating, as part of the next safety reviews, an equipment monitoring programme completeness procedure in order to identify as early as possible the potential installation ageing mechanisms and to better distribute the inspection work load over the years. The current methods of detection (based primarily on thickness measurements) could thus be supplemented by other criteria such as counting the number of operating cycles.

ASN notes that ageing is attached to the directive on managing the conformity of the installations, which does not constitute an ageing management programme. This is because the aim of the periodic inspections and tests is usually to check the operation of an EIP. However, the ageing management procedure is currently reinforced in the context of the periodic safety reviews. ASN considers that the updated procedure must integrate the identification of the ageing mechanisms and the definition of the monitoring, inspection and preventive maintenance measures for each EIP or family of EIPs. If necessary, ASN will ask Orano to supplement its procedure.

6.2.2.6. BNI Nos. 116, 117 and 118 (UP3-A, UP2-800 and STE3) – Orano, La Hague site

There is a uniform ageing management procedure for all the BNIs on the La Hague site[18]. The actions and investigations concerning ageing management have been undertaken within the framework of the periodic safety reviews[19].

Ageing management is an activity important to protection (AIP). Orano has several technical notices relative to ageing, in particular concerning the methodology for performing conformity and ageing reviews within the framework of the periodic safety reviews and the evolutions in these reviews.

With all these installations, the La Hague site comprises some 50,000 EIPs. The various EIPs are analysed in order to place them in a three-level hierarchy corresponding to a grading of the associated requirements. For its ageing management programme, Orano has divided the level 1 and 2 EIPs into about 500 families corresponding to similar safety functions / risks and to types of equipment.

For each family,

- defined requirements are allocated and the potential ageing mechanisms are determined,
- one or more control EIP(s) representative of ageing are identified in the light of the feared risks, the technologies and the EIP levels.

Each controlled EIP undergoes:

- a verification of applicability of the defined requirements and of conformity of the EIP with the applicable requirements,
- an ageing management study,
- an *in situ* visit whenever possible.

The methodology provides for 2 main ways of treating EIP conformity depending on whether they are replaceable or not planned to be replaced (in view of the technical conditions):

1. Replaceable EIPs
   The replaceable EIPs include relatively large equipment volumes. The methodology is applied as follows:
   - selection of control EIPs: an analysis is carried out according to the types of equipment, the OEF of the EIPs, favouring those with a higher failure rate, the operating environment and its stresses (reagent room, pulsing / vibration, etc.). EIPs are also allocated by level

[18] In addition to the 3 BNIs (in operation) concerned by this report, the La Hague site includes 4 other installations which are currently undergoing decommissioning and are classified as category 1 (BNI Nos. 33, 38 and 80) and category 2 (BNI No. 47).
[19] The conclusions were submitted in 2010 for BNI No. 116 and in 2017 for BNI Nos. 117 and 118

and workshop. This approach aims at covering the various identified ageing risks and having representative control EIPs,

- analysis of the requirements and checking compliance with them,
- analysis of EIP ageing including an *in situ* visit, possibly supplemented by non-destructive tests.

2. EIPs not planned to be replaced
   - selection of control EIPs: a risks analysis is carried out integrating:
     - the flows: temperatures, acidities, presence of ions favouring aggression mechanisms,
     - the equipment materials,
     - the particle content of fluids,
     - the operating cycles (fatigue), in pressure or temperature,
     - the level of the EIPs.
   - analysis of the requirements and checking compliance with them,
   - ageing analysis from the aspects of corrosion, wear, fatigue, deformation. This analysis is based on:
     - historical tracking of operating control parameters (acidity, temperature, etc.),
     - an analysis of the design,
     - an analysis of the modifications,
     - an analysis of the monitoring methods,
     - an analysis of the OEF from similar equipment.
   - the in situ visits and the necessary non-destructive tests are initiated in the light of the ageing analysis. If access is impossible, the visit can be conducted on an item of equipment displaying similar deterioration factors,
   - in certain cases, if investigations are impossible or if the analysis is complex (e.g. pool liner), more detailed studies are carried out in the form of durability ratings. The aim of these ratings is to precisely identify the ageing mechanisms and the degree of their control by using experience feedback, results documented in the literature, analyses by specialists, etc.

The above steps lead to:

- the establishing of a corrective action plan to deal with any nonconformities noted. The corrective actions are prioritised in time according to the level and the nature of the action. This includes repairs or replacement of replaceable EIPs,
- an analysis of the transposability of the chosen action plans and which could turn out to be relevant for the EIPs represented by the control EIP,
- the defining or updating of monitoring plans produced on the basis of control EIPs allocated by functions (e.g. ventilation, cooling, etc.) or by technology (valves, cocks, etc.). All the EIPs shall ultimately be covered by a monitoring plan.

The ageing monitoring carried out during the first periodic safety review of BNI No. 116 revealed corrosion of the fission product evaporator-concentrators of BNIs 116 and 117 that was more severe than expected. These evaporator-concentrators are installed in individual cells with 1.2 metre-thick concrete walls in a highly irradiating and poorly accessible environment. The design of these cells does not allow the introduction of a probe to measure the thickness of the evaporator walls. Consequently, Orano had to bore borescope holes in the walls of the cells containing the evaporators in order to allow the introduction of a remotely controlled boom fitted with an ultrasound probe to measure the thicknesses. Detection of this phenomenon has led the licensee to modify the operating conditions of these evaporators, to subject them to tightened monitoring (annual checks of thickness measurements and pressure tests) and to put in place additional provisions to cater for the perforation of an evaporator.

The current way of handling things is governed by the time frames of the periodic safety reviews. On the basis of the lessons learned, Orano has decided to deploy during 2020-2021 a process for continuous monitoring of EIP ageing conformity. This process will also allow the control EIP selection criteria to be reviewed periodically, particularly for the replaceable EIPS, and if necessary give rise to changes of control EIPs and/or changes in the monitoring provisions. Orano will also strengthen the maintenance recommendations essentially for the replaceable EIP

ASN underlines the ambitious and rigorous methodological procedure for ageing monitoring put in place within the framework of the periodic safety reviews of the La Hague installations. ASN thus considers that the method adopted by Orano for monitoring the ageing of its installations is on the whole satisfactory. The ASN inspectors have nevertheless found during their inspections that on-site application of the procedure needs to be improved. Over the coming years, ASN will continue its oversight, particularly through inspections, to ensure that Orano's ageing monitoring procedure is applied with rigour.

7. TABLE: SUMMARY OF THE PLANNED ACTIONS

This table contains the planned actions resulting from the self-assessment and the peer review, the associated deadlines and the monitoring process by the regulator.

Installation	Thematics	Finding	Planned action	Deadline	Regulator's Approach to Monitoring
Cabri (research reactor)	OAMP	*A systematic and comprehensive OAMP is implemented for research reactors, in accordance with the graded approach to risk, the applicable national requirements, international safety standards and best practices. A systematic and comprehensive OAMP is implemented for research reactors, in accordance with the graded approach to risk, the applicable national requirements, international safety standards and best practices.* Finding in the self-assessment and from the peer review	Application of the new methodology for AMP based on IAEA guide SSG10 to all EIPs	Mid 2020	Examination of the application of this methodology to the reactor block and the containment in the frame of the periodic safety review
RJH (research reactor)			AMP addressed in the commissioning file as requested in ASN resolution	RJH commissioning	Examination of the AMP in the frame of the commissioning licensing
NPP fleet	OAMP	*The specific aspects of the site and of each reactor could be better taken into account in the local ageing management programme (PLMV) and the unit ageing analysis report (UAAR).* Finding from the self-assessment	Action plan to improve the quality and usability of PLMV and UAAR (guide issued by national and support to the site)	Start early 2020	Inspections on site to assess the effectiveness
NPP fleet (including EPR FA3)	OAMP	*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*. Finding from the peer review	For outages with a significantly extended duration, update of the national doctrine for the preservation of equipment For EPR FA3, proportionate means are already implemented	End of 2020	Evaluation of the doctrine with regard to IAEA future guidance and OEF Evaluation of the means to preserve the equipment in the frame of the commissioning delay (more than mentioned in the authorisation decree)

Installation	Thematics	Finding	Planned action	Deadline	Regulator's Approach to Monitoring
900 MWe series	Concealed pipework	*With a view to continued reactor operation beyond 40 years, EDF has undertaken an ageing management programme for buried or poorly accessible pipes in addition to its monitoring provisions. Under this programme EDF has performed inspections on the Tricastin, Fessenheim and Bugey sites, with the aim of defining a generic programme of verifications and being able to decide during VD4 whether the buried pipes are fit for continued service or need to be renovated. The examination is in progress and the conclusions are expected in 2018* Finding from the self-assessment	Application of the programme to 3 sites is completed which confirms the adequacy of the approach Supplementary inspections are planned for pipework with environmental implications on Tricastin 1	Post-VD4 start-up (end of 2019)	Examination of the results of the buried pipework programme
900 MWe series	Concealed pipework	*Opportunistic inspection of concealed pipework is undertaken whenever the pipework becomes accessible for other purposes* Finding from the peer review	New organization between national level and NPP level	End of 2020	Assess its effectiveness with inspections on site