# France



# CONVENTION ON NUCLEAR SAFETY

## Eighth National Report for the 2020 Review Meeting

August 2019

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RÉPUBLIQUE FRANÇAISE

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# A - Introduction

## 1. General

### 1.1 Purpose of the report

The Convention on Nuclear Safety, hereinafter referred to as "the Convention", is one of the results of international discussions initiated in 1992 in order to contribute to maintaining a high level of nuclear safety worldwide. The Convention sets a number of nuclear safety objectives and defines the measures which aim to achieve them. France signed the Convention on 20th September 1994, the date on which it was opened for signature during the IAEA General Conference, and approved it on 13th September 1995. The Convention entered into force on 24th October 1996.

France has been actively participating in international initiatives to enhance nuclear safety for many years. It considers the Convention on Nuclear Safety to be an important instrument for achieving this aim. The areas covered by the Convention have long been part of the French approach to nuclear safety.

The purpose of this eighth report, drafted pursuant to Article 5 of the Convention and which covers the period from 2016 to mid-2019, is to present the measures taken by France to fulfil each of the obligations of the Convention.

### 1.2 Installations concerned

The Convention as such applies to nuclear power reactors. However, as in previous reports, France has decided in this eighth report to also present the measures taken for all research reactors.

The reason for this is that in France, research reactors are subject to the same general regulations as nuclear power reactors with regard to nuclear safety and radiation protection. Furthermore, the reports on the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management, to which France is a contracting party, included the measures taken in those respective fields with regard to research reactors. Lastly, in March 2004, the Board of Governors of the International Atomic Energy Agency (IAEA), of which France is a member, approved the Code of Conduct on the Safety of Research Reactors, which reiterates most of the provisions of this present Convention.

In this report, the acronym BNI (Basic Nuclear Installation) is used to represent all the French nuclear facilities as a whole (nuclear power reactors, research reactors, fuel cycle facilities, research laboratories, radioactive waste disposal facilities, etc.). This acronym therefore concerns facilities outside the scope of this report, because the provisions of some French legislative texts apply to all BNIs without exception.

### 1.3 Report authors

This report was produced by ASN (the French nuclear safety authority), which coordinated the work, with contributions from IRSN (Institute for Radiation Protection and Nuclear Safety) and from the nuclear reactor licensees, namely Électricité de France (EDF), the CEA (French Alternative Energies and Atomic

Energy Commission), the Laue-Langevin Institute (ILL) and ITER Organization. The final version was completed in July 2019 after consultation with the French parties concerned.

## *1.4 Structure of the report*

In this report, France has taken into account the experience acquired with the seven preceding reports: it is a stand-alone document, established primarily from existing documents and reflecting the viewpoints of ASN and the licensees. Thus, for each of the chapters in which ASN is not the sole contributor, a three-part structure has been adopted, starting with a description of the regulations by ASN followed by an overview by the licensees of the measures taken to satisfy the regulations, and ending with ASN's analysis of the measures taken by the licensees.

This report is structured according to the guidelines on national reports. The presentation is made "article by article", with each one giving rise to a separate chapter which begins by showing the corresponding article of the Convention in a shaded box. After the introduction, which presents some general aspects as well as the national nuclear safety policy, the summary gives a description of the main changes that have taken place since the seventh national report and the safety prospects for the next three years. As a complement, it also indicates the references of the paragraphs of this report that address the issues resulting from the last review cycle of the Convention: six issues for France, nine subjects with common issues, including the two subjects adopted for the thematic sessions of the 8th review meeting (i.e. the management of ageing and the safety culture). Part C addresses the general provisions (chapters 4 to 6), part D summarises the legislation and regulations (chapters 7 to 9), part E is devoted to general nuclear safety considerations (chapters 10 to 16), part F presents the safety of the facilities (chapters 17 to 19), and lastly part G presents the international cooperation measures (chapter 20). The report is supplemented by four appendices.

## *1.5 Publication of the report*

The Convention on Nuclear Safety does not stipulate any obligation regarding public communication of the national reports. Nevertheless, on account of its mission to inform the public and its concern to continuously improve the transparency of its activities, ASN makes the French national report available to the public. Consequently, this report is available in French and in English on ASN's website (www.asn.fr), along with the questions/answers relating to the report.

# 2. French nuclear safety policy

## *2.1 Nuclear safety policy*

The first decision of the French government concerning nuclear energy was to create in 1945 a public research organisation, the French Atomic Energy Commission (CEA), which was renamed the French Atomic and Alternative Energies Commission (keeping its acronym "CEA") on 10th March 2010. The first French experimental reactor became critical in December 1948, thus paving the way for the construction of other research reactors, followed by further reactors designed to generate electricity.

The French nuclear power reactors within the scope of the Convention were built and are today operated by a single licensee, Électricité de France (EDF). All the reactors except one, the high-flux reactor (HFR), operated by the Laue-Langevin Institute (ILL), were built and are operated by CEA. The ITER facility is still under construction to date.

Act 2006-686 of 13th June 2006 on *transparency and safety in the nuclear field*, called the "TSN Act", and its implementing texts, have completely overhauled the legislation and regulations concerning the nuclear safety of nuclear facilities.

The Government sets the general regulations applicable to nuclear activities by decree or by order. It takes the major individual decisions – few in number - concerning the major nuclear facilities, notably the creation and decommissioning authorisations. It takes its decisions on the basis of ASN opinions which are made public.

The TSN Act also created ASN, an independent administrative authority tasked firstly, in the name of the State, with monitoring nuclear safety and radiation protection to protect workers, patients, the public and the environment against the risks associated with civil nuclear activities, and secondly with informing the public.

Act 2015-992 of 17th August 2015 on *energy transition for green growth,* called the "TECV" act, has reinforced the legislative framework governing nuclear safety and informing citizens, and permitted regulation of the use of service providers and subcontractors within BNIs for activities involving significant safety implications, in accordance with a graded system. Lastly, the decommissioning policy has been overhauled to enshrine in law the principle of decommissioning within as short a time frame as possible. It stipulates in particular that a facility which has been shut down for 2 years shall be considered to be definitively shut down, except in special cases validated by the Minister responsible for nuclear safety, but which may not exceed 5 years.

Ordinance 2016-128 of 10th February 2016 introducing various provisions concerning nuclear activities reinforces the oversight of nuclear safety and the safeguarding of radioactive sources and nuclear materials against malicious acts.

This ordinance, issued in application of the TECV Act, reinforces ASN's means of oversight and powers of sanction, by giving the authority more graded tools, such as fines and administrative penalties, and creating a sanctions committee that will be responsible for determining the fines. ASN can now also inspect nuclear licensees outside the strict perimeter of the facilities.

The ordinance institutes a new obligation to physically protect radioactive sources against theft or malicious use. This system is overseen by ASN. It also gives the Defence High Official at the Ministry of Ecological and Solidarity-Based Transition (MTES) increased and graded powers of inspection in order to ensure that nuclear licensees effectively protect nuclear materials against the risks of theft and malicious use.

## *2.2 Energy policy*

To meet the major climatic and energy challenges of the coming decades, France has engaged in an energy transition, set out in the TECV act and based firstly on energy restraint and efficiency, and secondly on the diversification of production and supply sources through the development of renewable energies. The TECV act thus sets out the broad medium- and long-term objectives.

The multi-year energy programme (PPE) sets a target of 50% nuclear-powered electricity in the energy mix by 2035. This reduction in the nuclear share shall be achieved without new fossil fuel power plant projects and will not lead to an increase in greenhouse gas emissions from French electricity production. To achieve these objectives, the following approaches have been adopted:

- the closure of fourteen 900 MW nuclear reactors, including the two Fessenheim reactors;
- the nuclear power plant closure schedule shall follow the deadlines of the 5th 10-yearly outage of the reactors concerned, with the exception of 2 reactors which will close in the second period of the PPE in 2027 and 2028, provided that the security of energy supply criterion is satisfied;
- if certain conditions concerning the price of electricity and the development of the European electricity market are fulfilled, a further two reactors could be closed by 2025-2026, on the basis of a decision to be taken in 2023;
- the nuclear fuel reprocessing-recycling strategy shall be maintained over the period of the PPE and beyond, until the years 2040. To this end, a number of 1300 MW reactors shall be made MOX-compatible and studies shall be carried out with a view to deploying multi-recycling of fuels in the current reactor fleet.

The Act also aims to enable the electricity mix to be controlled through operating licenses for electricity production installations. A license will only be issued if the installation is compatible with the objectives of the Act and the multi-year energy programme (PPE). In particular, any new authorisation to operate a nuclear electricity production installation will need to comply with the current nuclear production capacity ceiling (63.2 GW) as stipulated in the Act.

# B – SUMMARY

# 3. Summary

## *3.1 Main changes since France's 7th national report*

### 3.1.1 Change in the legislative and regulatory framework

The TSN Act of 2006 and its implementation texts (Decree 2019-190 of 14th March 2019 – see appendix 2, § 2.1 -, "BNI" Order of 7th February 2012 - see § 7.1.3.1.2 – and ASN regulations) set out a strict work and intervention framework in which the integration of the "reference level" of WENRA, the European Nuclear Regulators Association, is continuing.

Ordinance 2016-128 of 10th February 2016 constituting various nuclear safety provisions, comprises legislative measures for the transposition of the Directive of 8th July 2014 and measures designed to reinforce the regulation of nuclear safety and radiation protection, by extending ASN's powers of oversight and sanction (see § 7.1).

Ordinance 2016-128 of 10th February 2016 provides in particular for the maintaining and improvement of the regulations concerning nuclear safety and its oversight (Article L. 591-2 of the Environment Code). This Code (Article L. 591-6) now requires that every ten years at least, the State conduct periodic self-assessments of its regulations and its regulatory authority (ASN) and undergo an international peer review with a view to the continuous improvement of nuclear safety. This obligation, which already figured in the ASN internal regulations, is now enshrined in law. These assessments will be organised jointly by the Ministers responsible for nuclear safety or radiation protection and by ASN. They take the form of "IRRS" missions as indicated in § 10.4.1 and 20.3. Lastly, Articles L. 591-7 and L. 591-8 of the Environment Code stipulate on the one hand that thematic nuclear safety and radiation protection reviews shall be organised every six years by the State in the form of national evaluations followed by peer reviews and, on the other, that an international peer review will be held in the event of an accident. These assessments and peer reviews will be organised jointly by the Ministers responsible for nuclear safety, radiation protection and civil security, and by ASN. Furthermore, Decree 2018-437 of 4th June 2018 now enhances the radiation protection of workers.

French regulations, which require that a periodic safety review of nuclear installations be held, and the objectives set by ASN for the ongoing periodic safety reviews, both comply with the objectives of the Vienna declaration on nuclear safety, described in § 3.4 for existing reactors (periodic safety review, compliance with relevant standards and best practices), as well as Council Directive 2014/87/Euratom of 8th July 2014.

Decree 2019-190 of 14 March 2019 has updated and codified in the Environment Code the provisions applicable to BNIs, to the transport of radioactive substances and to transparency in nuclear matters taken from eight decrees relative to BNIs and transparency in nuclear matters (see § 2.1 of appendix 2). The decree amends the regulatory procedures relative to BNIs which were hitherto governed by the "BNI Procedures" Decree of 2nd November 2007, in order to tie them in which the new regulatory requirements associated with the environmental assessment of projects resulting from the Ordinance of 3rd August

2016 and its implementation Decree of 11th August 2016, which transpose a European Community Directive concerning the environmental impacts of certain public and private projects.

Furthermore, the decree:

- supplements the provisions relative to the Local Information Committees (CLI) in application of Article 123 of the Energy Transition for Green Growth (TECV) Act of 17th August 2015, with the aim, when BNIs are located in a *département* which borders another country (or countries), of including representatives from the country or countries concerned in the relevant CLIs;
- defines the conditions of renewal of half of the members of the ASN Commission, other than its chairperson, every three years in application of Act 2017-55 of 20th January 2017 introducing the general status of the independent administrative authorities and the independent public authorities;
- defines the functioning of the ASN sanctions committee instituted by Ordinance 2016-128 of 10th February 2016 introducing various provisions concerning nuclear activities and detailing the procedures giving rise to administrative fines;
- clarifies the system applicable to BNIs containing equipment or facilities coming under the Industrial Emissions Directive 2010/75/EU of 24th November 2010 (the "IED"), and the system of BNIs coming under Directive 2012/18/EU of 4th July 2012 concerning control of the hazards associated with major accidents involving substances (called the "SEVESO 3 Directive") in application of Ordinance 2016-128 of 10th February 2016 introducing various provisions concerning nuclear activities.

### 3.1.2 A new strategic plan, a new oversight policy of ASN

In order to exercise its responsibilities and to ensure progress in nuclear safety and radiation protection, ASN must implement consistent actions that are commensurate with the issues involved. In order to do this, ASN relies on its values (independence, competence, rigorousness, transparency), on the commitment of its personnel and on a policy of continuous improvement. ASN carries out its oversight role by using the regulatory framework and licensing decisions, inspections, and if necessary, enforcement measures, in a way that is complementary and tailored to each situation, to ensure optimal control of the risks that nuclear activities represent for people and the environment. ASN's aim is to exercise regulation and oversight that is recognised by the citizens and seen as a benchmark internationally.

During the course of 2017, ASN worked on an in-depth overhaul of its strategy and on adapting its regulation and oversight methods to present and future issues and challenges. All of the ASN personnel contributed to drafting a new three-year strategic plan and a new oversight policy, which has been implemented on a daily basis since 2018. The oversight policy thus defined places the emphasis on reinforcing a graded approach to regulation and oversight. Two parameters must be taken into consideration when evaluating regulation and oversight priorities: on the one hand, the risks to individuals and the environment inherent in the activities and, on the other, the behaviour of those responsible for the activities and the means they deploy to control these risks.

The quality management system (QMS) promotes the involvement of everyone in the performance of ASN's duties. With the full endorsement of the ASN Commission and the Director General's Office, the QMS has the following objectives:

- to define means to enable us to perform our duties: the QMS sets out clear rules for everyone; it promotes the consistency of our actions nationwide and the exercise of individual responsibilities on a day to day basis;

- to improve the efficiency of our actions: monitoring, audit and review arrangements are able to identify areas for improvement and best practices for the performance of our duties.

### 3.1.3 Consultation for the 4th periodic safety review of the 900 MWe reactors

ASN regularly consults the public about its draft resolutions and regulations. As of 2016, ASN involved the public in the drafting of its position on the "major objectives" defined by EDF. This approach is continuing with regard to the preparation of its generic opinion which will concern all the 900 MWe reactors, which it intends to publish at the end of 2020.

By virtue of its role of information, consultation and debate regarding the risks linked to nuclear activities, the High Committee for Transparency and Information on Nuclear Safety decided to launch a consultation on the generic phase of the 4th periodic safety review of the 900 MWe reactors in the French NPP fleet (32 reactors operated by EDF on 8 sites).

This unprecedented consultation approach was timed to coincide with their 40th year of operation, in order to obtain the opinion of the public regarding the conditions for continued operation of these 900 MWe reactors, both on-line and at local consultation meetings. The consultation process was organised with the aid of a number of players (HCTISN, ASN, IRSN, EDF, ANCCLI, CLI).

The public was able to hold discussions with experts from EDF, ASN and IRSN during the public meetings, to ask questions and obtain information from the on-line platform created for this consultation. The public was asked to help determine the priority themes for the safety improvement debates, on the basis of 15 topics defined by EDF.

This consultation was held from 6th September 2018 to 31st March 2019. The public was informed and its questions and opinions collected at both regional and national levels, via a digital platform. A total of 16 meetings attracting 1,300 participants were held around each of the 8 sites concerned, as well as within a number of higher education facilities.

### 3.1.4 Monitoring of the environment

France has implemented a unique system to make available to the public on a dedicated website (www.mesure-radioactivite.fr) all the results of radioactivity measurements carried out in the environment by the various stakeholders (government, local authorities, non-governmental associations, public establishments and nuclear operators) who participate in environmental radioactivity monitoring. Each year, nearly 300,000 measurements are transmitted to the French national environmental radioactivity monitoring network (RNM), whose database currently contains more than 2.5 million measurement results.

In 2019, the 2015-2017 report on the radiological state of the French environment was published, presenting IRSN's analysis and interpretation of all environmental measurements made as part of the RNM. Based on these data, the radiological exposure of populations was also assessed, including doses to populations in the environment near nuclear power plants of about 1 microsievert per year (1 µSv/year), i.e. one-thousandth of the regulatory limit (1,000 µSv/year).

### 3.1.5 Modifications following the safety reassessments

The main results of the nuclear installation safety reassessments, whether following the periodic review process or the implementation of modifications, are presented in § 6.2.

For nuclear power reactors, the main subjects are:

- reinforcement of seismic resistance;
- control of the risks resulting from explosive gases;
- site robustness to external natural hazards and electrical disruption;
- improvement in the prevention of severe accident situations;
- limitation of the risks of rapid drainage of spent fuel storage pools;
- improved severe accident management;
- equipment qualification for post-accident conditions.

**Fourth periodic safety reviews of the 900 MWe reactors (PSR4)**

Within the context of the fourth periodic safety reviews of the 900 MWe reactors, ASN has set EDF the objective of being part of a continuous safety improvement process, and in particular to take into account international best practices (in particular the work of the WENRA association) as well as the evolution of knowledge and the regulations applicable to new reactors.

ASN made a position statement in April 2016 on the broad lines of the generic studies programme after consulting the public on the draft requests to EDF for additional information concerning the required studies and verifications.

ASN is currently examining the generic studies relating to this review. This is particularly the case with the methods for checking installation conformity and the management of ageing and obsolescence, and for the mechanical strength of the reactor pressure vessels, studies on the safety of the spent fuel pools, the mitigation of the consequences of accidents, improved management of accidents with core melt, and the ability of the installations to withstand internal and external hazards. These files shall be submitted to the advisory groups (GPR or the GPESPN) for their opinion. ASN plans making a position statement on the generic studies associated with this safety review at the end of 2020 after obtaining the GPR's opinion on safety review results in 2020.

Tricastin 1 will be the first reactor to carry out its fourth periodic safety review scheduled for 2019. The last PSR4 of a 900 MWe reactor is scheduled for 2030.

**Third periodic safety reviews of the 1300 MWe reactors (PSR3)**

In 2011, ASN issued a generic position statement on the orientations of the periodic safety review associated with the PSR3 of the 1300 MWe reactors and, in 2015, on their continued operation beyond their PSR3. More than eighty modifications were defined, notably to improve the robustness of the sites to external natural hazards (cooling of the premises and systems) as well as measures to prevent accidents or mitigate their consequences (resupply of tanks, reduction of consequences in the event of a SGTR, reduced risk of emptying of the fuel building pool, alkalinisation of sumps by baskets of tetraborate, etc.). At the end of 2018, 6 reactors completed their 10-yearly outage and integrated the modifications associated with PSR3. The last PSR3 of a 1300 MWe reactor is scheduled for the end of 2024.

**Second periodic safety reviews of the 1450 MWe reactors (PSR2)**

In 2015, ASN made a position statement on the broad lines of the periodic safety review associated with the second periodic safety reviews of the 1450 MWe reactors.

More than fifty modifications were defined, notably to improve the robustness of the sites to external natural hazards (cooling of the premises and systems) as well as measures to prevent accidents or mitigate their consequences (resupply of tanks, reduction of consequences in the event of a SGTR, reduced risk of emptying of the fuel building pool, alkalinisation of sumps by baskets of tetraborate, reactor pressure vessel melt-through detection measures, etc.).

Chooz B 2 will be the first reactor to carry out its second periodic review scheduled for 2019. The last PSR4 of a 1450 MWe reactor is scheduled for 2022.

**Research reactors**

For the research reactors, the safety reassessments primarily concern the following areas:

- seismic resistance;
- fire protection;
- containment of radioactive substances;
- improvement in the management of aspects common to several installations on the same given site.

Moreover, a more harmonised approach to safety, derived from the rules applicable to power reactors, has been developed in recent years for these highly diverse installations. This approach in particular concerns the safety assessment based on "plant conditions" (postulated initiating events) and the safety classification of the associated equipment. This has led to significant progress in terms of safety.

### 3.1.6 Developments following the implementation of post-Fukushima measures

On the basis of the conclusions of the stress tests carried out in Europe and in France, ASN issued a set of resolutions dated 26th June 2012 (concerning EDF and CEA) and 10th July 2012 (concerning ILL).

**PWR**

Further to the accident at the Fukushima Daiichi NPP, ASN adopted a set of resolutions dated 26th June 2012, requiring EDF to put in place:

- a hardened safety core of material and organisational provisions aiming to:
  - ➢ prevent an accident with fuel melt, or limit its progression,
  - ➢ limit large-scale radioactive releases,
  - ➢ enable the licensee to perform its emergency management duties.
- a local emergency centre allowing emergency management of the nuclear site as a whole in the event of an extreme external hazard,
- a Nuclear Rapid Intervention Force (FARN - see § 16.3.1.2), which can, using mobile means external to the site, be deployed on a nuclear site in an accident situation;
- a range of corrective measures or improvements (notably the acquisition of additional communication and radiological protection means, the implementation of additional instrumentation, the extensive consideration of internal and external hazard risks, improvements in the handling of emergency situations).

To take account of both the engineering constraints involved in these major works and the need to introduce the post-Fukushima improvements as soon as possible, their implementation by EDF is planned in three phases (see § 6.2.1.2, § 14.2.1.6 for the in-service reactors):

- Phase 1 (2012-2015): implementation of temporary or mobile provisions to reinforce the response to the main situations of total loss of the heat sink or loss of the electrical power supplies.
- Phase 2 (2015-2021): implementation of definitive design and organisational means that are robust to extreme hazards, such as the fundamental elements of the hardened safety core designed to respond to the main situations of total loss of the heat sink or loss of the electrical power supplies beyond the baseline safety requirements in force.
- Phase 3 (as of 2019 during the periodic safety reviews): this phase supplements phase 2, in particular to improve the level of coverage of the potential accident scenarios considered.

**Research reactors**

As a result of the lessons learned from the accident on the Fukushima Daiichi NPP, the ILL implemented significant reinforcements, including a bunkerised emergency operations control centre situated at a sufficient height to protect it from extreme flooding.

The implementation of robust emergency management facilities at the CEA Cadarache, Marcoule and Saclay centres, which are robust in the event of extreme situations, is not yet complete and must continue in the coming years.

### 3.1.7 Main events during the period

2017 was marked by four significant events rated level 2 on the INES scale, each of which affected several reactors. Of particular note is the event concerning the resistance deficiency found in the Donzère-Mondragon canal embankment protecting the Tricastin NPP. In September 2017, this event led ASN to require that EDF temporarily shut down the four reactors of the NPP as rapidly as possible. In December 2017, further to the investigations and repairs carried out by EDF, ASN considered that the condition of the Donzère-Mondragon canal embankment allowed restart of the reactors of the Tricastin nuclear power plant.

The three other events rated level 2 on the INES scale involved the availability of certain systems important for the safety of the installations, such as electrical systems or the heat sink. Some of the deviations identified are linked to equipment design, others to its assembly or maintenance. These events highlight the difficulties experienced by EDF in ensuring the conformity of its facilities and maintaining this over time. These difficulties also underline the need to continue with the design reviews in progress: these are bearing fruit and revealing anomalies, some of which have been present since the reactors were built. Detection of these deviations also indicates inadequacies in the maintenance programmes of certain equipment items. ASN also considers that EDF must reinforce its actions and decision-making processes in dealing with deviations.

### 3.1.8 The follow-ups to the detection of technical anomalies due to carbon segregation

At the end of 2014, Framatome revealed an anomaly in the chemical composition of the steel used in the Flamanville EPR reactor pressure vessel closure and bottom heads, which could impair its ability to withstand crack propagation.

- **Flamanville EPR:** Together with EDF, Framatome initiated a test programme to demonstrate that the mechanical strength of the steel is sufficient in all operating situations, including accident situations. Framatome submitted its technical conclusions to ASN in December 2016. ASN gave its opinion on this anomaly on 10th October 2017. It indicated that, with certain reservations, it considered that this anomaly did not compromise the commissioning of the reactor pressure vessel. ASN subsequently authorised the commissioning and operation of the reactor pressure vessel on 9th October 2018, subject to the performance of a test programme to monitor thermal ageing, plus specific inspections during operation of the facility. As the current state of knowledge does not enable the feasibility of these inspections to be confirmed for the vessel closure head, ASN set the end of 2024 as the service life limit for the existing vessel closure head.

- **Nuclear power reactor fleet in service**: following detection of this anomaly, EDF informed ASN that some of the steam generator (SG) channel heads equipping 18 reactors in service, manufactured by the Creusot Forge plant and Japan Casting and Forging Corporation (JCFC), were also concerned by the carbon segregation problem. The measurements carried out by EDF, in particular those specified by ASN on 18th October 2016, required the shutdown of 5 reactors and were completed at the beginning of 2017. They enabled EDF to demonstrate that there was no risk of fracture of the channel heads of the 46 SGs concerned. The conservative hypotheses adopted by EDF in its fracture strength calculations led it to modify the operating conditions of the 18 reactors concerned. An experimental programme is currently in progress to characterise more precisely the mechanical properties of the channel heads affected by the carbon segregations. This programme must continue until 2020.

### 3.1.9 Development of the oversight activities in response to the risk of fraud

Following the irregularities discovered in the manufacturing files from Creusot Forge, ASN initiated a review of its regulation and oversight activities, so that cases of fraud could be prevented, detected and dealt with.

In 2018, ASN defined an action plan to optimise the prevention, detection and handling of suspected cases of fraud. Within this framework, ASN has more specifically enhanced its own oversight process with the addition of a search for fraud during the course of inspections. It has also adopted a system for reporting of fraud or falsification on its website, as well as an in-house process for responding to these reports. It has also asked industry to tighten up its actions in this respect.

In this regard, EDF has put in place specific provisions aiming to prevent and detect these risks (see § 13.2).

ASN follows up all potential cases of fraud reported to it by the licensees or whistle-blowers. In the light of the actual cases encountered, thought is being given to identifying means of regulation and oversight such as to reduce the risk of fraud.

The EDF and Framatome review of the manufacturing files for all the forged equipment from the Le Creusot plant was completed in 2018. The ASN analysis of this review on each reactor brought to light no new deviation prejudicial to their safety, which would have required corrective measures prior to their restart authorisation. Some additional inspections or tests however still need to be carried out.

### 3.1.10 The EPR

ASN has set requirements regarding the design, construction and start-up tests of the Flamanville 3 reactor and the operation of reactors 1 and 2 situated close to the construction site. The main oversight steps taken by ASN are about:

- oversight of the construction, assembly and test activities on the Flamanville 3 EPR reactor site;
- oversight of the Flamanville EPR engineering activities;
- labour inspection on the Flamanville 3 EPR reactor construction site.

ASN also ensures oversight of the manufacture of the nuclear pressure equipment (NPE) that will be integrated in the primary and secondary systems of the nuclear steam supply system.

On 19th March 2015, ASN received the commissioning authorisation application for Flamanville 3. Assisted by IRSN, its technical support organisation, ASN carried out a review of this application. Between 2014 and 2018, seven meetings of the GPR advisory committee were devoted to Flamanville 3. They specifically covered the level 1 probabilistic safety assessments, the safety classification principles, the correspondence between the reactor control means and the organisation of the control crew, severe accidents and their radiological consequences, the design of safety systems and protection against the effects of internal and external hazards, examination of the safety analysis report and the safety of fuel assembly storage and handling operations.

On 26 July 2018, ASN authorised EDF to use steam containing tritium from Flamanville NPP reactors 1 and 2, in addition to or in place of other on-site sources of steam production (auxiliary and temporary boilers), for the preparation and performance of the hot tests. The introduction of tritium into the facility requires an authorisation referred to as the “partial commissioning authorisation” pursuant to Article 20 of the Decree of 2nd November 2007 concerning BNIs and the oversight of nuclear safety of the transport of radioactive substances. This authorisation is limited to the period corresponding to the time needed to perform these tests. It states that ASN consent is required prior to initial pressurisation of the main secondary systems, on which certain welds contain flaws.

As a matter of fact, at the beginning of 2017, EDF informed ASN of deviations that occurred in the welding of the Flamanville EPR reactor main steam pipes, which are break preclusion parts. In July 2018, EDF undertook to restore the required mechanical properties of the welds concerned by the identified deviations, except for the eight welds located in the annulus between the two containment walls of the reactor building, where access is harder. In December 2018, EDF sent ASN a file aiming to demonstrate that the quality of these eight welds is sufficient, enabling their break to be ruled out with a high level of confidence. This demonstration is more particularly based on an in-depth characterisation of the welds material. The conclusions of ASN’s review of the EDF file, with the support of IRSN, were presented to the Advisory Committee on 9th and 10th April 2019. The Advisory Committee considered that the numerous deviations affecting these eight welds were major obstacles to the application of a break preclusion approach and that EDF should repair these eight welds and bring them into conformity or abandon the break preclusion approach concerning them by making modifications to the reactor enabling such breaks to be covered by its safety case.

In June 2019, EDF asked ASN for its opinion on the possibility of repairing these welds in about 2024, after commissioning of the reactor. In its letter of 19 June, ASN notes that the repair of the penetration welds prior to commissioning of the reactor is technically feasible. Postponement of the repair operations until after reactor commissioning would pose a number of problems, notably with regard to demonstrating the safety of the reactor during the interim period. ASN therefore considers that repair of the welds concerned before commissioning of the reactor is the baseline solution.

On 7th April 2015, ASN released information concerning an anomaly in the composition of the steel in the centre of the Flamanville 3 EPR vessel closure head and bottom head. This anomaly is linked to the presence of a high carbon concentration which results in mechanical properties that are not as good as initially specified.

Together with EDF, Framatome initiated a test programme to demonstrate that the mechanical strength of the steel is sufficient in all operating situations, including accident situations. Framatome transmitted its technical conclusions to ASN in December 2016. Based on an assessment of the files transmitted by Framatome and the additional technical data supplied by EDF, carried out by its nuclear pressure equipment department and its technical support organisation, IRSN, on the basis of the opinions of its Advisory Committee for nuclear pressure equipment and of the High Council for the Prevention of Technological Risks, as well as the observations collected during the course of the public consultation, ASN issued its opinion on this anomaly on 10th October 2017.

As the commissioning and operation of the Flamanville EPR reactor pressure vessel also requires ASN authorisation, notably with regard to compliance with other requirements applicable to the reactor pressure vessel as a whole, Framatome submitted an application in this respect on 13th July 2018, which was then supplemented following requests from ASN. ASN reviewed this application, drawing on the conclusions of its 2017 opinion and it also verified compliance with the technical and regulatory requirements other than those concerning the chemical composition of the steel of the reactor vessel closure and bottom heads. On the basis of the conclusions of this review, ASN authorised the commissioning and operation of the Flamanville EPR reactor pressure vessel on 9th October 2018, subject to the performance of a test programme to monitor thermal ageing, plus specific inspections during operation of the facility. As the current state of knowledge does not enable the feasibility of these inspections to be confirmed for the vessel closure head, ASN set a service life limit of the end of 2024 for the existing vessel closure head.

### 3.1.11 International peer reviews

France regularly hosts and participates in international reviews, particularly under the auspices of the IAEA or the European Commission.

**Reviews coordinated by the IAEA**

IRRS: ASN has always supported the development of the peer review missions, either by participating in IRRS (Integrated Regulatory Review Service) missions in foreign countries or by hosting them in France (see § 10.4.1 and § 20.3).

Thus, after an initial plenary mission and a follow-up mission which took place in 2006 and 2009 respectively, ASN hosted another "full scope" IRRS mission in 2014, further to which the auditors issued 46 recommendations and suggestions.

ASN developed an action plan to take appropriate measures in response to these recommendations and suggestions. The follow-up mission was held from 1st to 9th October 2017. The auditors concluded that France has significantly strengthened the framework of its oversight of nuclear safety and radiation protection, but also indicated the need for ASN to remain vigilant with regard to the question of human resources in view of the safety issues at the French nuclear facilities. A total of 40 recommendations were closed or are considered to be closed "subject to implementation of the ongoing measures". The concluding report of this mission - like the previous reports - was put on line on the ASN website in March 2017.

OSART: For many years now, France has also asked the IAEA to conduct OSART (Operational Safety Review Team) missions to assess operating safety. On average, one OSART mission is organised in France each year. In 2016, all French NPPs underwent at least one OSART mission.

Half a dozen missions are planned over the 2019-2021 period, including two follow-up (FU) missions. One mission took place on the EPR in June 2019.

**Topical peer review (TPR)**

Council Directive 2014/87/EURATOM of 8th July 2014 amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations, institutes a six-yearly peer review of a technical aspect relating to the safety of nuclear facilities.

The first review focused on the management of ageing. Within the framework of this peer review, a report was drawn up by ASN, the coordinator, with contributions from IRSN, EDF. CEA and ILL.

The peer review identified areas for improvement in the French facilities. An action plan is developed to respond to the conclusions of this review. This subject is addressed in § 14.2.1.4.

**WANO review**

The safety performance of the NPPs in the French fleet is assessed by the World Association of Nuclear Operators (WANO) by means of peer reviews. Since 2013, each unit undergoes a review every four years, in conjunction with an EDF nuclear inspectorate audit.

## *3.2 Safety outlook for the next three years*

ASN work and oversight measures will be focused on the following main elements:

### 3.2.1 Oversight of the nuclear reactors in service

ASN regularly identifies and reassesses its oversight priorities, based on scientific and technical knowledge, current topics requiring special attention and information gathered (inspections, events, file review, facility modifications). As such, the first 1450 MWe and 900 MWe nuclear power reactors implementing the safety improvements associated with their second and fourth periodic safety reviews respectively will be subject to particular vigilance by the ASN.

In addition, the ASN's strategic plan aims to strengthen the effectiveness of its field action, in particular by strengthening the inspectors' capacity to detect deviations and developing new inspection practices. Actions in this direction are being taken at the instigation of the ASN Chief Inspector.

Periodic safety reviews of reactors in service will continue in the coming years and ASN will take a specific position on the continued operation of each reactor, in particular for 1300 MWe (PSR3) and 1450 MWe (PSR2) reactors.

For 900 MWe reactors, ASN plans to issue a position statement on the generic studies related to this review at the end of 2020.

### 3.2.2 The follow-ups to the implementation of post-Fukushima measures

Over the coming years, ASN will maintain particular vigilance in monitoring the implementation of all the requirements it has laid down, especially the deployment of definitive design and organisation means that are robust to extreme hazards and designed to cope with the main situations of total loss of the heat sink or loss of the electrical power supplies beyond the baseline safety requirements in effect.

On this account, ASN shall monitor:

- the commissioning of all the large-capacity ultimate backup diesel-generator sets, including the construction of the dedicated buildings, before 31st December 2020,
- the commissioning of a dedicated ultimate water source, before 31st December 2021,

- the commissioning of an ultimate water makeup system for each reactor and each pool, before 31st December 2021,
- the construction of the local emergency management centres (CCL), before 31st December 2024.

### 3.2.3 Oversight of the Flamanville EPR reactor

ASN will continue to monitor the installation of equipment, the preparation for and performance of the start-up tests and the preparation of the various operating support documents. The nuclear safety inspectors will continue with inspections at a sustained rate.

ASN will continue to examine the commissioning authorisation application and will issue a position statement on the partial commissioning application, corresponding to the arrival of nuclear fuel on the site.

Finally, ASN will continue to examine the processing of deviations affecting the main secondary system welds, along with the conformity assessments of the nuclear pressure equipment most important for safety.

### 3.2.4 Monitoring of the RJH and ITER reactors

The two main research facilities currently under construction in France are the Jules Horwitz reactor (RJH) and ITER. ASN regulated the main steps in the design and construction of these facilities through resolutions issued in 2011 and 2013. Regular inspections on site and at the suppliers have demonstrated that the safety risks on these worksites are generally well controlled.

The fact that these worksites have fallen significantly behind schedule has had no impact on the safety risks as yet. In view of the slippage in the project schedule and in certain R&D actions, ASN has issued requirements regulating the new strategy for gradual commissioning of the ITER facility through until 2035. For the RJH, ASN is examining the CEA's request made to the Minister responsible for nuclear safety to push back the deadline for commissioning the facility further to delays in the construction work.

## *3.3 The challenges identified at the 7th review meeting*

A number of challenges emerged from the 7th CSN review meeting.

Some of these challenges are specific to France. The cross-references to corresponding points in this report are indicated between parentheses:

- Addressing the human resourcing needs for successful execution of demanding concurrent projects (see § 8.1.2);
- Collaborating with international counterparts to evaluate and (as needed) supplement codes and standards for large equipment manufacturing to address carbon segregation issue and other relevant subjects (see § 3.1.8);
- Completing evaluation and regulatory response to manufacturing practice irregularities (see § 19.3.2.2);
- Ensuring adequate maintenance of power plants, including through efforts being developed such as in-field technical training and supervision (see § 11 and 19.3.2.2);
- Coming to a technical/regulatory position by 2019 regarding the reasonable application, as part of the PSR process, of EPR (Generation III) safety objectives and lessons learned from previous PSRs and regulatory ten-year inspections to existing reactors (see § 6.1.1.2).

Furthermore, one issue that emerged from the 6th review meeting is still on the agenda, namely finalizing implementation of Fukushima lessons learned (see § 14.2.1.6).

In addition, nine subjects have been identified as challenges for all the Convention Contracting Parties. For each of these subjects, the cross-references to corresponding points in this report are indicated between parentheses:

- Safety culture (see § 10);
- International peer reviews (see § 10.4.1, § 14.2.1.4 and § 20.3);
- Legal framework and independence of regulator body (see § 7 and § 8);
- Financial and human resources (see § 8.1.2 and § 11);
- Knowledge management (see § 11.2);
- Supply chain (see § 13, 18.2 and 19.3);
- Managing the safety of ageing nuclear facilities and plant life extension (see § 14.2.1.4);
- Emergency preparedness (see § 16);
- Stakeholder consultation and communication (see § 7.1.3.2, § 7.2.3 , § 8, § 9.2, § 17.1.4 and § 17.1.5).

Lastly, the two thematic subjects chosen by the contracting parties at the organisation meeting of 18th October 2018 (safety culture and ageing) are essentially covered by the two underlined points in this list.

## *3.4 Implementation of the principles of the Vienna declaration*

Adopted in February 2015, the Vienna declaration contains three main principles which reflect one of the three fundamental objectives of the Convention, namely to prevent accidents with radiological consequences and to mitigate the consequences should an accident occur.

1. **New nuclear power plants are to be designed, sited, and constructed, consistent with the objective of preventing accidents in the commissioning and operation and, should an accident occur, mitigating possible releases of radionuclides causing long-term off site contamination and avoiding early radioactive releases or radioactive releases large enough to require long-term protective measures and actions.**

   With regard to the new NPPs (EPR reactor under construction), see more specifically § 7 concerning the legislative and regulatory framework, § 18.3 concerning the design criteria and § 19.4 concerning the management of incidents and accidents.
   The Flamanville 3 authorisation decree (Decree 2007-534) specifies that “accidents with core melt which could lead to early large-scale releases are the subject of designed-in preventive measures, supplemented if necessary by operational provisions, the performance and reliability of which should consider this type of situation to be precluded” and “that in the event of an accident situation with low-pressure core melt, it would only be necessary to resort to population protection measures that are extremely limited in terms of scope and duration”. Furthermore, for accidents without fuel meltdown (in the reactor core or pool), the objective is that the radiological consequences should be as low as reasonably achievable and, whatever the case, they must not lead to the need to implement population protection measures (no sheltering, no taking of stable iodine tablets, no evacuation);

In its commissioning authorisation application file, EDF provided a demonstration case which was examined and reviewed by the GPR (Advisory Committee for Nuclear Reactors) in October 2015. ASN considers that the Flamanville 3 reactor design on the whole meets the objectives defined by Decree 2007-534 for the management of accidents with core melt. This demonstration is based on equipment qualifications which EDF must provide before the reactor is commissioned.

2. **Comprehensive and systematic safety assessments are to be carried out periodically and regularly for existing installations throughout their lifetime in order to identify safety improvements that are oriented to meet the above objective. Reasonably practicable or achievable safety improvements are to be implemented in a timely manner.**

   With regard to the existing nuclear power reactors, see § 6.2 and § 14.2.1.3 concerning periodic safety reviews, § 19.7 concerning modifications made further to operating experience feedback, § 6.2.1.2 concerning steps taken further to the stress tests, § 7.1 concerning the technical and regulatory framework and § 19.4 concerning the management of incidents and accidents.

   France carries out periodic safety reviews of the facilities every ten years, enabling operating experience feedback and developments in knowledge to be integrated and modifications to be made to improve reactor safety (see § 6.2). These periodic safety reviews comprise not only a verification of conformity of the facility, which includes an assessment of the control of equipment ageing, but also a reassessment of the safety of the facility, taking the safety objectives of the most recent facilities as the reference.

   The "BNI" order (see § 7.1.3.1.2) asks the licensees to implement a system for processing deviations detected during operation. These deviations may in particular lead to questioning of the quality of the design and construction of the BNI. Relevant corrective or preventive measures are then taken, under ASN supervision, without waiting for the next periodic safety reviews.

3. **National requirements and regulations for addressing this objective throughout the lifetime of nuclear power plants are to take into account the relevant IAEA Safety Standards and, as appropriate, other good practices as identified inter alia in the Review Meetings of the CNS**

   French legislation and the regulations applicable to BNIs are based on the fundamental principle of the prevention of accidents with radiological consequences and the mitigation of said consequences should an accident occur.

   The Environment Code (article L. 593-7) thus states that a creation authorisation may only be issued for a BNI if, in the light of scientific and technical knowledge, the licensee can demonstrate that the technical or organisational measures it is required to take at the design, construction and operating stages, as well as the general principles proposed for decommissioning, are such as to prevent or adequately mitigate the risks or drawbacks of the facility for the protected interests (public health and safety and the protection of nature and the environment).

   The Environment Code (Article L.593-18) requires that the licensee of a BNI periodically conduct a safety review of its facility, taking international best practices into account. The purpose of this periodic review is to assess the situation of the facility in the light of the applicable rules and to update the assessment of the risks or adverse effects the facility presents with regard to the above-mentioned protected interests, more specifically taking account of the condition of the facility, the experience acquired during its operation, developments in knowledge and in the rules applicable to similar facilities. These safety reviews are held every ten years.

The periodic safety review process is framed by the examination of operating experience feedback, developments in knowledge and in the safety standards, particularly those of the IAEA. With regard to the nuclear power reactors, the OSART missions conducted on the sites or at the licensee's head offices are also based on the IAEA standards and current best practices.

Lastly, the Ordinance 2016-128 of 10th February 2016 introducing various provisions concerning nuclear activities includes legislative provisions for transposition of the Directive of 8th July and provisions that reinforce oversight of nuclear safety and radiation protection.

In addition to this, the BNI Order and the ASN regulatory resolutions (see appendix 2) incorporate the WENRA reference levels as a whole into the French regulations.

## C –General provisions

### 4. Article 4: Implementation measures

*Each Contracting Party shall take, within the framework of its national law, the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention.*

This report presents the legislative, regulatory and administrative measures and other measures taken by France to implement its obligations under the Convention on Nuclear Safety.

### 5. Article 5: Presentation of reports

*Each Contracting Party shall submit for review, prior to each meeting referred to in Article 20, a report on the measures it has taken to implement each of the obligations of this Convention.*

This report is the eighth French report submitted for review in compliance with article 5 of the Convention.

# 6. Article 6: Existing nuclear installations

*Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shut-down may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact.*

## *6.1 Nuclear installations in France*

### 6.1.1 The nuclear power reactors

#### 6.1.1.1 The existing nuclear reactor fleet

The fleet of nuclear power reactors currently covered by the scope of the Convention comprises 58 pressurised water reactors (PWR), built in successive standardised series, which were coupled to the grid between 1977 and 1999 and are all in service (see table 11 of appendix 1).

In 2018, the PWR nuclear power reactors produced 393.2 TWh, i.e. about 71.6% of France's electricity production (379.1 TWh or 71.6% in 2017, 383.9 TWh or 72.3% in 2016 respectively). The reactors are situated in 19 nuclear power plants (NPPs), each comprising from two to six reactors of the same plant series. The 58 reactors were built by the same supplier, Framatome. They comprise (see location map in § 1.1 of appendix 1):

Among the 34 reactors of 900 MWe:

- the CP0 series, comprising the 2 reactors at Fessenheim and the 4 reactors at Le Bugey;
- the CPY series, comprising the 28 900 MWe reactors (Dampierre, Gravelines, Blayais, Tricastin, Chinon, Cruas and Saint-Laurent-des-Eaux NPPs).

Among the 20 reactors of 1300 MWe:

- the P4 series, consisting of 4 reactors at Paluel, 2 reactors at Flamanville and 2 reactors at Saint-Alban;
- the P'4 series, consisting of 2 reactors at Belleville-sur-Loire, 4 reactors at Cattenom, 2 reactors at Golfech, 2 reactors at Nogent-sur-Seine and 2 reactors at Penly.

The N4 series, comprising 4 reactors of 1450 MWe, 2 at Chooz and 2 at Civaux.

In December 2018, the average age of the reactors, based on the dates of the first reactor criticality phases, stood as follows:

- 37 years for the thirty-four 900 MWe reactors;
- 31 years for the twenty 1300 MWe reactors;
- 21 years for the four 1450 MWe reactors.

#### 6.1.1.2 The Flamanville 3 EPR reactor

At the end of 2018, the main electromechanical installation and civil engineering activities of the Flamanville 3 reactor were completed and, following the preliminary tests of the equipment and systems, the overall pre-operational tests - initiated as of March 2017 with the "primary system flushing" (CEC) - continued with the "functional tests with reactor vessel open" (EFCO), the "cold tests" (EAF), the hydrostatic test of the primary system and the reactor containment test. The hot tests (EAC) have started.

The electromechanical installation and civil engineering finishing activities are also well advanced, to the extent that operation of the pumping station building has been transferred to the future reactor licensee ahead of schedule.

As the finishing work in the other buildings is completed, the facility tests are continuing, as is their gradual transfer to the future licensee.

### 6.1.2 Research reactors

9 research facilities are considered in this report: 3 are in operation in mid-2019, 4 have been definitively shut down during the period from mid-2016 to mid-2019, and 2 are currently under construction.

Reactors in operation in mid-2019:

3 research reactors are still in operation in France in mid-2019, namely the HFR, Cabri and Orphée reactors.

The High-Flux Reactor (HFR) is located close to CEA's Grenoble site and is operated by the Laue-Langevin Institute (ILL), a research institute comprising several European partners.

The Cabri reactor, used for experimental programmes aiming to acquire a better understanding of the behaviour of pressurised water reactor fuel in the event of a reactivity accident, began a new research programme in 2018, after major modification work was carried out on the facility.

Orphée is a reactor that uses neutron beams for research. It is operated by the CEA at its Saclay centre. Its final shutdown is planned for the end of 2019.

Reactors which operated from 2016 to 2019 but have now been finally shut down:

The Masurca reactor is a critical mock-up reactor. This reactor was definitively shut down in December 2018.

The Éole and Minerve reactors, which are also critical mock-ups operated by CEA at the Cadarache centre, were definitively shut down in 2017.

The critical mock-up Isis, situated at the Saclay centre in BNI 40 along with the Osiris reactor (which was shut down at the end of 2015), underwent final shutdown in March 2019.

Reactors under construction:

CEA, in partnership with EDF, Framatome and other foreign entities, is building the Jules Horowitz reactor (RJH) in Cadarache, with a view to it taking over from the European irradiation reactors currently in service. The civil engineering work is being finalised and reactor commissioning is currently scheduled for 2023.

The list of French research reactors in service, along with a map showing their locations, is given in § 1.1 and 1.3 of appendix 1.

Added to these reactors is the ITER (International Thermonuclear Experimental Reactor) project, an experimental facility the aim of which is to demonstrate control of thermonuclear fusion energy. The construction of this facility, situated near Cadarache, is continuing.

## *6.2 Safety reassessment of the nuclear facilities*

Pursuant to Article L. 593-18 of the Environment Code, the licensee is required to conduct a periodic safety review of its facilities every ten years. The periodic safety reviews provide the ideal opportunity to carry out large-scale inspections and to make modifications to the facilities to enhance their safety, taking into account the evolution of requirements, practices and knowledge, and experience feedback. They comprise not only a verification of conformity of the facility, which includes an assessment of the control of equipment ageing, but also a reassessment of the safety of the facility. The mechanism for safety reassessment is presented in chapter 14.

### 6.2.1 Measures taken for nuclear power reactors

#### 6.2.1.1 The periodic safety reviews

With regard to the industrial programme associated with the safety reviews (PSR3 1300 series, PSR2 N4 series, PSR4 900 series and PSR4 1300 series), given the extent of the modifications, EDF has decided to deploy them in two distinct phases (during the 10-yearly outage and during a maintenance outage).

Table 1 shows the progress of the periodic safety reviews (PSR) for the various standardised nuclear reactor plant series.

| | PSR1 10 years | PSR2 20 years | PSR3 30 years | PSR4 40 years |
|---|---|---|---|---|
| 900 MWe 3 loops (34 units) | Done | Done | 2009 to 2020 | 2019 to 2030 |
| 1300 MWe 4 loops (20 units) | Done | Done | 2015 to 2024 | 2025 to 2034 |
| 1450 MWe 4 loops (4 units) | Done | 2019 to 2022 | 2029 to 2032 | 2039 to 2042 |

Table 1 : Periodic safety reviews of the nuclear power reactor plant series (green: PSR completed; blue in progress; yellow: under preparation; orange: not started).

Over the 2016-2018 period, the main projects concerned the 900 MWe reactors (performance of PSR3 and preparation of PSR4), the 1300 MWe reactors (performance of PSR3 and preparation of PSR4) and the four 1450 MWe reactors (preparation of PSR2).

##### 6.2.1.1.1 Third periodic safety reviews (PSR3) of the 900 MWe reactors

In 2009, ASN issued a generic opinion on the continued operation of the 900 MWe reactors beyond thirty years. This opinion is supplemented by individual reactor-by-reactor resolutions which lay down the conditions of continued operation until the next periodic safety review.

In 2018, reactor 6 of the Gravelines NPP and reactor 2 of the Cruas NPP integrated the improvements resulting from the 3rd PSR, taking the number of 900 MWe reactors having undergone their 3rd PSR to 32 out of a total of 34.

##### 6.2.1.1.2 Fourth periodic safety reviews (PSR4) of the 900 MWe reactors

For this periodic safety review, ASN has set EDF the objective of adopting a continuous safety improvement approach, and more specifically to take into account the best international practices (especially the work of WENRA) and the development of knowledge and the rules applicable to new reactors.

EDF proposes the following objectives for this periodic safety review:

- Integration of the post-Fukushima "hardened safety core";
- Review of the conditions of reactor operation and the associated radiological consequences to tend towards situations where it is not necessary to deploy population protection measures, and the management of severe accidents, with the aim of reducing the risks of early or significant radiological releases;
- Review of the risks associated with the storage of fuel in the spent fuel pool (the aim is to reduce the risk of exposure of fuel assemblies stored under water to the minimum residual risk);

- The level-1 probabilistic safety studies concerning core melt (by targeting a residual risk level that is about the same as the targeted level for the 3rd-generation reactors), the scope of which is extended to include risks associated with fire, on-site flooding, on-site explosion and earthquake;
- The level-2 probabilistic safety studies concerning discharges;
- The reassessment of the risks of internal hazards and the risks of external natural hazards associated with the climate, earthquakes, the environment, or human activities, verification of the adequacy and effectiveness of the protective measures and, if necessary, defining new measures;
- The assessment of the behaviour of the installation in an extreme contingency situation, with the aim of avoiding significant discharges and lasting radiological consequences in space and in time;
- The assessment of the behaviour of the 900 MWe reactors to operator response times and the reference operating conditions (PCC – Controls Command Post) of the EPR;
- Improvement in the operating conditions with regard to organisational and human factors (OHF);
- Control of ageing and obsolescence.

After analysing the elements provided by EDF, ASN made a position statement on 20th April 2016 concerning the general guidance file and asked EDF for several supplements to the planned inspections and schedules, such as the consideration of certain requirements adopted for the EPR and certain requests made in 2015 in the context of the 3rd periodic safety review of the 1300 MWe reactors. The Tricastin reactor 1 shall be the first to undergo its fourth periodic safety review in 2019. The last periodic safety review (PSR4) of a 900 MWe reactor is planned for 2030.

##### 6.2.1.1.3 Third periodic safety reviews (PSR3) of the 1300 MWe reactors

ASN made a position statement 2011 on the broad lines of the PSR3 safety review of the 1300 MWe reactors, and in 2015 it made a more general position statement on their continued operation beyond PSR3.

In 2017, the ten-year inspections were carried out and the modifications associated with the PSR3 were integrated for reactor 3 of Paluel and reactor 1 of Saint-Alban.

In 2018, the ten-year inspections were carried out and the modifications associated with the PSR3 were integrated for reactor 2 of Paluel, reactor 1 of Flamanville, reactor 2 of Saint-Alban and reactor 2 of Cattenom.

The last PSR3 of a 1300 MWe reactor is planned for the end of 2024.

##### 6.2.1.1.4 Second periodic safety reviews (PSR2) of the 1450 MWe reactors.

In 2015, ASN made a position statement on the broad lines of the periodic safety review associated with the second periodic safety reviews of the 1450 MWe reactors.

Reactor 2 of Chooz B was the first to undergo its PSR2 in 2019. The last PSR2 of a 1450 MWe reactor is planned for the end of 2022.

ASN will state its position on the continued operation of the reactors and transmit it to the Minister responsible for nuclear safety in the same way as for the other reactors after examining the conclusions report submitted by EDF.

#### 6.2.1.2 Measures taken further to the stress tests

Further to the accident at the Fukushima Daiichi NPP, ASN adopted a set of resolutions dated 26th June 2012, requiring EDF to put in place:

- a hardened safety core of material and organisational provisions aiming to:
  - prevent an accident with fuel melt, or limit its progression,
  - limit large-scale radioactive releases,
  - enable the licensee to perform its emergency management duties.
- a local emergency centre allowing emergency management of the nuclear site as a whole in the event of an extreme external hazard,
- a Nuclear Rapid Intervention Force (FARN) - see § 16.3.1.2), which can, using mobile means external to the site, be deployed on a nuclear site in an accident situation;
- a range of corrective measures or improvements (notably the acquisition of additional communication and radiological protection means, the implementation of additional instrumentation, the extensive consideration of internal and external hazard risks, improvements in the handling of emergency situations).

ASN has supplemented its demands with a set of resolutions dated 21 January 2014 aiming to clarify certain design provisions for the hardened safety core.

To take account of both the engineering constraints involved in these major works and the need to introduce the post-Fukushima improvements as soon as possible, their implementation by EDF is planned in three phases:

**Phase 1 (2012-2015):** implementation of temporary or mobile provisions to reinforce the response to the main situations of total loss of the heat sink or loss of the electrical power supplies: At the end of 2015, EDF had deployed the provisions of phase 1, which is now completed. More particularly, connection means were installed so that, in the event of an emergency, the mobile systems can be connected to provide water. Furthermore, the FARN, which is one of the main emergency management resources, was set up. Since 31st December 2015, the FARN teams have the capacity for simultaneous intervention on all the reactors of a site in less than 24 hours (up to six reactors in the case of the Gravelines site).

**Phase 2 (2015-2021):** implementation of definitive design and organisational means that are robust to extreme hazards, such as the fundamental elements of the hardened safety core designed to respond to the main situations of total loss of the heat sink or loss of the electrical power supplies beyond the baseline safety requirements in force: The most important measures are:

- the installation of a large-capacity ultimate backup diesel-generator set, requiring the construction of a dedicated building to house it;
- the setting up of an ultimate water source;
- the installation of an ultimate water make-up system for each reactor and each spent fuel pool;
- the reinforcement of the earthquake resistance of the containment venting filter;
- the construction on each site of a local emergency centre capable of withstanding extreme external hazards (functionally independent in an emergency situation).

On the various sites, EDF has started to implement a large part of the final measures mentioned above, particularly the construction of the ultimate back-up diesel generator sets. ASN inspects the performance of the works.

**Phase 3 (as of 2019 during the periodic safety reviews)**: this phase supplements phase 2, in particular to improve the level of coverage of the potential accident scenarios considered. EDF states that these means have also been defined with a view to continued operation of the reactors beyond forty years. The most important measures are:

- addition of a new supplemental pump to the primary system;
- completion of the fixed connection systems for the SG backup feedwater supply, the PTR cooling water tank and the spent fuel pit;
- installation of an ultimate instrumentation & control system and the definitive instrumentation of the "hardened safety core",
- installation of a reactor containment ultimate cooling system that does not require opening of the containment venting-filtration system in the event of a severe accident;
- the installation of a corium flooding solution which would be installed in the reactor pit, to prevent basemat melt-through in the event of core melt.

In anticipation of setting up the "hardened safety core" and in particular the provisions for phases 2 and 3, ASN has examined the design hypotheses for the material provisions and confirms that the solutions proposed by EDF can meet the set safety objectives.

### 6.2.2 Measures taken for research reactors:

#### 6.2.2.1 The CEA reactors

**The periodic safety reviews**

For reactors which are not yet in the decommissioning phase:

- The periodic safety review file for the Cabri reactor was received at the end of 2017. This review follows on from major modification work on the facility to equip the reactor with a pressurised water loop for new experimental programmes and to upgrade it to the required safety standards.
- The periodic safety review file for the Orphée reactor was submitted in March 2019. At the end of 2017, the CEA informed the Government that it wanted to definitively shut down the reactor before the end of 2019. The decommissioning file will also be expected by that date.
- The periodic safety review file for the Osiris and Isis reactors was submitted in March 2019. The two reactors are in final shutdown status (Osiris has been shut down since the end of 2015) and the actions decided upon further to the previous safety review have been duly carried out.
- The Éole and Minerve reactors were definitively shut down at the end of 2018. Their decommissioning file was submitted in July 2018. The actions decided upon further to the previous safety review have been completed and the next safety review will be in 2020.
- The periodic safety review file for the Masurca reactor was submitted in 2015. The CEA declared its final shutdown on 31st December 2018.

**The stress tests**

The majority of the CEA facilities have undergone stress tests further to the accident at the Fukushima Daiichi NPP, in accordance with the measures imposed by ASN for these assessments. The first batch of facilities considered to be priorities concerned 5 reactors: Osiris and Isis, the RJH, Masurca and Phénix. The second batch concerned the other 3 reactors: Cabri, Orphée and ITER.

On 26th June 2012 for the first batch of facilities assessed and on 8th January 2015 for the second batch, ASN issued resolutions setting complementary requirements for the batch 1 and 2 facilities, and for the measures common to the Cadarache, Marcoule and Saclay centres. The main requirements concerned:

- the removal, by 31st December 2014 at the latest, of the fissile material from the Masurca facility to a facility with a satisfactory seismic design-basis;
- the implementation of emergency shutdown of the Orphée reactor on seismic detection.

The ASN requirements resulted in major works, particularly for the construction and reinforcement of the emergency response centres.

Although the RJH is of very recent design integrating experience feedback from the other experimental reactors, the stress tests led the CEA to identify improvements that could be implemented. In September 2012, CEA proposed a "hardened safety core" of robust material and organisational measures for the RJH, intended to protect it from the situations envisaged in the stress tests. ASN prescribed the implementation of these provisions in a resolution of 8th January 2015 (particularly concerning the improvements in protection against the risks of flooding and loss of the heat sink, or in behaviour in the event of an earthquake). These improvements are put in place as the construction work progresses.

#### 6.2.2.2 The high flux reactor (HFR) in the Laue-Langevin Institute (ILL)

**The periodic safety reviews**

ASN received the periodic safety review file for the HFR at the end of 2017. The ASN noted the substantial work carried out by the operator, in particular on the conformity examination and the updating of the safety reference system.

**The stress tests**

The hardened safety core for the ILL and the associated requirements were defined in ASN resolutions dated 10th July 2012 and 21st November 2013. The ILL has put in place substantial reinforcements, based on the lessons learned from the Fukushima Daiichi NPP accident.

The ILL has carried out a great deal of work and has set up a "hardened safety core" of backup equipment. More specifically:

- the seismic depressurisation system which prevents the release of non-filtered emissions,
- the groundwater system, enabling the pools and the reactor block to be supplied with water pumped from the groundwater;
- a bunkerised emergency operations control centre situated high enough to be out of reach of an extreme flooding event.

The above works at the HFR were completed in 2018.

#### 6.2.2.3 ITER

The stress tests on ITER, required in response to the lessons learned from the Fukushima Daiichi NPP accident, were transmitted in September 2012 by ITER Organisation. The conclusions of these tests were examined by the ASN Advisory Committee of Experts in July 2013 and resulted in ASN requesting complementary studies in 2014. The measures stemming from the lessons learned from the Fukushima

Daiichi NPP accident are being implemented as the construction and changes in design of the facility progress.

# D - Legislation and regulations

## 7. Article 7: Community, legislative and regulatory framework

*Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.*

*The legislative and regulatory framework shall provide for:*

*i) the establishment of applicable national safety requirements and regulations;*

*ii) a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a licence;*

*iii) a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licences;*

*iv) the enforcement of applicable regulations and of the terms of licences, including suspension, modification or revocation.*

### *7.1 Community, legislative and regulatory framework*

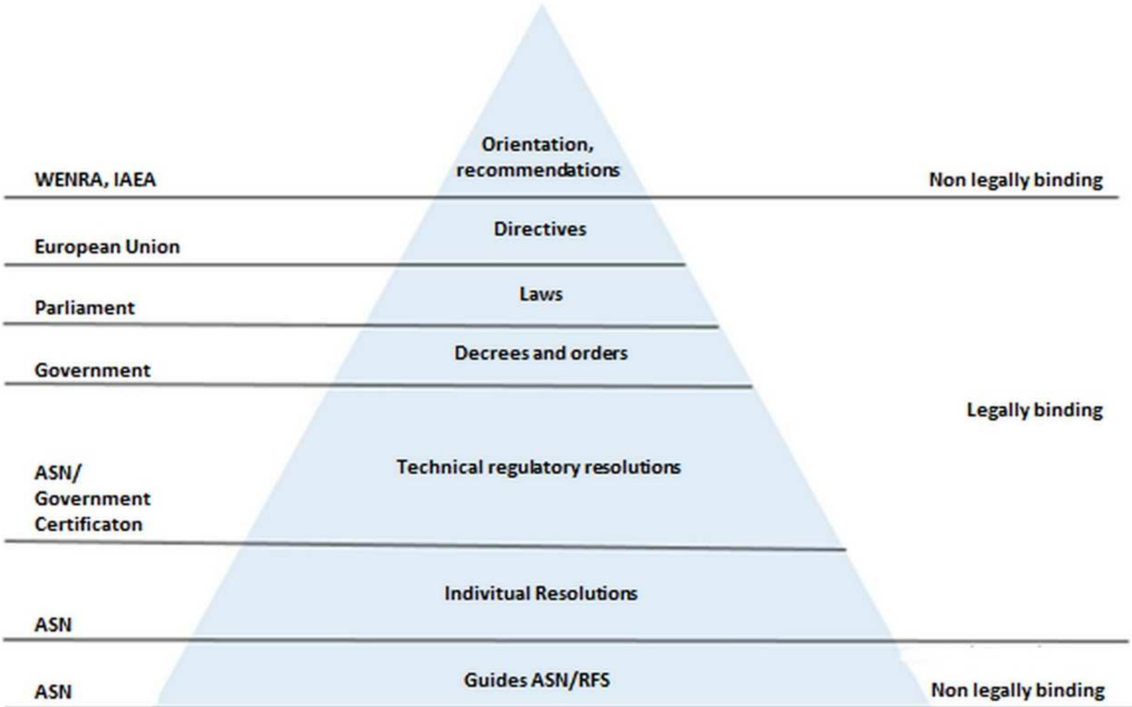


Figure 1: Different levels of regulation

The legal system applicable to BNIs was extensively overhauled by the "TSN Act" of 13th June 2006 and its implementing decrees, more particularly the Decree of 14th March 2019 which modifies the regulatory procedures concerning BNIs, which had hitherto been governed by the "BNI Procedures" Decree of 2nd November 2007, but also – from the technical standpoint – by the Order of 7th February 2012 setting the general rules concerning BNIs (known as the "BNI order", see. § 7.1.3.1.2) which will eventually be supplemented by about twenty ASN regulations. Three Acts specifically concerning BNIs – the TSN Act, Programme Act 2006-739 of 28th June 2006 on the sustainable management of radioactive materials and waste (known as the "waste" Act) and Act 68-943 of 30th October 1968 on civil liability in the nuclear energy field (known as the "RCN" Act) – are codified in the Environment Code.

Some of the provisions of Part VII of Book I and Parts I, IV and provisions of Part IX of Book V of the Environment Code thus underpin the BNI authorisation, monitoring and enforcement system.

The provisions of the Environment Code, its implementing decrees and the Order of 7th February 2012, some of which predated Directive 2009/71/Euratom of 25th June 2009 establishing a community framework for the nuclear safety of nuclear facilities, ensures its transposition. This Directive was modified by Directive 2014/87 of 8th July 2014.

Ordinance 2016-128 of 10th February 2016 containing various provisions concerning nuclear activities, issued on approval of the "TECV Act", allows the transposition of the legislative part of several Directives, including the above-mentioned Directive of 8th July 2014.

This act and this ordinance also bring substantial modifications to the legislative framework governing nuclear activities and their oversight.

The main provisions of this Act in the nuclear field concern:

- **reinforcement of transparency and information of the citizens**, in particular by reinforcing and extending the remit of the local information committees (CLI) and by reinforcing certain procedures for informing the local populations;
- **reinforcement of the BNI system** with regulation of the use of subcontracting, changes to the BNI authorisation system and overhaul of the system for BNI final shutdown and decommissioning;
- **clarification of the organisation of the oversight of nuclear safety and radiation protection by ASN and IRSN**

This Ordinance of 10th February 2016 enhances the effectiveness of nuclear safety and radiation protection oversight by giving ASN power to impose daily penalty payments and pecuniary sanctions, by extending ASN's powers of oversight and sanction to certain activities performed outside the BNI perimeter (head office departments of the licensees, subcontractors, etc.) and by instituting a sanctions committee within ASN.

Finally, the above-mentioned Decree 2019-190 of 14th March 2019, updated and codified in the Environment Code the provisions applicable to BNIs, the transport of radioactive substances and transparency on nuclear matters contained in eight decrees concerning BNIs and nuclear transparency.

### 7.1.1 Principles

This BNI legal system is said to be "integrated", because it aims to prevent or control all risks and detrimental effects a BNI is liable to create for humans and the environment, whether or not these are radioactive. It confirms that the four main principles of environmental protection apply to nuclear activities: prevention, precaution, polluter-pays, and public participation. In this regard it reproduces the Environmental Charter, which is now part of the Constitution. It refers to the Public Health Code's radiation protection principles: justification, optimisation and limitation. It lays down the fundamental principle of the responsibility of the licensee for the safety of its facility, enshrined in international law, applicable on a day-to-day basis and essential to ensuring that both the licensee and the regulatory authority are fully aware of their responsibilities.

### 7.1.2 Regulatory provisions

Decree 2019-190 of 14th March 2019 codified the provisions applicable to BNIs, the transport of radioactive substances and transparency on nuclear matters in the Environment Code. Eight decrees concerning BNIs and nuclear transparency, including Decree 2007-1557 of 2nd November 2007 setting out the regulatory procedures for BNIs, were thus updated and codified. It also reproduced the legislative provisions derived from Ordinance 2016-128 of 10th February 2016 containing various nuclear-related provisions, Article 123 of Act 2015-992 of 17th August 2015 concerning Energy Transition for Green Growth and Act 2017-55 of 20th January 2017 regarding the general status of independent administrative authorities and independent public authorities.

Most of the regulatory provisions are therefore now incorporated into the Environment Code. Only ten or so decrees remain uncodified.

### 7.1.3 Technical rules applicable to BNIs

#### 7.1.3.1 Ministerial and interministerial orders

##### 7.1.3.1.1 Pressure equipment

BNIs comprise two types of pressure equipment: on the one hand, nuclear pressure equipment (NPE), in other words that making up the main primary and secondary systems (MPS and MSS) and that confining radioactive products and, on the other hand, conventional equipment which is not specific to nuclear facilities but which is installed in them. The regulations applicable to it are detailed in table 2.

Table 2 : Legislation and regulations covering pressure equipment

installed within the perimeter of BNIs

| | **NUCLEAR PRESSURE EQUIPMENT** | | **PRESSURE EQUIPMENT AND SIMPLE PRESSURE VESSELS INSTALLED WITHIN THE PERIMETER OF BNIs (In-service monitoring)** |
|---|---|---|---|
| | **PRESSURISED WATER REACTOR MAIN PRIMARY AND SECONDARY SYSTEMS** | **OTHER NUCLEAR PRESSURE EQUIPMENT** | |
| **GENERAL PROVISIONS** | Legislative and regulatory parts of the Environment Code (Chapter VII of Part V of Book V) | | |

| | | | |
|---|---|---|---|
| **PROVISIONS CONCERNING EQUIPMENT MANUFACTURE** | Section 12 of Chapter VII of Part V of Book V of the Environment Code (regulatory part)<br><br>Order of 30th December 2015 | Section 12 of Chapter VII of Part V of Book V of the Environment Code (regulatory part)<br><br>Order of 30th December 2015 | Sections 9 and 10 of Chapter VII of Part V of Book V of the Environment Code |
| **OPERATIONAL PROVISIONS** | Section 14 of Chapter VII of Part V of Book V of the Environment Code<br><br>Order of 10th November 1999 | Section 14 of Chapter VII of Part V of Book V of the Environment Code<br><br>Order of 30th December 2015 | Section 14 of Chapter VII of Part V of Book V of the Environment Code<br><br>Order of 20th November 2017 |

##### 7.1.3.1.2 The "BNI Order" of 7th February 2012

Initiated further to the publication of the "TSN" Act in 2006, the overhaul of the general regulations relative to BNIs incorporates the principles ("reference levels") of the common baseline requirements developed by WENRA, the European Nuclear Regulators' Association.

Implementing a legislative provision of the Environment Code, the Order of 7th February 2012 setting out the general rules for BNIs, known as the "BNI Order", thus defines the essential requirements applicable to BNIs for protection of the interests enumerated by the act: public health and safety, protection of nature and the environment. It notably incorporates rules corresponding to the best international practices into French law. It takes up and reinforces prior regulations, more specifically giving a legal foundation for ASN's requests.

It was published in the Official Journal of 8th February 2012 and most of its provisions entered into force on 1st July 2013 and can be broken down into the following 8 points (see Figure 2: ):

- General provisions (concept of "integrated safety")
- Organisation and responsibility
- Demonstration of nuclear safety
- Control of detrimental effects and impact on health and the environment
- Pressure equipment designed specifically for the BNIs
- Waste management
- Preparedness for and management of emergency situations
- Particular provisions applicable to certain categories of facilities or to certain activities within a BNI

After seven years of application of this Order and feedback from its utilisation, a general revision of it began in 2018.

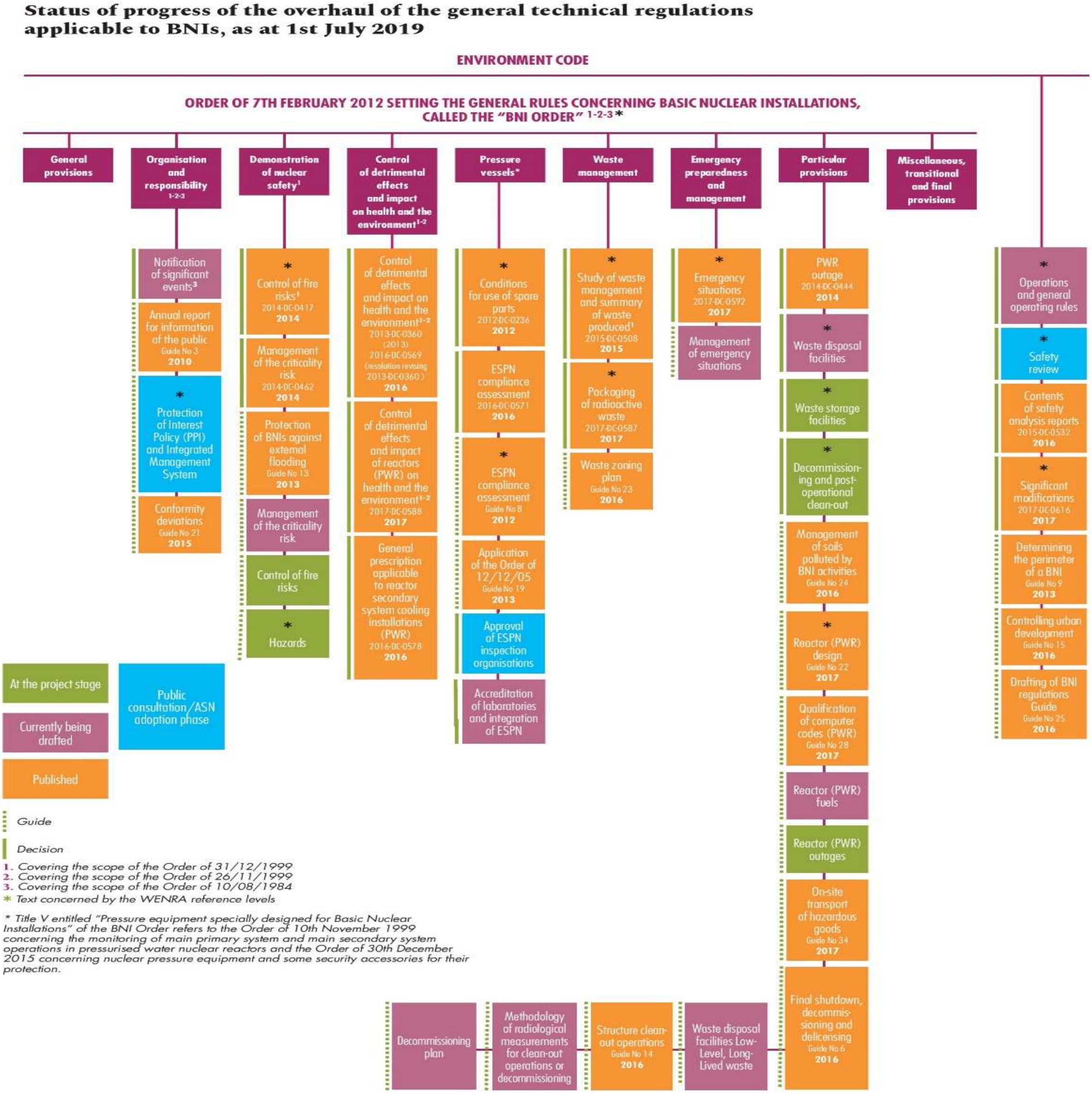


Figure 2: Structure of the draft of the new technical regulations on 1st July 2019

#### 7.1.3.2 Technical regulatory resolutions issued by ASN

Pursuant to the Environment Code, ASN can issue regulatory resolutions to clarify the decrees and orders relating to nuclear safety and radiation protection. They are subject to approval by the Minister in charge of nuclear safety or radiation protection.

The ASN regulatory resolutions issued at the end of 2018 are listed in table 12 of appendix 2.

The ASN regulatory resolutions are subject to consultation by the public, which is thus associated with the drafting of the texts establishing the regulations relative to nuclear safety.

#### 7.1.3.3 Basic safety rules and ASN guidelines

ASN has developed basic safety rules (RFS) on various technical subjects concerning both PWRs and the other BNIs. These are recommendations which clarify safety objectives and describe practices ASN considers to be satisfactory to ensure compliance with them.

They are not regulatory texts. A licensee may not follow the provisions of an RFS if it can demonstrate that the alternatives it proposes implementing are able to attain the safety objectives set by the RFS.

As part of the overhaul of the general technical regulations, the RFS are either integrated into the regulations, or modified and updated in the form of ASN guidelines.

There are at present about forty RFS and other technical rules published by ASN which can be consulted on its website. The list of RFS and of the guidelines is given in appendix 2 – § 2.3.

#### 7.1.3.4 French nuclear industry professional codes and standards

The nuclear industry produces detailed rules dealing with the state of the art and industrial practices, which it compiles in “industrial codes”. These rules allow concrete transposition of the requirements of the general technical regulations, while reflecting best industrial practice. They thus facilitate contractual relations between customers and suppliers.

In the particular field of nuclear safety, the industrial codes are drafted by AFCEN, the French association for rules on design, construction and in-service monitoring of nuclear steam supply systems, which comprises 60 French and international industrial firms, including EDF, Framatome and CEA. The RCC (design and construction rules) codes were drafted for the design, manufacture and commissioning of electrical equipment, civil engineering structures, mechanical equipment and fuel assemblies in NPPs.

Production of these documents is the responsibility of industry, not ASN.

## *7.2 Authorisation procedures*

French legislation and regulations prohibit the operation of a nuclear facility without authorisation. The BNIs are currently regulated by Part IX of Book V of the Environment Code. This part provides for a creation authorisation procedure followed by a commissioning authorisation and authorisations for substantial or significant modifications to the installation. With regard to decommissioning, once the licensee has notified both the Minister responsible for nuclear safety and ASN of final shutdown of its BNI, this is carried out under the conditions prescribed in the decommissioning decree.

Any licensee which operates a facility, either without the required authorisations or decree, or in breach of these authorisations, may be subject to administrative and criminal sanctions as stipulated in the Environment Code.

### 7.2.1 Safety options

An industrial firm envisaging operating a BNI may, even before initiating the authorisation procedure, ask ASN for an opinion on some or all of the options it has adopted to ensure the safety of its facility. The applicant is advised of ASN's opinion, which may provide for additional studies and justifications that could be necessary for a possible creation authorisation application.

The safety options must then be presented in the authorisation application file in a preliminary version of the safety analysis report (RPS). This preparatory procedure does not take the place of the subsequent regulation reviews, but aims to facilitate them.

### 7.2.2 The creation authorisation

The creation authorisation application is filed with the Minister responsible for nuclear safety. The application is accompanied by a file comprising a number of items, including the detailed plan of the facility, the impact assessment, the preliminary version of the safety analysis report (RPS), the risk management study and the decommissioning plan.

ASN reviews BNI creation authorisation or decommissioning applications and proposes a draft decree to the Government. It defines the requirements applicable to the facility with regard to the prevention of risks, pollution and detrimental effects.

### 7.2.3 The public inquiry and environmental assessment

In addition to the possible organisation of a public debate, as presented in § 17.1.5, or the consultation of the member States of the European Union (see § 17.1.4 and § 7.2.5), the BNI creation authorisations and then the decommissioning decree are published following a public inquiry.

The purpose of this inquiry is to inform the public and obtain their assessments, suggestions and counter-proposals, in order to provide the competent authority with all the information it needs prior to any decision.

Ordinance 2016-1058 of 3rd August 2016, issued on the basis of Article 106 (2° of I) of Act 2015-990 of 6th August 2015 on growth, activity and equal economic opportunity, modified the rules applicable to the environmental assessment of projects, plans and programmes.

This ordinance has three objectives: simplification and clarification of these rules, improved interfacing between the environmental assessments of different projects and between the environmental assessments of projects, plans and programmes, the compliance of these rules with European Union law, by transposing Directive 2011/92/EU of 13th December 2011 concerning the evaluation of the environmental impacts of certain public and private projects (as modified by Directive 2014/52/EU of 16th April 2014).

The result was a modification of the provisions of the legislative and regulatory parts of the Environmental Code dealing with environmental assessments.

### 7.2.4 Creation of a Local Information Committee (CLI)

A CLI (see § 8.3.5) can be created as soon as the BNI creation authorisation application is submitted. In any case, it must be in effect once the authorisation has been issued.

### 7.2.5 Consultation of other countries of the European Union

Pursuant to article 37 of the treaty instituting the European atomic energy community and the decree of 14th March 2019, the creation authorisation for a facility liable to discharge radioactive effluents into the environment is only possible after consulting the Commission of the European Union.

### 7.2.6 Consultation of technical organisations

The preliminary safety analysis report (RPS) appended to the creation authorisation application is transmitted to ASN, which submits it for review to one of its Advisory Committees.

### 7.2.7 The creation authorisation decree (DAC)

The Minister responsible for nuclear safety sends the licensee a preliminary draft decree granting or refusing creation authorisation. The licensee has a period of two months in which to present its comments. The Minister issues the decree, then obtains the opinion of ASN.

The BNI creation authorisation is issued by a decree signed by the Prime Minister and countersigned by the Minister responsible for nuclear safety.

The creation authorisation decree (DAC) determines the perimeter and characteristics of the facility. It also sets the duration of the authorisation, as applicable and the maximum time until commissioning of the facility. It also designates the essential components that require protective measures regarding public health and safety or the protection of nature and the environment.

### 7.2.8 ASN requirements for DAC implementation

For implementation of the DAC, ASN defines requirements relative to BNI design, construction and operation, that it deems necessary for nuclear safety.

ASN defines requirements concerning BNI water intake and discharges. The specific requirements setting the limits on discharges into the environment from the BNI (whether under construction or in operation) are subject to approval by the Minister responsible for nuclear safety. BNI modification projects that could cause a significant increase in its water intake or discharges into the environment are made available to the public.

ASN resolution 2013-DC-0352 of 18th June 2013, specifies how the procedure for making project information available to the public is to be implemented.

### 7.2.9 Commissioning authorisations

Commissioning corresponds to the first use of nuclear materials in the installation. In preparation for commissioning, the licensee sends ASN a file comprising the updated safety analysis report for the facility "as-built", the general operating rules, a waste management study, the on-site emergency plan and the decommissioning plan.

The authorisation to commission a BNI is issued by ASN. It is described in detail in § 19.1.

### 7.2.10 Modification of a BNI

Any substantial modification of the facility must undergo a procedure similar to that for a creation authorisation application.

As the regulatory texts currently stand, a modification is considered to be substantial in the cases mentioned in Article R.593-47 of the Environment Code:

- a change in the nature of the facility or an increase in its maximum capacity;
- a modification of the elements essential for protection of the interests mentioned in the first paragraph of Article L.593-1 of the Environment Code, which are included in the authorisation decree;
- the addition, within the perimeter of the facility, of a new BNI, whose operation is linked to that of the facility in question.

The other modifications are "significant" modifications of the facility and, depending on their significance, require either notification of ASN or authorisation by ASN under the terms of article L. 593-15 of the Environment Code.

On 30th November 2017, ASN adopted resolution 2017-DC-0616 concerning significant modifications to BNIs, which specifies the criteria for distinguishing the significant modifications requiring ASN authorisation from those requiring notification.

It also defines the requirements applicable to the management of significant modifications, more particularly the internal checks procedures to be implemented by the licensees.

This resolution confirms the responsibility of the licensees for managing significant modifications to their facilities, while ensuring that they draw on an appropriate organisation, and reinforces the overall consistency of the system by making ASN’s oversight more proportionate to the specific implications of each modification.

### 7.2.11 The other facilities located within a BNI perimeter

The following are located within the perimeter of a BNI:

- the BNI;
- the equipment and facilities necessary for operation of the BNI; depending on its type, this equipment may technically be comparable to classified installations but, as it is a part of the BNI, it is subject to the regulations applicable to BNIs;
- classified equipment and installations which do not necessarily have a direct link with the BNI.

The equipment required for operation of the BNI is subject to the BNI System in full, as stipulated in the Decree of 14th March 2019. The other equipment within the perimeter of the BNI and by its nature subject to another administrative regime (IOTA or ICPE) remains subject to this regime. ASN nonetheless has competence to take individual measures and monitor them.

### 7.2.12 Decommissioning decree

The decommissioning of a facility is prescribed by a decree, issued after consulting ASN. The decommissioning file presented by the licensee undergoes the same consultations and inquiries as those applicable to BNI creation authorisation applications and in accordance with the same procedures. The decommissioning decree more particularly sets out the characteristics of decommissioning and its completion time-frame. Until the decommissioning decree comes into force, the facility remains governed by the provisions of its creation authorisation decree and the ASN requirements, which may be added to or modified if necessary.

On completion of decommissioning, a facility can be delicensed.

## *7.3 Regulation and oversight of nuclear activities*

The regulation and oversight of nuclear activities is one of ASN's fundamental duties. This regulation and oversight consists in verifying that all parties in charge of a nuclear activity assume their responsibility in full and comply with the requirements of the regulations concerning nuclear safety and radiation protection. It contributes to assessing the performance of a licensee and enables the issues and implications associated with a nuclear activity to be estimated.

In the case of BNIs, ASN regulation and oversight of nuclear safety and radiation protection extends to include protection of the environment and, in the NPPs, to labour inspectorate duties.

Regulation and oversight take place at several levels:

- before the licensee carries out any activity subject to authorisation, by means of a review and analysis of the files, documents and information supplied by the licensee to justify its actions. This monitoring aims to ensure that the information and demonstrations supplied is pertinent and adequate;
- during operation, by means of visits, by inspections on all or part of the facility, by documentary and field checks during interventions with significant implications, such as scheduled nuclear reactor outages, and by analysing the PSR reports and the significant events. This monitoring involves sampling and analysis of the justifications provided by the licensee concerning the performance of its activities. In 2018, 2,122 inspector.days were devoted to inspecting BNIs and PE, broken down into 748 inspections, about 20% of which were unannounced. This inspection work is broken down into 1,150 inspector.days in the NPPs (370 inspections), 741 inspector.days in the other BNIs (286 inspections), in other words mainly fuel cycle facilities, research facilities and installations being decommissioned, along with 231 for pressure equipment (92 inspections). In 2018, 186 inspector.days were devoted to inspecting approved organisations and laboratories (of all types, not only pressure equipment), consisting of 106 inspections, of which 48% were unannounced.

ASN aims to ensure that the principle of the operator's prime responsibility for safety and radiation protection is adhered to (see § 9.1). It applies the concept of proportionality when determining its actions, so that the scope and thoroughness of its oversight is commensurate with the nuclear, health and environmental safety issues.

### 7.3.1 Scope of regulatory oversight

#### 7.3.1.1 Regulation and oversight of nuclear safety

Nuclear safety encompasses all the technical provisions and organisational measures relative to the design, construction, operation, shutdown and decommissioning of BNIs, and to the transport of radioactive substances, defined with a view to preventing accidents or mitigating their consequences in order to protect workers, the general public and the environment against the effects of ionising radiation. Moreover, technical measures to optimise the management of radioactive waste and effluents are usually included in these provisions.

Regulation and oversight by ASN covers installation equipment, operators of this equipment, working methods and organisation. ASN examines the steps taken regarding safety or monitoring and limitation of the doses received by those working in the facilities, as well as procedures for environmental protection.

#### 7.3.1.2 Regulation and oversight of radiation protection

In BNIs, ASN ensures that the regulations for the protection of individuals against ionising radiation are implemented. In the same way as for nuclear safety, this work continues throughout the operating lifetime of nuclear facilities.

#### 7.3.1.3 Pressure equipment

A large number of systems contain or carry pressurised fluids and are consequently subject to the pressure equipment regulations, oversight of which is the responsibility of ASN in the BNIs.

This equipment includes the particularly important main primary and secondary systems in EDF's PWRs. Owing to the fact that in normal conditions they operate at high pressure and temperature, their good in-service performance is one of the keys to the safety of the NPPs. ASN therefore exercises particularly close monitoring of these systems.

The operation of pressure equipment is subject to oversight in particular covering in-service monitoring programmes, non-destructive testing, maintenance work, processing of anomalies affecting the systems and periodic system requalification.

#### 7.3.1.4 Labour law in the nuclear power plants

Monitoring the application of all provisions relating to labour regulations (in particular concerning occupational safety or social measures to protect the personnel) is the responsibility of the staff of the labour inspectorate.

There are three main labour inspectorate duties – monitoring, information and advice – concerning working conditions and worker protection.

### 7.3.2 BNI oversight procedures

The licensee is required to provide ASN with the information necessary for its regulatory oversight. This information must enable the technical demonstrations presented by the licensee to be analysed and the inspections to be targeted. It must also allow identification and monitoring of the key events marking the operation of a BNI.

The ASN oversight and monitoring procedures are tailored to the specificities and risks of each of the areas concerned (NPPs, hospital and industrial facilities using ionising radiation, research laboratories, transport of radioactive substances, nuclear waste facilities, etc.) and are implemented by means of the following actions:

- inspection, generally on the site, or in an inspected department, or at carriers of radioactive substances. This consists in performing spot checks on the conformity of a given situation with

regulatory or technical baseline requirements but may also include an assessment of the licensee's practices by comparison with current best practices;
- authorisation, following analysis of the applicant's demonstration that its activities are satisfactorily managed in terms of radiation protection and safety;
- analysis of operating experience feedback, more specifically through analysis of significant events;
- approval of organisations and laboratories taking part in radioactivity measurements and radiation protection inspections, as well as qualification of pressure equipment monitoring organisations;
- presence in the field, which is also frequent outside actual inspections;
- consultation with the professional organisations (trades unions, professional orders, learned societies, etc.).

The performance of certain inspections by organisations and laboratories offering the necessary guarantees, as validated by ASN approval or qualification, contributes to the oversight of nuclear activities.

When ASN oversight actions reveal breaches of compliance with the regulations, penalties (see § 7.4) can be imposed on the licensees. These penalties can include prohibition of restart or suspension of operation of a nuclear facility until corrective measures have been taken.

### 7.3.3 ASN organisation for BNI oversight

#### 7.3.3.1 Inspection in the BNIs

To achieve its objectives, ASN has inspectors designated and accredited by the ASN Chairman, in accordance with the procedures defined by Articles R.596-1 to R.596-4 of the Environment Code, provided that they have acquired the requisite legal and technical skills through professional experience, mentoring or training courses. They carry out their inspection activity under the authority of the ASN Director-General and have regularly updated practical tools at their disposal for the performance of their inspections. They take an oath and are bound by professional secrecy.

As at 31st December 2018, the number of nuclear safety inspectors stood at 221. These inspectors carry out most of the inspections in the BNIs. Labour or radiation protection inspectors may also intervene in these installations.

#### 7.3.3.2 Oversight of the manufacture of nuclear pressure equipment

The assessment of the conformity of design and manufacture of the MPS and MSS equipment (N1[1] NPE) is carried out directly by ASN, assisted by an approved organisation if it so wishes. The assessment of conformity of design and manufacture of the other NPE (N2 and N3) is carried out by approved organisations and monitored by ASN.

All the inspections at the manufacturers carried out by the organisations are presented in § 18.2.4.1.

#### 7.3.3.3 Significant events

Operators must report safety significant incidents to ASN.

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[1] The NPE are classified at 3 levels, mainly according to the scale of the radioactive emissions that could result from their failure (from N1 to N3 in decreasing order of releases). The "Level N1 NPE" are therefore the most important for safety.

These are events which are sufficiently important in terms of safety, the environment or radiation protection, to justify that ASN be rapidly informed of their occurrence and subsequently receive a fuller analysis.

ASN felt that it would be useful to transpose this approach, which was initially limited to nuclear safety, to radiation protection and protection of the environment. This is specified in the legal texts (environment, public health and labour codes), the "BNI Order" and the Order of 29 May 2009 on the transport of dangerous goods.

The criteria for notifying the public authorities of events deemed to be significant take account of:

- the actual or potential consequences for the workers, the general public, patients or the environment, of events which could involve safety or radiation protection;
- the main technical, human or organisational causes that led to the occurrence of such an event.

ASN has also published guides which describe in greater detail the principles and criteria for reporting significant events.

This notification process is part of the continuous safety improvement approach. It requires the active participation of all players (users of ionising radiation, carriers, etc.) in the detection and analysis of deviations. It enables the authorities:

- to ensure that the licensee has suitably analysed the event and taken appropriate measures to remedy the situation and prevent it from happening again;
- to analyse the event in the light of the experience available to other parties in charge of similar activities.

The purpose of this system is not to identify or penalise any individual person or party.

The analysis of a significant event covers compliance with the significant event detection and notification rules in force, the immediate technical measures taken by the licensee to maintain the facility in or bring it to a safe state and, finally, the pertinence of the significant event reports supplied by the licensee. The procedures for the review and analysis of these events at a later date by ASN and its technical support organisation, IRSN, are described in detail in §19.6.4.

Moreover, the number and rating on the INES scale (International Nuclear and Radiological Event Scale) of the significant events which have occurred in a nuclear facility are not on their own indicators of the facility's level of safety. On the one hand, a given rating level is an over-simplification and is unable to reflect the complexity of an event and, on the other, the number of events listed depends on the level of notification compliance. The trend in the number of events does not therefore reflect any real trend in the safety level of the facility concerned.

## *7.4 Penalties*

When ASN observes failures to comply with safety regulations, enforcement measures and administrative penalties may be imposed on the licensees after serving formal notice.

If an infringement is observed, the Environment Code comprises enforcement measures and graduated administrative penalties that become applicable after formal notice, as defined in its articles L. 171-8 and L.596-5:

- the consignment with a public accountant of an amount corresponding to the cost of the work to be carried out;
- the automatic completion of the work at the licensee's expense, with the possibility of using the sums previously consigned to pay for the work concerned;
- suspension of operation of the facility or of the procedure in progress (restart for example) until the licensee has restored conformity.

The ordinance of 10th February 2016 supplemented these provisions to enable ASN to order:

- the payment of a maximum daily fine of 15,000 euros;
- the payment of a maximum administrative fine of 10 million euros for non-compliance with the provisions applicable to BNIs, of 1 million euros for non-compliance with the provisions applicable to NPE and of 30,000 euros in other cases. This fine is determined by a sanctions committee which comprises four members who are members neither of the ASN Commission nor of ASN departments.

The law also makes provision for interim measures to protect public health and safety or to protect the environment. ASN may therefore:

- in the event of severe and imminent risks, provisionally suspend operation of a BNI, immediately informing the Minister responsible for nuclear safety;
- at all times, require the performance of assessments and the implementation of the steps necessary if the above-mentioned interests are threatened.

In addition, any criminal infringements are recorded in reports drawn up by the inspectors and sent to the public prosecutor's office, which then decides on whether or not further action is warranted.

The Environment Code makes provision for criminal penalties, as detailed in its Articles L. 596-11 and L.596-12; these penalties comprise fines of from €7,500 to €150,000 € plus a possible prison term of from 1 to 3 years, depending on the nature of the infringement. For legal persons found to be criminally liable, the amount of the fine can reach €10,000,000.

The number of administrative measures issued by ASN and the number of formal notices served on the licensees between 2013 and 2018 are shown in table 3.

Table 3 : Administrative measures and reports concerning BNIs to the public prosecutor's office

| Year | Administrative measures (formal notices) | Report transmitted to public prosecutor | Number of labour inspection reports |
|---|---|---|---|
| 2013 | 16 | 10 | 10 |
| 2014 | 9 | 6 | 9 |
| 2015 | 4 | 4 | 3 |
| 2016 | 6 | 2 | 1 |
| 2017 | 2 | 13 | 5 |
| 2018 | 5 | 14 | 2 |

# 8. Article 8: Regulatory organisation

*Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.*

*Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organisation concerned with the promotion or utilisation of nuclear energy.*

## *8.1 The Nuclear Safety Authority (ASN)*

Act 2006-686 of 13th June 2006 (codified in the Environment Code) created an independent administrative authority, ASN, responsible for the regulation and oversight of nuclear safety and radiation protection for all civil nuclear activities.

The Act gives ASN competence to issue regulations to clarify the decrees and orders relating to nuclear safety and radiation protection, which are subject to approval by the Minister in charge of nuclear safety or radiation protection. ASN prepares draft regulatory texts for the Government and specifies the regulations through technical decisions.

The Government retains the power to define the general regulations applicable to nuclear activities, by decree or by order. ASN must be consulted by the Government on general regulatory texts within its areas of competence and on the main licensing decisions

ASN examines all requests for individual authorisations from BNIs. It may grant all authorizations, with the exception of major BNI authorizations such as their creation and dismantling, taken by the Government.

The Act also gives ASN authority to impose binding requirements on the licensee throughout the lifetime of the facility, including during its decommissioning, for example to request correction of an anomaly or prevent a particular risk.

The Government is responsible for civil protection in emergency situations.

The nuclear safety and radiation protection inspectors designated by ASN monitor and control nuclear activities. Labour inspectorate duties in the NPPs is entrusted to ASN inspectors placed under the authority of the Minister responsible for labour for the purposes of these duties.

ASN contributes to the management of radiological emergencies.

ASN contributes to informing the public.

On technical matters, ASN relies on the expertise provided primarily by IRSN and by the Advisory Committees of experts.

In more detail:

- ASN is consulted on draft decrees and ministerial orders of a regulatory nature relating to nuclear safety, as defined in Article L.593-25 of the Environment Code, which includes nuclear safety.
- ASN examines BNI creation authorisation applications and decommissioning files, as well as substantial modification requests concerning these facilities and makes proposals

to the Government concerning the decrees to be issued in these areas. For more details, see § 7.2.

- ASN verifies compliance with the general rules and specific requirements for nuclear safety and radiation protection applicable to BNIs, the construction and use of nuclear pressure equipment, the transport of radioactive substances and nuclear activities outside BNIs. It issues the required approvals to the organisations participating in the verifications and monitoring concerning nuclear safety or radiation protection. For more details, see § 7.3.
- ASN is involved in the management of radiological emergency situations. It provides the competent authorities with technical support in order to develop appropriate measures, within the framework of the emergency organisation plans, taking due account of the risks resulting from nuclear activities. When such an emergency situation arises, it assists the Government on all relevant issues within its areas of competence. It submits its recommendations on the measures to be taken concerning medical, health or civil security aspects, it informs the public about the situation, about potential releases into the environment and their consequences. These measures are detailed in chapter 16.
- ASN takes part in public information within its areas of competence, notably by making the information in these fields accessible to the greatest number. It regularly reports on its activity, notably by submitting its annual report to Parliament, to the Government and to the President of the Republic. It also uses various channels, written media (monthly ASN newsletter, annual report), the www.asn.fr website, the public information and documentation centre, press conferences, seminars and exhibitions.

### 8.1.1 Organisation

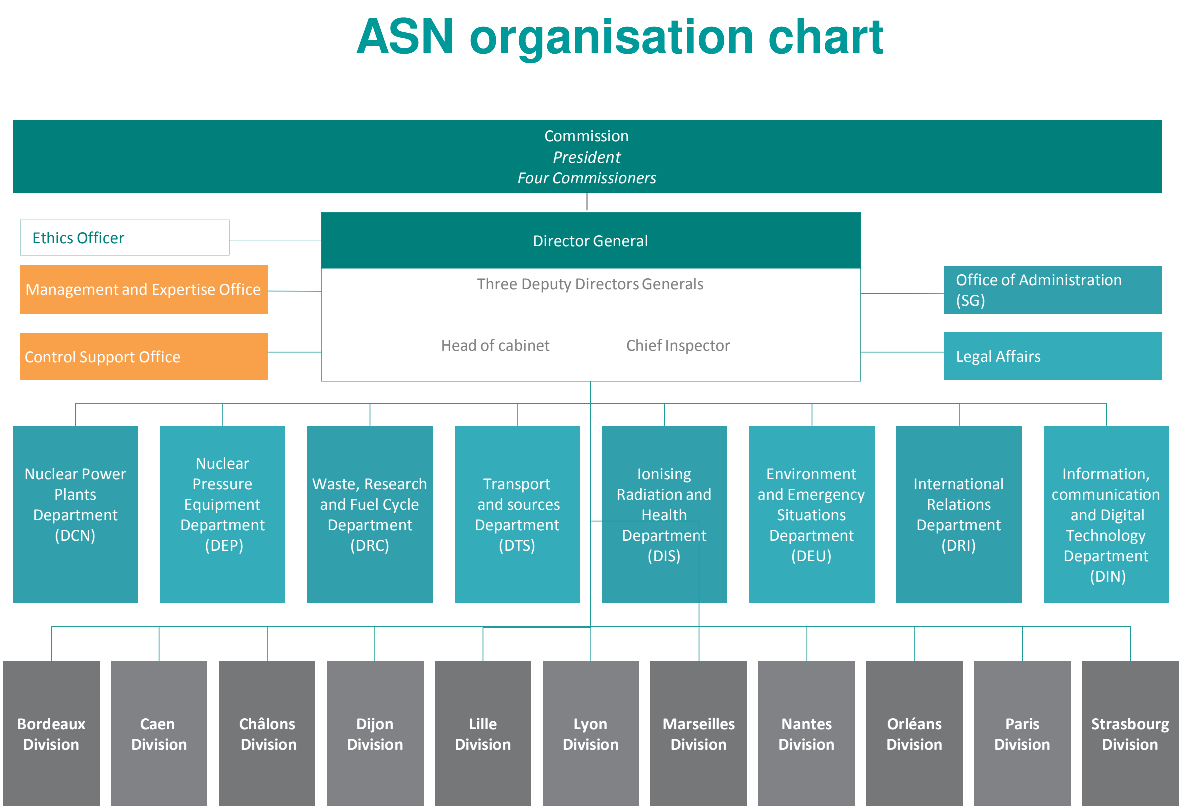


Figure 3: ASN - General organisation

#### 8.1.1.1 The ASN Commission

ASN is run by a Commission consisting of five commissioners appointed by decree on account of their competence in the fields of nuclear safety and radiation protection. Three of the commissioners, including the Chairman, are appointed by the French President. The other two commissioners are appointed by the president of the National Assembly (lower house of the French Parliament) and by the president of the Senate (upper house), respectively. The members of the Commission are appointed for a non-renewable term of six years. The ASN commissioners exercise their functions on a full-time basis.

The Commission defines ASN's strategy. In this respect, it is more specifically involved in defining general policies, that is the ASN doctrines and action principles for its essential missions, which include regulation, oversight, transparency, the management of emergency situations, international relations, etc. In accordance with the law, the Commission sends ASN opinions to the Government and takes the main ASN resolutions.

Both in the exercise of their duties and at other times, the Commissioners shall ensure that they do not place themselves in a position that could compromise their independence with regard to persons or entities over which ASN has oversight or which could be perceived as being liable to compromise the impartial exercise of their duties. In the performance of their duties, the Commissioners neither receive nor ask for instruction from any authority. The Commissioners refrain from disseminating information and from making known publicly any personal opinions which could compromise the satisfactory working of ASN.

The ethical rules binding on the Commissioners are recalled in the Ethical Charter for the Commissioners and Personnel of ASN, which constitutes appendix 1 of the ASN internal regulations published in the Official Journal of 26th October 2018 (ASN resolution 2018-DC-0644 of 9th October 2018).

The Commissioners are required to submit two declarations of interests and a declaration of assets, in accordance with two different legal systems.

#### 8.1.1.2 The ASN departments

Under the authority of the ASN Chairman, the ASN Director-General organises and manages ASN's head office departments and its eleven regional divisions.

The head office consists of 9 thematic departments, an Office of Administration, plus the Management and Expertise Office and the Regulation and Oversight Support Office (see Figure 3). The role of the ASN head office departments is to manage national matters concerning the activities for which they are responsible. They take part in defining the general regulations and coordinate and manage the work of the teams in the regions responsible for field monitoring of facilities and activities. Each ASN entity contributes to public information on nuclear safety and radiation protection.

ASN's regional divisions operate under the authority of the ASN regional representatives. The divisions conduct most of the direct oversight of nuclear facilities, radioactive material transport and other small-scale nuclear activities. They review most creation authorisation applications submitted by licensees within their geographical jurisdiction. They also support ASN's head office departments in their review of major decisions. In emergency situations, they assist the *département* Prefect who is responsible for the protection of the population of the *département*. Finally, they contribute to the public information role entrusted to ASN by law.

### 8.1.2 ASN operation

#### 8.1.2.1 Human resources

As at 31st December 2018, ASN's total workforce stood at 516 staff, including 289 in head office departments, 226 in the regional divisions and 1 abroad.
As at 31st December 2018, the average age of the ASN staff was 47 years old. This balanced age pyramid and the diversification of profiles in terms of recruitment, and thus of background, ensures that ASN has the qualified and complementary human resources it needs to fulfil its mission. In addition, training, the way younger staff are integrated and the transmission of knowledge guarantee the required level of expert know-how.
Competence is one of ASN's four key values. A tutoring system, allied with initial and continuous training, whether general, associated with nuclear techniques, or in the legal or communication field, constitute essential aspects of the professionalism of ASN staff. The management of its staff's skills is based notably on a formalised series of technical training courses. In 2018, more than 4,600 days of training were provided to the ASN staff. The financial cost of the courses provided by organisations other than ASN amounted to €390,000.

#### 8.1.2.2 Financial resources

Since 2000, all the personnel and operating resources involved in the performance of the tasks entrusted to ASN have been covered by the State's general budget. In 2018, the ASN budget amounted to €84.45 M. It comprised €45.89 M of payroll credits and €38.56 M of operating credits for the head office department and the eleven regional divisions of ASN

Moreover, as stipulated by law, ASN relies on IRSN for technical expertise, backed up whenever necessary by research, for a total value of €84.3 M in 2018.

#### 8.1.2.3 Quality management system

To guarantee and improve the quality and effectiveness of its action, ASN defines and implements a quality management system derived from the ISO and IAEA international standards and built around:

- a multi-year strategic plan and shared annual objectives;
- an organisation manual containing organisational notes and procedures defining the ASN internal rules for the satisfactory performance of each of its missions;
- internal and external audits concerning implementation of the measures contained in ASN's quality management system;
- performance indicators for measuring the effectiveness of ASN's actions;
- listening to the stakeholders (public, elected officials, associations, media, trade unions, industry);
- annual reviews of the management system with the aim of continuously improving its operation.

## *8.2 ASN's technical support organisations*

ASN benefits from the expertise of technical support organisations in preparing its resolutions and decisions. The main organisation is IRSN. In preparing its decisions and resolutions, ASN also relies on the opinions and recommendations of the Advisory Committees.

### 8.2.1 French Institute for Radiation Protection and Nuclear Safety (IRSN)

IRSN is an independent public and commercial establishment created by Article 5 of Act 2001-398 and its roles and duties are defined by the TECV Act of 2015. It is the public expert in the field of nuclear and radiological risks. In this capacity, it deals with all scientific and technical questions associated with these risks, both in France and internationally. Its activities therefore cover numerous fields: environmental monitoring, intervention in the event of a radiological risk, radiation protection of humans in normal and accident situations, prevention of major accidents, safety and security of nuclear reactors, plants, laboratories, transport and waste. IRSN is also present in the field of defence-related nuclear assessment and analysis.

The Institute contributes to public policies in the fields of health, nuclear safety, environment and emergency management. In this context, it interacts with all the stakeholders concerned, while taking care to maintain its independence of judgement, that is public authorities, more particularly nuclear safety and security regulators, research organisations and associations of stakeholders. IRSN also contributes to training and to public information about nuclear and radiological risks.

The Institute runs and implements research programmes with a view to consolidating national public expert capability around the most advanced scientific knowledge at the international level and to contribute to the development of scientific knowledge concerning nuclear and radiological risks. It is tasked with technical support of the public authorities with competence for safety, radiation protection and security, in both the civil and national defence sectors. According to its creation decree, it also performs certain public interest duties outside the research field, more specifically with regard to monitoring of the environment and of persons exposed to ionising radiation and management of the inventory of radioactive sources.

IRSN received ISO 9001 certification in 2007 and it develops its quality policy on the basis of a continuous-improvement approach in order to enhance the quality of its expertise. In accordance with this approach, the opinion of ASN and of all organisations benefiting from IRSN’s technical support is taken into account. Periodic meetings are also held to enable ASN and IRSN to discuss past, present and future expert assessment and analysis work.

The Government consults ASN regarding the share of the State’s subsidy to IRSN for the technical support it provides to ASN. A five-year agreement signed by ASN and IRSN determines the technical support procedures, which involve more than 400 staff. It is described every year in a protocol which fine-tunes priorities according to the nuclear safety and radiation protection issues.

IRSN is ASN's technical support organisation. In concrete terms, the licensees submit authorisation application files to ASN. In order to prepare its decision, ASN can refer the matter to IRSN, which produces a technical opinion. To review the matter referred to it and produce its technical opinion, IRSN conducts exchanges with the licensee as and when needed. The technical opinion produced by IRSN is reviewed by ASN and, depending on the subjects, by the Advisory Committees. The IRSN opinions are made public.

### 8.2.2 Advisory Committees of experts

In preparing its resolutions, ASN relies on the Advisory Committees’ opinions and recommendations.

Height Advisory Committees (GPE) have been set up and report to the ASN Director General. The GPE are consulted by ASN regarding the nuclear safety and radiation protection of facilities and activities within their area of competence: nuclear reactors, laboratories and plants using radioactive materials, facilities undergoing decommissioning, radiation protection in medical facilities, radiation protection in facilities other than medical, waste, transport and nuclear pressurise equipment.

For each of the subjects covered, the Advisory Committees study reports prepared by IRSN or other duly mandated expert, by a working group created for the occasion or by one of the ASN entities. They issue an opinion together with recommendations.

The GPE comprise experts individually appointed for their competence, from industrial, university and association backgrounds. For several years now, ASN has been making efforts to diversify these experts. Each GPE may call upon any person recognised for his or her particular competence. It may also conduct a hearing of the licensee’s representatives. The participation of foreign experts can input more diverse approaches to problems and benefit more widely from international experience.

With the aim of improving the transparency of nuclear safety and radiation protection, ASN publishes the documents relating to Advisory Committee meetings, more particularly their opinions and the position adopted by ASN. The summary of the instruction reports of IRSN presented to the Advisory Committees of experts are also published.

## *8.3 The other nuclear safety and radiation protection stakeholders*

### 8.3.1 The Parliamentary Office for the Evaluation of Scientific and Technical Choices (OPECST)

The OPECST was created in July 1983 and is tasked with informing Parliament of the consequences of scientific and technological choices so that it can take informed decisions. The Parliamentary Office is assisted by a Scientific Council made up of 24 members who reflect the diversity of the scientific and technical disciplines.

The hearings open to the press are a well-established tradition within the OPECST. Then enable all interested parties to express an opinion, put forward their arguments and hold a public debate on a given topic, under the supervision of the OPECST rapporteur.

ASN presents its Report on the State of Nuclear Safety and Radiation Protection in France to the OPECST every year.

### 8.3.2 The High Committee for Transparency and Information on Nuclear Security (HCTISN)

In matters of nuclear safety and radiation protection, the TSN Act created the HCTISN, an information, consultation and discussion body for the risks linked to nuclear activities and the impact of these activities on human health, the environment and nuclear safety.

The High committee can issue an opinion on all questions in these fields, as well as on the relevant controls and information. It may also examine all questions concerning the accessibility of information on nuclear safety and propose all measures such as to guarantee or improve nuclear transparency.

Any question concerning information about nuclear safety and its regulation and oversight can be referred to the High Committee by the Minister with responsibility for nuclear safety, by the chairmen of the competent committees of the National Assembly and the Senate, by the Chairman of the OPECST, by the chairmen of the local information committees or by the BNI licensees.

The Chairman of the High Committee is appointed by decree from among members of Parliament, representatives of the local information committees and public figures chosen for their competence.

With the support of ASN, IRSN, EdF and the national association of local information committees and commissions, the HCTISN has set up a consultation on the continued operation of 900 MWe reactors.

In 2017, the HCTISN issued two opinions:

- public information and transparency measures on manufacturing anomalies in the Flamanville 3 EPR pressure vessel;
- carbon concentration anomalies in some steam generators in EdF reactors.

### 8.3.3 The Nuclear Safety and Radiation Protection Mission (MSNR)

The Nuclear Safety and Radiation Protection Mission (MSNR) is a ministerial department handling files under Government jurisdiction within the field of nuclear safety and radiation protection.

The MSNR thus:

- prepares general regulatory texts, jointly with ASN;
- coordinates the individual administrative procedures under the jurisdiction of the Ministers;

- provides secretariat services for the HCTISN (see § 8.3.2);
- ensures the consistency of regulatory texts between BNIs and Installations Classified for Protection of the Environment (ICPE);

### 8.3.4 The French High Council for Technological Risk Prevention (CSPRT)

The CSPRT assists the Ministers responsible for Installations Classified for Protection of the Environment (ICPE), for nuclear safety and for industrial safety. One of its duties is to examine any draft regulation or any question concerning BNIs that the Ministers responsible for these subjects or the ASN considers should be submitted to it.

The CSPRT gives its opinion in all cases where the law or regulations so require, notably on draft decrees provided for in Article L. 593-2 of the Environment Code.

### 8.3.5 The Local Information Committees (CLI).

The CLIs, which creation is of the responsability of the President of the Conseil Départemental and comprising elected officials, associations, trade unions, qualified personalities and representatives from the economic world, have a general duty to monitor, inform and discuss nuclear safety, radiation protection and the impact of nuclear activities on people and the environment with regard to the facilities that concern them.

The “TECV Act” expanded the remit of the CLIs, which can notably ask the licensee to organise visits of the BNIs or to organise visits of facilities after an appropriate waiting period following incidents rated level 1 or higher on the INES scale. CLIs must must organise once a year a public meeting that is open to all

The CLIs of nuclear sites situated in *départements* bordering other countries are open to the members of the neighbouring countries. Decree 2019-190 of 14th March 2019 codified the provisions applicable to BNIs, the transport of radioactive substances and transparency on nuclear matters in the Environment Code (see § 7.1.2). It also incorporates new provisions concerning CLIs into this code.

The texts concerning individual measures for BNIs (creation authorisation or decommissioning decree for instance) are the subject of a hearing of the licensee and the CLI by ASN, as specified in an ASN resolution of 13th April 2010.

# 9. Article 9: Responsibility of a licence holder

*Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.*

## *9.1 Prime responsibility for the safety of a BNI*

The French nuclear safety organisation and regulations are based on the responsibility of the licensee. This principle of licensee prime responsibility is defined by the Environment Code.

The BNI order also deals with the licensee's integrated management system and requires that this latter define and implement a management system enabling it to ensure that the requirements concerning protection of the interests of the BNI system are systematically taken into account in all decisions concerning its facility.

On behalf of the State, ASN ensures that this responsibility is assumed in full, in compliance with the regulatory requirements. The interaction between the respective roles of ASN and the licensee is as follows:

- ASN defines the general safety and radiation protection objectives;
- the licensee proposes and substantiates the technical means of achieving them;
- ASN checks that these means enable these objectives to be achieved;
- the licensee implements the approved measures;
- by means of inspections, ASN checks correct implementation of these measures and draws the corresponding conclusions.

## *9.2 Transparency and public information by the licensees*

### 9.2.1 Measures taken by EDF

As a responsible industrial firm and being aware of the specific nature of the nuclear power generating activity, EDF has, since the beginning of operation of the NPPs, always sought to inform the public about the operation of the facilities, technical events and activities concerning this form of energy in general and safety aspects in particular.

EDF's policy aims to ensure that dialogue and transparency result from clear and accurate information about events and their potential impacts. This policy of dialogue and transparency is sought and maintained with the staff and its representatives, the subcontractors, the oversight bodies, the local communities, especially the CLIs, (see § 8.3) and all other nuclear safety stakeholders.

For example, these transparency and communication actions take a variety of forms: annual report, CLI meetings and thematic visits, meetings with elected officials, press releases, monthly newsletters, public information centre, website (www.edf.com), toll-free telephone number, and answering public queries about the safety, radiation protection and environmental protection measures taken.

Article L.125-15 of the Environment Code more particularly requires that each site publish an annual report more specifically describing the steps taken concerning nuclear safety and radiation protection, nuclear safety and radiation protection incidents and accidents, the nature and results of radioactive and non-radioactive environmental discharge measurements, the nature and quantity of radioactive waste stored on the facility site. This report is made public and transmitted to the CLI set up for each site.

EDF also takes part in the work of the HCTISN.

### 9.2.2 Measures taken by CEA

CEA keeps the committees regularly informed of research activities, of the changing regulatory situation of the facilities and of any events concerning nuclear safety and radiation protection. A CLI (see § 8.3.5) is in place for each CEA centre.

The follow-up to the Fukushima Daiichi NPP accident, more specifically the stress tests, was the subject of special presentations by CEA and was widely discussed within the CLIs.

The CEA general management takes part in the annual meeting of the representatives of all French CLIs for the EDF, Orano and CEA facilities.

For the review of the RAPSODIE reactor decommissioning file, CEA, its Cadarache centre in particular, took part in the public inquiry and the hearings organised by the State services concerned, as required by the procedure.

CEA takes part in the work of the HCTISN.

### 9.2.3 Measures taken by ILL

The ILL participates in a large number of actions to promote transparency and public information, more specifically:

- participation in the plenary meetings and public meetings of the CLI;
- participation in the industrial risks regional information campaigns;
- updating its website (www.ill.eu) with information concerning legislation, reactor safety, environmental monitoring, security, inspections, emergency exercises and incidents. The follow-up to the Fukushima Daiichi NPP accident is the subject of detailed presentations. Question-and-answer sections were included.
- participation in technical and scientific forums;
- public meetings with the municipalities and local companies.

# E – General safety considerations

## 10. Article 10: Priority given to safety

*Each Contracting Party shall take the appropriate steps to ensure that all organisations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety.*

### *10.1 ASN requests*

In accordance with the duties entrusted to it, ASN from the outset asked the BNI licensees to adopt an organisation ensuring that priority is given to nuclear safety.

By enshrining it in the legislation, Ordinance 2016-128 of 10th February 2016 reinforced the requirement on a BNI licensee to give priority to the protection of the protected interests[2] and the permanent improvement thereof. The law also requires the licensee to formally define its corresponding policy in a document which must explicitly stipulate this priority. The licensee must finally set up and formally define an integrated management system ensuring that the requirements concerning the protection of the protected interests are taken into account in the management of its facility.

Historically, this safety management system is more particularly based on a quality assurance approach and on the development of a nuclear safety culture. Safety management must be integrated into the company's management system in order to guarantee protection of the interests mentioned by the Environment Code, while giving priority to the prevention of accidents and the mitigation of their consequences.

### *10.2 Measures taken for nuclear power reactors*

Nuclear licensee responsibility for nuclear reactors within EDF is described in appendix 3. The integrated management system is explained in § 13.2.

Given the importance of all EDF's nuclear activities in France, but also in Great Britain and the United States, EDF has adopted a Nuclear Safety Policy which applies to all its activities within each Group company operating nuclear facilities (design and construction of new projects, operation of existing fleets, maintenance, waste management, dismantling).

This policy, which is inspired by international guidelines and safety requirements (IAEA SF N° 1 and GSR Part 2, INSAG 4 for safety culture, INSAG 13 for safety management, INSAG 18 for change management), aims to reaffirm the priority given to safety within the Group and to help each manager clearly embody this, with the involvement of the industrial partners.

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[2] As defined in the Environment Code, these are interests vis-a-vis risks and detrimental effects that the licensee's activities could present for public health and safety or protection of nature and the environment.

The responsibility for implementing this policy in each professional sector and each company lies with the corresponding managerial line. It reaffirms the priority given to safety, to allow the sustainable use of nuclear energy, with strong commitments in terms of behaviour and safety culture, the search for constant progress, openness to international best practices, preparedness for emergency situations and transparency and dialogue. This policy is disseminated to each member of staff and to each contractor.

An independent safety assessment is carried out on each site, on each company and on the EDF Group. In France, it is carried out: by the safety quality mission in the NPPs, by the director delegate for safety and the nuclear inspectorate at the Division of Nuclear Production (DPN), by the general inspectorate for nuclear safety and radiation protection reporting to the Group CEO.

In addition to this EDF group safety policy, the DPN, the Division for Nuclear Fuel (DCN) and the Division of Engineering and New Nuclear Projects (DIPNN) have established an Integrated Management policy to cover the protection of interests, over and above just safety. In order to more closely comply with the requirements of the regulations, each BNI of the DPN has adopted a formal protection of interests policy, confirming the priority given to protection of the protected interests and the constant improvement thereof. This policy of protection of the interests of the BNIs of the DPN is taken into account by the national units carrying out activities important for protection (AIP) on behalf of a BNI, as well as by the contractors working on the BNIs.

In order to ensure that the required priority is given to safety, EDF set up a system based on defence in depth as of the beginning of operation of its facilities (in particular a quality approach with risk assessment, inspection and verification, an independent safety system) which was reinforced over time in order to ensure continuous progress, by integrating the lessons learned from operating experience feedback and best practices in the nuclear industry.

In order to meet the two-fold goal of safety management (INSAG 13, 1999) – improve safety results and reinforce the safety culture – the traditional arrangements have been added to since the early 2000s in two areas:

- “manager practices”, with the deployment of the Safety Management Guide, built around 3 key principles: safety leadership, development and engagement of the personnel and continuous improvement,
- “personnel practices”, with the development of work error-reduction practices (pre-job briefing, stop-and-think pause, self-check, cross-check, secure communication, debriefing).

On the basis of international practices and its own convictions on this subject, EDF produced:

- a safety culture guide, which presents the traditional approach followed by EDF and the common points of reference in terms of safety culture;
- a range of tools making it possible to determine a position, to debate and discuss safety practices within a unit, the departments and the safety teams.

## *10.3 Measures taken for research reactors*

### 10.3.1 CEA reactors

Nuclear safety is a priority at CEA. It is based on:

- a clear organisation, in which each player, at each level, is trained in, made aware of and given responsibility for the role which is clearly assigned to him or her (refer to the organisation chart in appendix 3, §3.2);
- a safety culture that is taught, maintained and developed;
- staff that are professional, skilled and capable of teamwork.

At the central level, the Chairman sets the broad safety guidelines and defines measures designed on the one hand to implement the legislative, regulatory and specific provisions applicable and, on the other, CEA's nuclear safety management. The Chairman also makes final strategic decisions.

With regard to nuclear safety, radiation protection and transport, the Chairman is assisted by the nuclear safety and security division. For the CEA, this division defines safety policy, which is based on a constant progress approach.

The nuclear energy director, assisted by the quality and environment division of the DEN, implements and monitors application of the CEA safety policy in all the facilities.

Existing doctrine is more specifically collated in the CEA nuclear safety manual.

At the local level, the centre directors and facility managers comprise the management hierarchy; they ensure that the defined safety policy is applied in each facility for which they have responsibility.

The monitoring function is carried out by entities independent of those constituting the management hierarchy. The monitoring function consists in verifying the efficiency and adequacy of the actions taken and of the internal technical controls. General nuclear safety support units provide the facilities with assistance in the centres.

At the level of the Chairman, the monitoring function is performed by the General and Nuclear Inspectorate (IGN). The IGN carries out scheduled inspections and reactive inspections in response to significant events. The IGN Director may decide on the inspectorate's intervention on relevant topics.

The measures taken by CEA to ensure safety take account of the wide diversity of its facilities, resulting from the variety of research programmes it carries out, how they develop over time and the consequent diversity of potential risks. Since 2006, CEA has adopted a safety policy which is implemented through a three-year safety improvement plan. This approach has led to contracts which formally define precise safety and radiation protection targets and the associated means. CEA also committed to a self-assessment approach based on a certain number of indicators for monitoring safety and the correct working of the organisation.

CEA has reinforced the organisational and radiation protection arrangements in the operations performed by outside contractors.

CEA is also continuing to reinforce certain areas for progress, including:

- the organisation of the technical support provided to the facilities in certain areas of expertise, such as earthquakes, civil engineering, criticality and human factors;
- organisational arrangements concerning management of contractors;
- the organisation of decommissioning operations.

### 10.3.2 The ILL high-flux reactor (HFR)

Nuclear safety has always been and remains the priority at ILL. The level of safety reached by ILL is based on the following organisation:

- a radiation protection-safety-environment unit reporting directly to the Institute's Director;
- a quality-risk-safety unit reporting directly to the senior management;
- a reactor division, the head of which, with authority delegated by the director, is responsible for the operation and safety of the reactor and its auxiliaries.

The management of the equipment and activities important for protection (EIP and AIP) is defined in the integrated management system, in accordance with the BNI Order.

## *10.4 ASN analysis and oversight*

### 10.4.1 ASN

In the name of the State, ASN ensures the regulation and oversight of nuclear safety and radiation protection to protect people and the environment.

In order to exercise its responsibilities and to ensure progress in nuclear safety and radiation protection, ASN must implement consistent actions that are commensurate with the issues involved. In order to do this, ASN relies on its values (independence, competence, rigorousness, transparency), on the commitment of its personnel and on a policy of continuous improvement. ASN carries out its oversight role by using the regulatory framework and licensing decisions, inspections, and if necessary, enforcement measures, in a way that is complementary and tailored to each situation, to ensure optimal control of the risks that nuclear activities represent for people and the environment. ASN's aim is to exercise regulation and oversight that is recognised by the citizens and seen as a benchmark internationally.

During the course of 2017, ASN worked on an in-depth overhaul of its strategy and on adapting its regulation and oversight methods to present and future issues and challenges. All of the ASN personnel contributed to drafting a new three-year strategic plan and a new oversight policy, which has been implemented on a daily basis since 2018. The oversight policy thus defined places the emphasis on reinforcing a graded approach to regulation and oversight. Two parameters must be taken into consideration when evaluating regulation and oversight priorities: on the one hand, the risks to individuals and the environment inherent in the activities and, on the other, the behaviour of those responsible for the activities and the means they deploy to control these risks.

The quality management system (QMS) promotes the involvement of everyone in the performance of ASN's duties. With the full endorsement of the ASN Commission and the Director General's Office, the QMS has the following objectives:

- to define means to enable us to perform our duties: the QMS sets out clear rules for everyone; it promotes the consistency of our actions nationwide and the exercise of individual responsibilities on a day to day basis;
- to improve the efficiency of our actions: monitoring, audit and review arrangements are able to identify areas for improvement and best practices for the performance of our duties.

More specifically, ASN regularly hosts IRRS missions:

- in 2006, an IRRS mission covering all of its activities,
- in 2009, a follow-up mission,
- in 2014, an IRRS mission covering all of its activities,
- in 2017, a follow-up mission (from 1st to 9th October 2017): 40 of the 46 recommendations and suggestions made following the 2014 mission were closed or considered to be closed by the follow-up mission “subject to completion of the measures currently under way”. The IAEA final report was transmitted to France in March 2017 and posted on the ASN website.

ASN also takes part in IRRS missions to other safety regulators abroad, which also enables it to take advantage of international best practices in order to advance nuclear safety and radiation protection in France.

### 10.4.2 The licensees

ASN’s oversight of the BNI licensees’ safety management policy and system (both local and national) is carried out at several levels:

- verify that the commitments made by the licensee are met, in particular when they lead to concrete measures being taken in the facilities concerned;
- during reviews of generic subjects with major implications, examine the organisations put into place by the licensee and how they function, including from the managerial standpoint;
- analyse the methods for assessing the effectiveness of licensee safety management, the improvement solutions that they identify and the gains achieved by the organisational modifications implemented.

ASN’s actions in this field are presented in the following chapters, chapter 12 in particular.

# 11. Article 11: Financial and human resources

*Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.*

*Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life.*

## *11.1 Financial resources*

### 11.1.1 ASN requests

The Environment Code requires that, when creating a BNI subject to authorisation, "the authorisation takes account of the technical and financial capacities of the licensee". These capacities must enable it to carry out its project while protecting the interests mentioned, "in particular to cover the costs of decommissioning of the installation and rehabilitation, monitoring and maintenance of its site or, for radioactive waste disposal facilities, to cover the costs of final shutdown, upkeep and surveillance".

The BNI order requires that the licensee have adequate resources - specifically financial resources – for defining, implementing, maintaining, evaluating and improving an integrated management system. It also requires that the licensee have adequate resources to implement the policy for public health and safety and protection of nature and the environment.

In addition, the 28th June 2006 Act creates an arrangement for ring-fencing funds to meet the costs of decommissioning nuclear facilities and managing radioactive waste.

The legal arrangement aims to secure the funding for nuclear costs, in compliance with the "polluter-pays" principle. It is therefore up to the nuclear licensees to cover the cost of this funding, by creating a portfolio of specific assets able to cover the anticipated costs. This is done under the direct control of the State, which analyses the licensees' situation and can prescribe the measures necessary if the identified resources are found to be insufficient or inadequate. In any case, the nuclear licensees remain responsible for adequate financing of their long-term costs.

The legal arrangements require that the licensees make a prudent assessment of the cost of decommissioning their facilities or, for radioactive waste disposal facilities, their final shutdown, upkeep and surveillance costs. They also evaluate the cost of managing their spent fuel and their radioactive waste. They thus submit three-yearly reports and annual updates.

### 11.1.2 Measures taken for nuclear power reactors

With a net installed power of 129.3 GWe around the world as at 31st December 2018, for global production of 580.8 TWh, the EDF Group has one of the world's largest production fleets and, among the planet's ten largest energy producers, it operates the fleet with the lowest $CO_2$ emissions per kilowatt-hour produced, thanks to the share of nuclear energy (72.9 GWe), hydraulic energy (21.5 GWe) and other renewable energies (9.4 GWe) in its production mix.

In 2017, the Group achieved consolidated sales of 69.6 billion euros, an EBITDA of 13.7 billion euros and a Group share of net income of 3.2 billion euros.

In mainland France, the net production of electricity by EDF in 2017 was 424.7 TWh, of which 379.1 TWh was nuclear (63.1 GWe installed capacity), 29.5 TWh hydraulic (19.8 GWe) and 16.1 TWh thermal (9.4 GWe),

With regard to nuclear production in France, the EDF Board gave its approval in principle to the "*Grand carénage*" major overhaul programme in early 2015, the aim of which is to renew the French nuclear fleet, increase the safety level of the reactors and, if the relevant conditions are met, extend their operating lifetime. The total amount of the investments, initially evaluated at 55 billion $euros_{2013}$, or 60 billion euros in present-day terms, between 2014 and 2025 for the 58 reactors in service, was re-evaluated at 45 billion $euros_{2013}$, or 48.1 billion euros in present-day terms.

This industrial programme is being gradually implemented in order to meet the objectives of the Energy Transition Act, multi-year energy planning, the ASN opinions and requirements and the authorisation procedures involved in allowing reactor operation beyond 40 years.

In this context, EDF will continue with a large amount of work and aims to ensure the long-term future of its technical and industrial assets, through measures that are technical as well as organisational and human. The programmes to renovate or replace large components in the NPPs, such as electricity generators, transformers or steam generators, will continue.

Furthermore, to secure financing of its long-term nuclear commitments, EDF has in the past few years set up a portfolio of assets exclusively devoted to meeting provisions linked to dismantling of the NPPs and to the back-end fuel cycle facilities (long-term management of radioactive waste, share of the provision for the last NPP cores concerning the future cost of long-term management of radioactive waste). As at 31st December 2017, these dedicated assets represented a value of 25.9 billion euros.

EDF considers that all of the above shows that adequate financial resources are available to ensure the safety of each nuclear facility throughout its lifetime.

### 11.1.3 Measures taken for research reactors

#### 11.1.3.1 CEA reactors

More than 33 million euros are devoted every year to the safety of CEA's research reactors. This evaluation does not include the works to be performed within the context of the stress tests.

As required by the regulations for all nuclear facilities, CEA makes provision for budgets to cover the future decommissioning of its research reactors. The decommissioning costs are re-evaluated every 3 years.

#### 11.1.3.2 The ILL high-flux reactor (HFR)

The annual budget of the ILL is about €90M, 20% of which is devoted to investments, both for major maintenance work, upgrades or new work on the reactor, and for continuous modernisation of the scientific instruments.

As with CEA, the ILL must make provision for a budget for the future decommissioning of the RHF. This budget is re-evaluated every 3 years.

### 11.1.4 ASN analysis and oversight

#### 11.1.4.1 The nuclear power reactors

Since 2000, EDF has undergone a series of changes, during which the domestic market and its statutes were modified. In late 2005, the company was partially privatised, with the State retaining an 83.7% stake as at 30th June 2018 and the legislative framework stipulating that it must hold at least 70% of the capital and voting rights.

In its dialogue with ASN, the licensee reaffirms that cost control remains a concern, particularly with regard to economic feasibility, the justification of certain requests or certain schedules and the handling of very urgent issues during reactor outages.

Pursuant to Article L. 594-4 of the Environment Code, the BNI licensees send a report to the administrative authority every three years, describing their evaluation of the costs mentioned in Article L. 594-1 of the Environment Code, the methods applied to calculate the provisions corresponding to these costs and the choices made regarding the composition and management of the assets dedicated to covering these provisions.

These reports, the last of which were submitted in 2016, are reviewed by the Directorate General for Energy and Climate, within the Ministry of the Ecological and Solidarity-based Transition. In addition, the licensees are required to submit annual updates of this three-yearly report.

Generally speaking, the methodology for evaluating decommissioning costs must be explained in detail. The uncertainties surrounding decommissioning and waste management operations, with an impact on the costs, must be clarified. ASN and the Ministry for Ecological and Solidarity-based Transition in particular identified the fact that greater account must be taken of the cost of soil remediation during installations decommissioning, as must the impact of possible delays in the availability of radioactive waste processing, packaging, storage or disposal facilities. The next reports shall take account of progress made regarding the Cigeo and LLW-LL (low level, long-lived waste) waste disposal projects, the creation of a second very low level (VLL) waste disposal centre and the creation of new radioactive waste and spent fuel storage capacity.

#### 11.1.4.2 Research reactors

Research facilities are frequently operated by major public research organisations. Their resources are thus sensitive to the context of the State Budget. If the funding source, represented by the State, provides certain guarantees, it also sometimes leads to decisions that could compromise the future of certain research facilities. The renovations and upgrades to meet current safety requirements, following periodic safety reviews, often entail extensive work and remain difficult. These operations can thus take several years. ASN ensures that budgetary constraints have no impact on the safety and radiation protection of research facility operations.

ASN considers that the result of the “major commitments” implemented by CEA since 2007 is on the whole positive, even though certain actions were postponed and the scope of certain commitments has been reduced, owing to the need for additional technical developments.

## *11.2 Human Resources*

### 11.2.1 ASN requests

It is up to the licensee of a BNI to have sufficient, appropriate and qualified human resources. The regulations more generally concerning the human resources that must be available to the licensee of a BNI are more particularly contained in the Environment Code and the BNI Order.

In addition, the BNI order states that "the activities important for protection, their technical control, the verifications and assessments are carried out by persons with the necessary skills and qualifications". The licensee must therefore adopt appropriate training procedures in order to maintain and develop the skills and qualifications of its own personnel or those of outside contractors.

### 11.2.2 Measures taken for nuclear power reactors

At the end of 2018, the workforce of EDF's Nuclear Operations Division (DPN), responsible for operating the nuclear reactors, stood at 22,685, spread among the 19 NPPs in operation, one unit under construction (FLA3) and the 2 national engineering units. Engineers and managers represent 36% of the workforce (8,235 staff), supervisors 60% (13,510 staff) and operatives 4% (940 staff).

To these 22,685 staff must be added EDF's human resources devoted to design, to new constructions, to engineering of the NPPs in service and to the support functions and to dismantling of nuclear reactors:

- about 5,670 engineers and technicians in the engineering centres split among management (80%) and supervisors (20%);
- nearly 230 engineers and technicians from the nuclear fuel division (DCN);
- more than 750 engineers and technicians from EDF's research and development division (EDF R&D).

For the development of a safety culture, the accountability policy implemented within the company means that a vast majority of the personnel devotes a significant percentage of their time and activities to nuclear safety and radiation protection.

If one considers only those whose role and duties exclusively concern nuclear safety, more than 450 persons are involved.

The number of personnel devoted to security and radiation protection activities stands at about 1,100.

Since 2006, EDF has been devoting considerable efforts to guaranteeing the skill levels and the careers of the staff, by adopting a succession planning (GPEC) approach, based on harmonised principles for all the NPPs, built up gradually from actual feedback from the field. These aspects are the subject of specific monitoring, coordination and oversight.

Between 2008 and 2018, the DPN experienced a significant renewal of its human resources, with considerable turnover (12,000 new arrivals). Until 2015, the rise in the numbers of staff undergoing training was considerable, with an increase in headcount (nearly 24%, up from 18,750 to 23,250 over the period) to address: performance improvements, regulatory changes and the aftermath of the Fukushima Daiichi NPP accident, preparation for the start-up of the Flamanville 3 EPR and the operating life extension with deployment of the *Grand Carénage* major overhaul programme. Since 2015, the number of staff undergoing training has decreased, as they completed their courses.

After a considerable upsurge owing to the extensive personnel turnover, the volume of training (3 million hours in 2015) is now falling (2.3 million hours in 2018) because the initial number of courses is falling. Skills management at the DPN is today based on operating experience feedback from the other international licensees. Training committees were set up at the various management levels, more specifically to allow reactive training to be carried out. Mock-up spaces for training prior to intervention by EDF and contractor personnel are in place on virtually all sites and the Systematic Approach to Training (SAT) is being gradually deployed in those disciplines with safety implications. This system focuses on improving the quality of maintenance and operation.

With regard to nuclear engineering, a "Skills Development Plan" (PDC) approach has since 2006 involved all the units concerned (engineering, production, R&D). This approach aims to develop the skills of the engineering disciplines and, through a cross-cutting, forward-looking approach, helps the units prepare their succession planning choices.

New engineering arrivals follow a 5-week training course on fundamental nuclear engineering know-how (operation, safety and quality culture, security and radiation protection, etc.). In addition, continuous training procedures exist to enable all staff to develop their skills in the various engineering fields. Each individual training plan is reviewed annually. A specific one-week "design safety" course presents the main problems of the design safety approach.

### 11.2.3 Measures taken for research reactors

#### 11.2.3.1 CEA reactors

At least one experienced safety engineer is on duty in each facility. The facility also has personnel with criticality expertise. The teams are sized according to the scale of the facility.

In accordance with the requirements of the BNI order, the skills of the persons assigned to positions that are important for the safety of a BNI must be guaranteed.

Prior to taking up their duties, the facility heads follow specific training covering the following aspects: management of staff and operations, nuclear safety at CEA, the operational legal responsibilities of the licensee, radiation protection and waste management.

Furthermore, safety issues are monitored, supervised and coordinated by the following various contributors:

- the nuclear safety unit within each centre;
- the nuclear security and safety department.

For certain aspects of technical dossiers, experts can be called on from one or more of the centres of expertise created by CEA and run by the DSSN.

The human resources needed for this work requires from 10 to 20 engineers on each site.

#### 11.2.3.2 The ILL high-flux reactor (HFR)

In order to meet safety requirements, the ILL has significantly increased the size of its teams and the ILL now has two engineers in its safety unit, reporting to the head of the reactor division, and three engineers in the safety quality-risk unit, reporting to the senior management. A third safety engineer is currently being hired.

For surveillance of the facility and radiological monitoring of the personnel, the radiation protection unit comprises 9 staff under the authority of a radiation protection engineer.

For environmental surveillance, the ILL set up a new laboratory in 2010, employing 7 technicians under the responsibility of an engineer.

In order to carry out the post-Fukushima actions, the ILL set up a project structure which utilises both the services of the ILL and personnel from outside contractors. An additional safety engineer was hired for the duration of this project.

### 11.2.4 ASN analysis and oversight

ASN oversight of human resources is based on inspections and assessments conducted with the support of IRSN and the Advisory Committees, covering the subjects of human and organisational factors (see chapter 12) and safety management (see chapter 10). Human resources are also checked during the inspections concerning BNI construction and decommissioning.

**Nuclear power reactors**

The success of the large-scale turnover faced by EDF entails an unprecedented effort in terms of training and support for the new hirings.

ASN considers that the skills management organisation in place on the sites is well-documented and coherent. Inadequacies on certain sites are however still being found during the inspections, concerning succession planning (GPEC) in preparation for personnel turnover.

Generally speaking, the training programmes are run satisfactorily and the deployment of the professional sector academies is identified as being a strong point for the training of new arrivals on the sites.

**Research reactors**

ASN considers that skills management in the key positions for research reactors is satisfactory. It should however be noted that CEA makes extensive use of subcontracting for related activities, such as waste management and decommissioning work. ASN will remain vigilant to ensuring that the specific skills necessary for monitoring these subcontracted activities are maintained and developed. On the Cabri reactor, for which IRSN takes part in designing the experimental programmes, sharing of knowledge between CEA and IRSN was considered by ASN to be satisfactory. Maintaining skills is also a major issue for the RJH reactor, in order to ensure the continuity of skills between the construction and future operation phases. ASN pays close attention to this point. Finally, for research reactors being decommissioned or being prepared for decommissioning, the number of which is rising, ASN is paying very close attention to ensuring that a historical record of the facility is maintained.

# 12. Article 12: Human factors

*Each Contracting Party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation.*

## *12.1 ASN requirements*

ASN expects organisational and human factors (OHF) to be integrated appropriately for the safety issues identified by the licensee, in the following fields of activity:

- engineering activities, during the design of a new facility or the modification of an existing one;
- the activities carried out for operation of existing facilities, throughout their service life;
- the compilation of experience feedback concerning reactor design, construction and operation.

Organisational and human factors received particular attention during the stress tests performed in France.

## *12.2 Measures taken for nuclear power reactors*

The way in which organisational and human factors (OHF) are taken into account in the engineering and operating activities comprises two main aspects:

- implementation of the Socio-Organisational and Human (SOH) impacts analysis in any design, modification and decommissioning project with safety implications;
- accompanying of the operating improvement measures by HF experts working with the operating personnel: Human Factors Consultants on the sites and EDF's national experts (UNIE - Operation Engineering Unit, R&D).

**SOH approach in engineering:**

Following on from what has been done since the end of the 1980s in new design projects, the SOH approach was initiated in 2006, to ensure that human and organisational aspects are taken into consideration in any technical, documentary and organisational changes.

After nearly 10 years of construction and deployment of this approach, the following progress can be observed today:

- an SOH expert is present in each engineering unit, providing expertise to senior management and project managers,
- oversight of projects and files within the units, identifying the designs/changes with SOH implications and ensuring that the necessary measures are taken in all phases up to deployment in the fleet,
- changes in the practices of the design managers, incorporating human and organisational aspects, jointly with the licensee and with the support of internal and external expertise, in particular for the field analyses, the validation phases, and to define the change management actions with the licensee,
- a key role for the plant series structures, to ensure cooperation between engineering and licensee in the design/change work,

- gradual implementation, with coverage of projects with major stakes: PSR, EPR UK, Grand Carénage, Colimo3, post-Fukushima or safeguard projects.

**Operational HF consultants:**

The incorporation of OHF aspects during operations is extensively supported by the work of the site HF Consultants and by the national teams (UNIE – Operation Engineering Unit, R&D). One or two HF consultant(s) are present on each site (one HFC per pair of reactors). Their work is usually relayed by HF correspondents in the departments.

Their duties cover three main fields: development of safety management and the safety culture, improvement of socio-technical and organisational situations, development of Human Factors skills.

Over the last few years, they have been particularly present during the initiatives concerning safety management and the safety culture: new method of events analysis, change in risk analysis, support in human performance practices, putting in place operational decision making, safety culture image projection.

## *12.3 Measures taken for research reactors*

### 12.3.1 The CEA reactors

Since 2008, CEA has set up an organisation dedicated to organisational and human factors. It comprises:

- specialists in the nuclear safety and protection department and in the safety support units of the CEA centres;
- contacts in the facilities, more specifically for each research reactor;
- correspondents in the monitoring units reporting to each centre director.

The specialists make up the centre of expertise which coordinates the network of OHF players. The latter organise a day each year to discuss OHF experience through testimonials from CEA employees and third-party contributors.

Actions are focused on several areas:

- The performance of OHF studies in several facilities, following the emergence of identified problems or incidents;
- The performance of systematic OHF interventions during the periodic safety reviews, more specifically concerning the operational management phases and the operations relating to the handling of fuel and experimental devices.
- The integration of OHF into the various steps of the new facility design projects.

The revised versions of three technical data sheets concerning respectively the integration of OHF in the analysis and handling of significant events, in the periodic safety reviews and in the design or modification projects, were published between 2016 and 2018.

[3] The Colimo project aims to modernise the lock-out methods in order to enhance safety and improve the peace of mind of those involved in operation and maintenance.

Training courses on the consideration of OHF in activities presenting both safety implications and a significant OHF component continued, and training in the integration of OHF into events analysis was provided in the various CEA centres.

With regard to R&D, the CEA continued its cooperation with the Institute for Energy in Halden (Norway) on the subject of operational management and MTO (Man Technology Organisation), and its partnership agreement with the Ecole des Mines of Paris on the study of mechanisms for monitoring the activities of quasi-integration service providers and the transmission of knowledge during transitions between two service providers.

Discussions external to the CEA were held:

- within the IMdR (Risk Control Institute) on the subject of “Organisation and control of risks”;
- at bi-annual meetings and at the "Human Performance" workshop of the “Working Group on Human and Organisational Factors” (OECD-CSNI-WGHOF).

### 12.3.2 The high flux reactor (HFR) at the ILL

The measures taken by the HFR in the field of OHF broadly follow those of the CEA. The two institutions have regular interchanges on this subject.

## *12.4 ASN oversight and analysis*

### 12.4.1 Organisational and human factors in nuclear power reactor operations

ASN monitors the steps taken by the licensee to improve the integration of organisational and human factors (OHF) into all phases of the NPP lifecycle.

With regard to the engineering activities during the design of a new facility or the modification of an existing one, ASN checks that the licensee correctly deploys the SOH approach enabling it to take account of people and organisations in the development of systems and in the changes to equipment and organisations.

ASN observes that the efforts made to deploy the SOH approach, in particular in all the engineering centres, must be continued in order to achieve the desired effects.

ASN also checks the activities carried out for the operation of existing NPPs, throughout their service life. ASN in particular checks the steps taken by the licensee to incorporate organisational and human factors on a day to day basis, the organisation of work and the intervention conditions by the EDF or subcontractor personnel, all of which can have an impact on the safety of facilities and workers, along with skills, training and qualifications management carried out by the licensee.

ASN notes that on the whole there is now greater presence of EDF managers in the field, mainly to disseminate and implement managerial policies and requirements. The realities in the field should however be better taken into account by site management.

Finally, ASN checks the analysis of operating experience feedback concerning reactor design, construction and operation. In particular, ASN checks EDF’s organisation for analysing events, the methodology employed and the depth of the analyses carried out to ensure that the underlying causes (organisational and human) of events are looked for and, lastly, the development and implementation of the follow-ups to the analyses, whether in the short, medium or long term. Root cause analysis should be further developed to identify organizational weaknesses.

ASN considers that the organisation and the specific actions to improve the integration of OHF in the operational activities vary from one site to another.

### 12.4.2 Organisational and human factors in the operation of research reactors

The CEA has created an OHF network of 80 people including 11 specialists attached to its Department of Security and Nuclear Safety (DSSN) (see appendix 3). The personnel are distributed among the central services and the operational units. It provides support and assistance for the operational units and contributes to the production of internal directives and guides. Although ASN considers this initiative satisfactory, it believes that the strategy for taking organisational and human factors into account in the safety policy can be further improved. In 2011, ASN adopted a position on the CEA's safety and radiation protection management file, which underwent an assessment by the Advisory Committees of Experts in 2010. The next five-yearly assessment of the CEA's safety and radiation protection management was submitted in the first quarter 2019. The subject will be reviewed by the Advisory Committee of Experts in 2020.

ASN observed with satisfaction the integration of OHF into the RJH reactor design process.

### 12.4.3 Work on organisational and human factors further to the stress tests

On completion of the expert assessments carried out for the stress tests, ASN has chosen three priority subjects for reflection:

- the renewal of the licensees' personnel and skills;
- the organisation of subcontracting, which is a major and difficult issue;
- research into these subjects, for which programmes must be initiated.

ASN has set up a pluralistic working group on these subjects called the COFSOH (Social, organisational and human factors steering committee). In addition to ASN, this committee includes representatives of institutions, environmental protection associations, personalities chosen for their scientific, technical, economic, legal or social, or information and communication expertise, persons in charge of nuclear activities, nuclear industry professional federations and representative employees' unions.

Since 2012, this committee has been meeting regularly, with two plenary sessions per year. Work is done by thematic working groups:

A. the contribution of subcontracting to the safety of the installations in normal operating situations;

B. the legal questions raised by the work of the other working groups;

C. management of emergency situations;

D. the interface between “managed safety” and “regulated safety”;

E. the decommissioning activities.

# 13. Article 13: Quality Assurance

*Each Contracting Party shall take the appropriate steps to ensure that quality assurance programmes are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation.*

## 13.1 ASN requirements

The BNI order contains provisions to be implemented by a BNI licensee in order to define, obtain and maintain the quality of its facility and the conditions necessary to ensure operating safety.

The licensee must also implement an integrated management system specifying the provisions applied in terms of organisation and resources of all types (see chapter 11), and must maintain, assess and improve its effectiveness.

This order requires the licensee to define quality requirements for each activity concerned that is important to ensuring operating safety, to apply appropriate skills and methods to achieve them and, finally, to guarantee quality by checking compliance with these requirements.

It also requires that:

- detected deviations and significant events be corrected with due diligence and that preventive measures be implemented;
- suitable documents provide evidence of the results obtained;
- the licensee supervises its contractors and checks that the organisation implemented to guarantee quality does indeed operate satisfactorily.

## 13.2 Measures taken for nuclear power reactors

To ensure control of the protection of interests over the entire life cycle of a BNI (design, construction, operation and decommissioning), the EDF entities (Nuclear Production Division-DPN and the entities of the Department of Engineering and New Projects-DIPNN, the Department of Dismantling Projects and Waste-DP2D, the Nuclear Fuel Division-DCN, and the Fleet Engineering, Dismantling and Environment Division-DIPDE, working on behalf of the BNIs) put in place a management system for their activities that ensures the quality of manufacturing and operations.

In this respect:

i. Each BNI and each entity (EDF SA and outside contractors) working for a BNI apply the policy developed by that BNI with regard to the protection of interests and make sure that the various people involved in AIPs (activities important to the protection of the interests) under its responsibility have understood the risks and the corresponding implications.

ii. Each BNI and each EDF SA entity working for a BNI, either directly or outsourcing all or part of the work to outside contractors, shall put in place and require their outside contractors to put in place a management system capable of controlling these AIPs. For the outside contractors, these requirements are defined in the General Quality Assurance Specification – Issue 2013, which is referenced in the contracts or the contract documents.

iii. The management system of each entity of the DPN, DP2D, DIPNN, DCN and DIPDE indicates the measures implemented in terms of organisation and resources to control these AIPs. It is based on written documents.

iv. This management system more specifically includes provisions for:

- identifying the AIPs and their specified requirements;
- identifying and dealing with deviations;
- gathering and capitalising on experience feedback associated with AIPs;
- defining appropriate effectiveness and performance indicators.

v. This management system covers:

- performance of the AIPs by persons who have the necessary skills and qualifications,
- verification of compliance of the deliverables with the specified requirements relating to the AIP families,
- verification of implementation of the corrective and preventive actions,
- appropriate verifications by random sampling,
- activity documentation and traceability to demonstrate compliance with the specified requirements,
- periodic performance assessment,
- identification and correction of deviations
- gathering experience feedback.

vi. This management system is subject to a periodic review by senior management. With respect to the permanent drive to improve the protection of interests, these reviews include a risk analysis that integrates the risks of occurrence of situations conducive to creating a risk of fraud on the AIPs or EIPs. This analysis may lead to the defining of improvement measures or AIP control measures.

vii. Each EDF SA entity develops the safety culture of the persons involved in performing AIPs under its responsibility.

**Relations with contractors**

To ensure the quality of its services, EDF first of all ensures that its contractors are capable of performing the services satisfactorily. It then monitors the activities entrusted to its contractors. This monitoring does not relieve the contractor of its contractual responsibilities, notably those concerning the implementation of the technical and quality assurance requirements. Contracts between the ordering customer and its contractors clearly define the responsibilities of each party, the applicable requirements and the commitments in terms of quality and results.

Furthermore, in order to strengthen the quality of the partnership with the contractors, an improvement programme is put into place. This concerns in particular the quality of work performance, of contracts which accord more importance to the “best bidder” and the facilitation of the work conditions in the field.

With regard to the risk of possible fraud or counterfeits (Counterfeit, Fraudulent and Suspect Items - CFSI - as defined by the IAEA), EDF has, since 2017, put in place specific provisions aiming to prevent and detect these risks, such as:

- putting in place a whistle-blower system guaranteeing anonymity, which can also be used by anybody from outside EDF,
- appointing of an "ethics and compliance" expert within each EDF entity,

- awareness-raising actions on the importance of integrity and the safety culture,
- data integrity and retention (archival of end-of-manufacturing reports, for example),
- manufacturing inspection measures on suppliers' premises focusing more on the detection of CFSI issues (see § 19.3.2.2),
- setting up calculation review means,
- General Quality Assurance Specification appended to the contracts EDF places with its suppliers, imposing a duty to inform of suspect situations and supervision of its subcontractors,
- integrating the CFSI risk in the supplier qualification process through specific questions.

## *13.3 Measures taken for research reactors*

### 13.3.1 The CEA reactors

The CEA Chairman sets in-house policy for the programming of its activities as well as in the functional fields, more specifically with regard to safety (including nuclear safety).

Each centre and each operational division thus defines its quality management system for the areas under its responsibility. In practice, it is up to the facility heads to implement in their own local system the rules defined for the centre in which their facility is located and the operational division to which they report. In accordance with the regulatory provisions in force, the activities important to safety are formally identified in this local system and the quality assurance provisions designed to ensure that the corresponding requirements are met are formally laid out in the facility's baseline safety requirements.

Furthermore, the Nuclear Energy Division (DEN), which manages research reactors, organises regular audits of its units or their contractors in order to measure the progress made and assess the ability of the suppliers and contractors to meet the CEA's quality requirements.

For research reactors, these audits concern the quality of activities linked to the programmes and the quality of the activities linked to their safe operation.

The management systems of the DEN and its centres (where all the research reactors are installed), include quality, health/safety and environment (QSE). They hold ISO 9001, ISO 14001 and OHSAS 18001 certification.

### 13.3.2 The high flux reactor (HFR) at the ILL

The Reactor Division is responsible for operating the reactor and its auxiliaries. Given the particular importance of these operational activities in terms of safety, and in accordance with the provisions of the BNI order, a quality assurance organisation is put into place to guarantee that the level of quality required is obtained and maintained and to provide the necessary evidence.

Six guiding principles underpinned the creation of this organisation:

- **Principe I:** The licensee defines the scope of the quality organisation, by identifying the safety-related activities and equipment important to the protection of the interests defined by the BNI order (AIP and EIP) and then defining the requirements for each one of them;
- **Principle II:** Persons qualified to carry out an AIP are designated by the Head of Operation. These persons are referred to as "accredited";

- **Principle III:** All AIPs are performed following written documentation prepared in advance, and performance of the activity is written up in reports. These documents are subject to a technical inspection (internal check), and management checks (external checks);
- **Principle IV:** The quality-monitored documents are updated and kept for a guaranteed time which depends on the document's importance;
- **Principle V:** The results of an AIP verified both technically (quality check) and as regards management (quality monitoring). The verification is formalised;
- **Principle VI:** The "performance" and "verification" functions are separate and assigned to different people. The quality-monitoring function is independent of the operational functions;
- **Principle VII:** A minimum of two supplier audits are scheduled each year.

## *13.4 ASN analysis and oversight*

### 13.4.1 Quality assurance in the construction and operation of nuclear power reactors

#### 13.4.1.1 General surveillance of quality in construction and operation

During its inspections on sites under construction or already in operation, regardless of the area of inspection, ASN verifies that the quality assurance principles are adhered to. The adequacy of resources for tasks, staff training, working methods and the quality of the documentation associated with the operations, and procedures for internal monitoring of operations can thus be checked.

ASN considers that the integrated management system (IMS) put in place by EDF on the whole meets the requirements of the BNI order. However, even if the steps taken enable deviations from the defined requirements applicable to equipment and organisations to be identified, the large number of tools involved and the players concerned make a significant contribution to the problem of building an accurate picture of the true state of the installations and their operating baseline requirements. The areas for progress include increased capitalisation on operating experience feedback on a number of sites and greater compliance with the deadlines for remedying the deviations detected.

**Quality aspects related to the use of contractors**

The maintenance of reactors in the French nuclear power fleet is to a large extent subcontracted by EDF to outside contractors. The decision to implement this industrial policy lies with the licensee. A system of prior contractor qualification has been put in place by EDF. It is based on an assessment of the technical know-how and quality organisation of the subcontractor companies and is formally written up in the Social Requirements document, a constituent of the contracts, created under the work of the CSFN (Nuclear Sector Strategic Committee) with EDF and its main contractors.

The role of ASN is to verify that EDF assumes its responsibility for the safety of its facilities by implementing a quality approach and in particular by monitoring the condition in which subcontracting takes place.

#### 13.4.1.2 Contractor selection and monitoring

ASN conducts inspections at the NPPs on the implementation of and compliance with the EDF baseline requirements for contractor monitoring. In the context of oversight of the construction of the Flamanville 3 reactor, ASN also conducts inspections on this subject within the various engineering departments responsible for the design studies.

More generally, ASN conducts a number of inspections every year at the suppliers of the reactors in service.

In principle, the contractor qualification and assessment system is satisfactory and meets the regulatory requirements. In practice, EDF must improve the monitoring of its contractors. Significant shortcomings in EDF's monitoring of outside contractors were brought to light in the assembly and inspection of the main secondary systems. ASN therefore asked for a quality review to be performed on the equipment of the Flamanville 3 EPR reactor (see § 18.2.4.2).

### 13.4.2 Quality assurance in the operation of research reactors

ASN checks, primarily by means of inspections, licensee application of the quality assurance principles during the operation and maintenance of its reactors. In recent years, ASN has observed an improvement in the contractual documenting of the safety requirements applicable to outside contractors. CEA must strengthen the supervision of subcontracted activities.

The CEA's efforts must also be continued, especially with regard to the sharing of experience feedback and the effectiveness of its integration. The action of the safety cells, which are in charge of carrying out the second level controls on behalf of centre directors, was reinforced with a view to improving the detection of weak points and selecting objectives aiming to correct them. Coordination between the various action, support and check levels, whether local or national, must continue to progress in order to make the actions more consistent and more effective.

With regard to the ILL, although the level of safety of the reactor is satisfactory, several deviations from the regulations in terms of safety management have been observed. ASN therefore expects ILL to reinforce its organisation with respect to the requirements of the regulations in 2019.

# 14. Article 14: Safety assessment and verification

*Each Contracting Party shall take the appropriate steps to ensure that:*

*i) comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body;*

*ii) verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.*

## *14.1 Safety assessment before the construction and commissioning of a BNI*

### 14.1.1 ASN requirements

#### 14.1.1.1 Regulatory framework

The Environment Code contains a creation authorisation procedure, which may be followed by a number of licensing operations during the life of a BNI, from its commissioning up to final shutdown and decommissioning, including any modifications made to the facility. These aspects are detailed in § 7.2.

The Preliminary Safety Analysis Report (RPS) incorporated in the authorisation application file is produced in compliance with ASN resolution 2015-DC-0532 of 17th November 2015 relative to the safety analysis report. It informs ASN of and substantiates the measures taken at each step in the life of the facility to comply with the regulations and guarantee safety. It contains all the information needed to verify that all risks (whether or not nuclear) and all possible hazards (internal or external) have indeed been taken into account and that in the event of an accident, the personnel, the population and the environment are adequately protected by the means put into place. This report takes account of the specific characteristics of the site and its environment (meteorology, geology, hydrology, industrial environment, etc.).

Commissioning corresponds to the first use of radioactive substances in the facility. In preparation for commissioning authorisation, the licensee sends ASN a file comprising the updated safety analysis report for the facility "as-built", the general operating rules (RGE), a waste management study, the on-site emergency plan, the impact study and the decommissioning plan. These aspects are reviewed by ASN with the support of IRSN and the Advisory Committees of Experts.

#### 14.1.1.2 The stress tests

The stress tests undertaken by the licensees at ASN's request following the Fukushima Daiichi NPP accident, were extended to include facilities under construction (EPR, RJH and ITER). A section has moreover also been devoted to subcontracting activities at the licensees.

See also § 6.2.1.2 and § 14.2.1.6 with regard to the stress tests.

### 14.1.2 Measures taken for nuclear power reactors

Creation of the EPR of Flamanville was authorized by a decree of 10 April 2007.

In March 2015, EDF sent its commissioning authorisation application. This application was considered acceptable, enabling ASN and its technical support body to commence its examination. EDF was however asked for additions, corrections and substantiations.

### 14.1.3 Measures taken for research reactors

Creation of the RJH was authorised by a decree of 12th October 2009 further to the submission of a creation authorisation application on 27th March 2006. The facility is currently under construction on the CEA Cadarache site.

With regard to the ITER international facility, its design began in the 1990's. Further to various international agreements and the choice of Cadarache (Bouches-du-Rhône *département*) as its installation site, ITER became a BNI within the meaning of the French regulations by a decree of 9th November 2012.

### 14.1.4 ASN analysis and oversight

**The Flamanville EPR reactor**

In the last few years, without waiting to have received the complete commissioning authorisation application file, ASN, assisted by IRSN, had started to prepare for the examination of the commissioning authorisation application by reviewing:

- the technical baseline requirements necessary for the safety case and for finalising the reactor's detailed design;
- the detailed design of certain systems important for safety presented in the safety analysis report;
- certain elements of the commissioning application file or used to assist with determining the contents of the file.

Following the stress tests, EDF proposed a number of measures to reinforce the robustness of the Flamanville 3 EPR reactor. ASN considers that these proposals are relevant and should be implemented.

The Advisory Committee for Reactors (GRP) held meetings on various topics of the safety analysis report, in particular the safety classification, the probabilistic safety assessments, the consideration of accidents with core melt in the design, the safety case for fuel storage and handling, the accident studies, the design of safety systems and protection against the effects of internal and external hazards. The GPR held a meeting on 4th and 5th July 2018 to examine the measures taken by EDF to ensure the safety of the Flamanville EPR reactor, such as they are presented and justified in the safety analysis report submitted to EDF for the EPR reactor commissioning authorisation. ASN is also examining the other regulatory documents submitted by EDF with the commissioning authorisation application.

The details of this review and the monitoring of the construction of the Flamanville 3 EPR reactor are presented in chapter 18.

**RJH**

After examining the preliminary version of the safety analysis report, a number of subjects requiring subsequent technical examination were identified. This concerns in particular:

- the dimensioning of the civil engineering of the safety-classified buildings,
- the dimensioning of the reactor pool and its liner,
- the dimensioning and robustness of the polar crane,

- continuation of the examination of the specific materials used for the primary system.

Given the importance of these subjects (particularly as concerns the civil engineering and dimensioning of the pool) and the discussions at the meetings of the Advisory Committee for Nuclear Reactors (GPR) during the examination, it was decided that these subjects would be examined prior to the commissioning application, at an intermediate Advisory Committee meeting (currently planned for late 2020).

**ITER**

The examination of its creation authorisation application underwent an in-depth review by two Advisory Committees of Experts (the GPU and the GPR). ASN had regulated the design changes and the construction of this experimental facility by its resolution of 12th November 2013. In 2017, ASN amended this resolution following the new strategy for gradual commissioning of the ITER facility. Several theme-based examination batches have been defined and will be initiated as the construction steps progress through to commissioning, planned for 2035.

## *14.2 Safety assessment and verification during operation*

### 14.2.1 ASN requirements

The regulations require the licensee to set up an integrated safety management system (IMS) that can maintain and continuously improve safety, notably during operation of the nuclear facilities. The methods of assessing the processes related to the IMS and the implementation of the improvement measures resulting from these assessments are checked by ASN.

#### 14.2.1.1 Correcting anomalies

Deviations are detected in the nuclear reactors through the proactive attitude of the licensees and through the systematic checks requested by ASN :

- “Continuous” checks are performed by the licensee as part of the periodic test and preventive maintenance programmes carried out on the equipment and systems (see § 19.3). ASN examines the methods and deadlines for compliance proposed by the operator. In particular, in 2015 it published a guide on the treatment of compliance deviations affecting equipment important for the protection of the interests of nuclear power reactors (guide No. 21, see appendix 2, § 2.3.4). This guide helps EDF to define the deadlines for closing gaps, taking into account in particular their severity in terms of safety.
- Systematic checks are also performed by the licensee every ten years on the occasion of the periodic safety reviews (see § 14.2.1.3 and § 14.2.3). The licensee then compares the actual condition of the facilities with the applicable safety requirements and lists any deviations.

ASN requires that deviations with an impact on safety be corrected within time frames compatible with their degree of severity.

#### 14.2.1.2 Examining significant events and operating experience feedback

The regulations require that the licensees notify ASN of any significant events (see § 19.6). These events are the subject of detailed analysis. The lessons that the licensee learns from the analysis of significant events are assessed by ASN. This analysis more specifically concerns the root causes of the events, most of which reveal problems with the licensee's organisations and with the interfaces between the licensee and its contractors.

Integrating experience feedback and processing of significant events are also subjects that receive particularly close attention during ASN inspections.

Lastly, the Advisory Committees of Experts (GPE) periodically review national and international experience feedback from the facilities in operation and their opinions help to improve practices in the BNIs.

#### 14.2.1.3 The periodic safety reviews

In addition to the procedures applicable to changes to the facilities or their operating mode, the Environment Code requires the licensee to carry out a periodic safety review of its installation every 10 years (see Figure 4 below and § 6.2). This system more specifically meets the requirements of the European directive on nuclear safety:

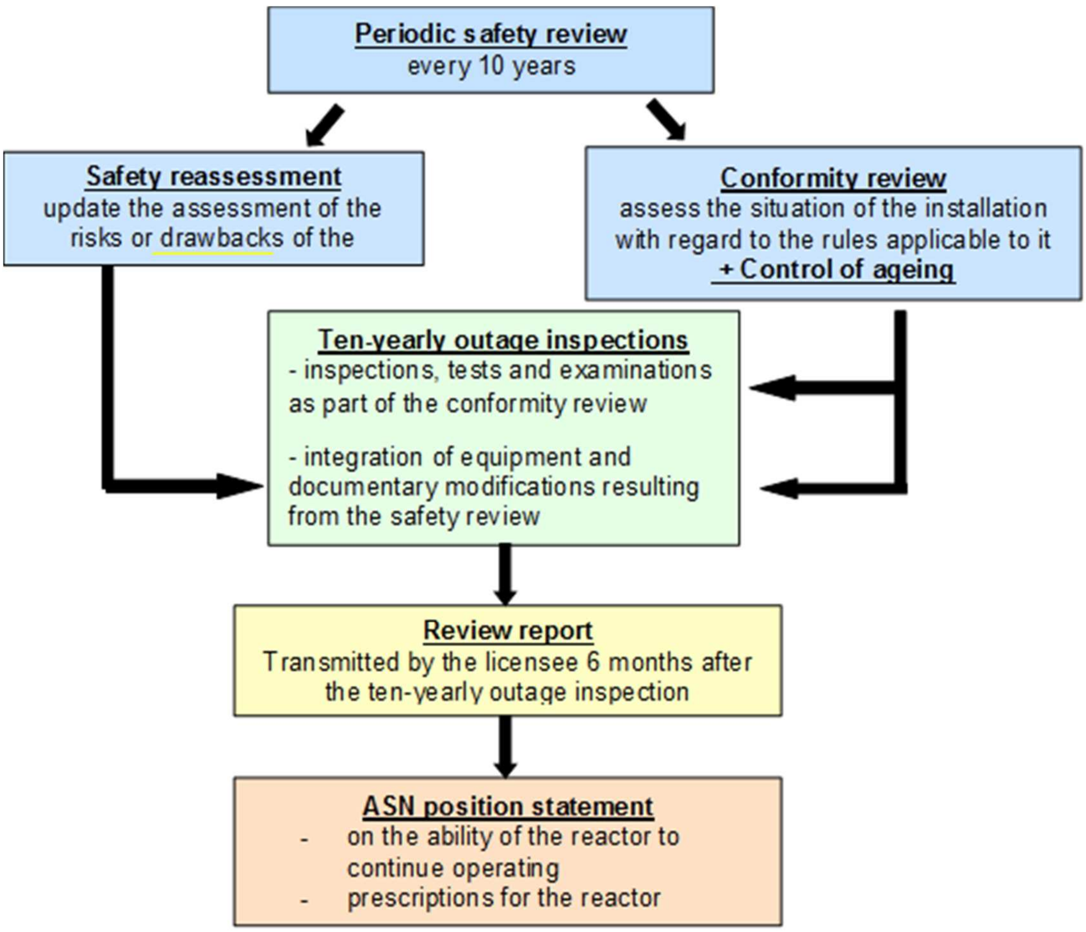


Figure 4: Periodic safety review process

The progress of the nuclear power reactor periodic safety reviews is presented in § 6.2.1.

In 2017, all the CEA research reactors and the HFR had undergone at least one periodic safety review in the last 10 years.

#### 14.2.1.4 Ageing phenomena

The phenomena linked to ageing must be taken into account in order to maintain a satisfactory level of safety for the entire operating life of the facilities.

Management of ageing must be demonstrated on the basis of operating experience feedback, the maintenance provisions and the possibility of either repairing or replacing the equipment.

To understand the ageing of an NPP, quite apart simply from the time elapsed since its commissioning, other factors must be taken into account, in particular physical phenomena which can modify the characteristics of the equipment, depending on their function or their conditions of use. Consideration must therefore be given to the deterioration of replaceable items, the lifetime of non-replaceable items and the obsolescence of equipment items or their components.

At the request of ASN, EDF has implemented an ageing management procedure for its nuclear power reactors, based on three lines of defence: the anticipation of ageing from the design stage, monitoring of the actual condition of the facilities and the repair, renovation or replacement of actually or potentially affected equipment. With a view towards the possible continued operation of the nuclear power reactors beyond their fourth periodic safety review, EDF plans to continue this approach and extend it to all systems, structures and components important for control not only of the radiological risks, but also of conventional risks.

**First topical peer review of the European Union nuclear regulators**

The question of ageing management was the subject of the first Topical Peer Review stipulated by Council Directive 2014/87/Euratom of 8th July 2014 amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations. This directive requires a peer review, every six years, of a technical aspect relating to the nuclear safety of their nuclear facilities. The conditions of this review have been defined by the ENSREG (European Nuclear Safety Regulators Group) with the support of WENRA. The objectives of this process were to:

- enable the participating countries to review their provisions with regard to ageing management in order to identify the best practices and possibilities for improvement;
- have European sharing of the individual experiences of the participating countries and identify problems in common which they all have to address;
- provide the participating States with an open and transparent framework for developing appropriate follow-up measures for the identified possibilities for improvement.

Within the framework of this peer review, a report was drawn up by ASN, the coordinator, with contributions from IRSN, EDF. CEA and ILL.

With regard to EDF's nuclear reactors, this report concludes that the ageing management approach, accompanied by an extensive R&D programme, is appropriate, especially in view of the requirements of the international standards.

With regard to research reactors, the report concludes that their ageing management programmes need to be laid down more formally.

The peer review identified areas for improvement in the French facilities, in particular:

- the need to supplement the ageing management programmes taking into account ageing phenomena specific to long construction phases or extended reactor outages;

- the benefit of "opportunity" inspections of underground pipes when rendered accessible by other works;
- the development of ageing management programmes for the research reactors.

A national action plan shall be produced in response to the conclusions of this review.

#### 14.2.1.5 Modifications made to equipment and operating rules

In accordance with the principle of continuous improvement of reactor safety levels, but also to improve the industrial performance of its production tool, the licensees periodically make modifications to the equipment and the operating rules. These modifications result, for example, from the processing of deviations, from periodic safety reviews or from the integration of experience feedback.

The Environment Code defines the requirements concerning the implementation of modifications by licensees and their examination by ASN. The procedures for managing and declaring significant modifications are specified in ASN resolution 2017-DC-0616 of 30/11/2017 (see appendix 2).

#### 14.2.1.6 The stress tests further to the Fukushima Daiichi accident and their follow-ups

In France, the stress tests approach (initiated in the wake of the Fukushima Daiichi accident) was implemented at two levels.

Firstly, within a European framework, with the organisation of stress tests of nuclear power plants by seventeen European countries, as requested by the European Council. These tests consisted in checking the robustness of the NPPs to exceptional situations such as those which led to the Fukushima Daiichi NPP accident.

Secondly, within a national framework, with the performance of a safety audit on the French civil nuclear facilities, requested by the Prime Minister. This study was conducted in accordance with the specifications produced at European level, but with two extensions:

- the study carried out in France concerned all nuclear facilities (including research and fuel processing facilities);
- the specifications were supplemented by points concerning the use of subcontracting.

In addition to the stress tests, ASN conducted a campaign of inspections targeting topics related to the Fukushima Daiichi accident. These inspections comprised field checks on the conformity of the licensee's equipment and organisation with the existing baseline safety standards.

At the end of these national assessments, ASN stated that the safety level of the French facilities examined was such that it would not request the immediate shutdown of any of them. At the same time, ASN considered that their continued operation required that their robustness to extreme situations be increased beyond their existing safety margins.

At the European level, the results of these stress tests were examined by a peer review carried out under the supervision of the European Nuclear Safety Regulators Group (ENSREG[4]) in April 2012.

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[4] ENSREG was created in March 2007 and brings together the heads of the safety regulators and Government representatives of the 28 countries of the European Union, along with representatives of the European Commission.

Following this review, ASN adopted 32 resolutions, each one setting some thirty complementary prescriptions. These resolutions concern the facilities examined in 2011, including the 59 EDF nuclear reactors (including the Flamanville 3 EPR) and the three highest-priority CEA research reactors (Osiris, Masurca and RJH). These measures significantly reinforce the safety margins of the facilities beyond their design-basis levels.

**Concerning nuclear power reactors:**

To ensure monitoring of the implementation of these post-Fukushima measures (which will take several years, see § 6.2.1) and also to take account of the recommendations arising from the second extraordinary meeting of the Contracting Parties to the CSN, held in August 2012, ENSREG asked that each safety regulator draft and publish a national action plan by December 2012. These national action plans were updated and peer reviewed at European level in 2013, 2015 and 2017.

### 14.2.2 Measures taken for nuclear power reactors

**Periodic safety review**

EDF carries out periodic safety reviews of its reactors every ten years to assess the situation of the facility with respect to the applicable rules and to update the assessment of the risks or adverse effects of the facility, taking into account aspects such as the condition of the facility, the experience acquired during its operation, the development of knowledge and the rules applicable to similar facilities.

This procedure is applied with an approach that is proportionate to the nuclear safety and environmental protection implications and under economically acceptable conditions.

During the periodic safety reviews, EDF implements a set of modifications (material, intellectual or operational) which contribute to achieving the objectives of the safety review. In most cases, these modifications are made in batches, each batch being implemented on all the reactors of the plant series concerned, with an initial reactor, referred to as the "first off". This grouping of modifications allows greater consistency in their implementation, by facilitating scheduling, documentation updates and operator training.

These batches are generally implemented during the ten-yearly outages in order to minimise the impact of the work on reactor availability.

For a given plant unit, the periodic safety review comprises two parts:

- a **verification of the conformity** of the plant unit with the applicable baseline requirements,
- a **reassessment of the safety of the plant unit**.

**Verification of reactor conformity by EDF**

The conformity of the facilities with the safety requirements is a major aspect of exercising the responsibility of a nuclear licensee, at several levels.

During the periodic safety reviews, EDF deploys substantial means to verify the conformity of the facilities, with the aim of guaranteeing the conformity of the reactors with the applicable baseline requirements, particularly on the basis of:

- the examination of plant unit conformity (ECOT), which supplements the existing operating and maintenance provisions (periodic tests, maintenance programmes), by means of physical and/or documentation inspections,

- the complementary investigations programme (PIC), the aim of which is to confirm the assumptions concerning the absence of in-service degradation in areas not covered by the preventive maintenance programmes,
- addressing conformity deviations identified during the operation of the facilities.

**Ageing management**

In addition to this, EDF implements a major programme of work on equipment ageing in view of the continued operation of the facilities beyond 40 years. EDF's industrial programme consists in:

- demonstrating the capability of the non-replaceable items to fulfil their function beyond 40 years (reactor pressure vessel and containment),
- demonstrate the capability of the replaceable items to fulfil their function beyond 40 years or else replace or renovate them.

This programme for managing the ageing of plant units after their third periodic safety review is based on:

- the analyses of the ageing mechanisms and of the capability for continued operation of the components for all the plant units of the 900 MWe and 1300 MWe series with regard to the behaviour of the equipment items and demonstrating control of their ageing,
- a specific analysis of each plant unit to verify that the general analyses do indeed cover the particularities of each reactor, and to demonstrate the plant unit's capability for continued operation,
- the maintenance, periodic test, renovation, and obsolescence management programmes decided nationally or locally.

**Safety reassessment**

The safety reassessment is based on the integration of new baseline requirements resulting from analyses underpinned more particularly by probabilistic safety studies, operating experience feedback (REX), the preceding periodic safety reviews, the development of knowledge and the integration of new regulatory requirements into the baseline requirements.

On the occasion of the 4th periodic safety review of the 900 MWe plant series (4th PSR 900), EDF adopted as the general direction for nuclear safety to tend towards the nuclear safety objectives set for the 3rd-generation reactors, for which the reference reactor for EDF is FLAMANVILLE 3 EPR. Furthermore, this safety review will benefit from the complete deployment of the hardened safety core provisions which followed on from the Fukushima accident. The hardened safety core consists of a set of material and organisational provisions dimensioned for hazard levels that are significantly higher than the design-basis levels, the aim of which is to prevent significant releases and lasting consequences for the environment.

### 14.2.3 Measures taken for research reactors

#### 14.2.3.1 CEA reactors

All of the research reactors operated by the CEA have now undergone a periodic safety review. This first safety review phase was completed in 2010, with the Éole and Minerve facilities. The periodic safety review report for the CABRI facility was submitted to ASN in October 2017, while those for the OSIRIS, ISIS and ORPHEE reactors were submitted in March 2019.

#### 14.2.3.2 The high flux reactor (HFR) at the ILL

Following the first periodic safety review held in 2002, a special project organisation was set up for the RHF, the "*Refit Management Committee*" which, together with the reactor division, carried out work between 2002 and 2006 on the seismic resistance of the buildings, fire detection and the seismic qualification of certain equipment.

Between 2009 and 2011, the RHF also strengthened its defence in depth, by adding a new backup system to prevent and mitigate the consequences of a core melt accident.

Between 2012 and 2018, the ILL continued to reinforce its defence in depth, with performance of work defined following the post-Fukushima stress tests to create a "hardened safety core" of backup equipment (see § 6.2.2.2).

The ILL submitted its periodic safety review report on 2nd November 2017. Particular emphasis was placed on:

- technical and regulatory conformity,
- the fire risk,
- the safety reassessment.

### 14.2.4 ASN analysis and oversight

#### 14.2.4.1 The nuclear power reactors

##### 14.2.4.1.1 The next periodic safety reviews

The periodic safety reviews (PSR) of the in-service reactors shall continue over the coming years. For the 900 MWe reactors, this is the 4th PSR for which ASN plans making a position statement at the end of 2020. For the 1300 MWe reactors, integration of the improvements resulting from the 3rd PSR began with the Paluel 2 reactor. With regard to the 1450 MWe reactors, integration of the improvements resulting from the 2nd PSR began in 2019 with the Chooz B2 reactor (see 3.1.2).

Following the stress tests, ASN asked EDF to include in the periodic safety reviews an assessment of the beyond-design-basis seismic robustness of the facilities. This assessment aims firstly to periodically analyse the risks of a beyond design-basis cliff-edge effect, on the basis of updated data and, secondly to identify the works, structures and equipment necessary to achieve and maintain a safe condition, which must undergo additional reinforcements.

The methods for assessing the seismic robustness beyond design-basis levels, which will be used by the licensee in the forthcoming generic phases of the safety reviews are analysed by ASN.

**Fourth periodic safety reviews of the 900 MWe reactors;**

The 34 EDF 900 MWe reactors were commissioned between 1977 and 1987 and the first of them are approaching their fourth periodic safety review. This is the context in which the conditions for the continued operation of these reactors will be defined.

This fourth periodic safety review presents particular challenges:

- some items of equipment are reaching the end of their design-basis lifetime. The studies concerning the conformity of the installations and the management of equipment ageing

therefore need to be reviewed to take account of the degradation mechanisms actually observed and the maintenance and replacement strategies adopted by EDF;
- the modifications associated with this periodic safety review will enable the integration of the modifications specified by ASN following the Fukushima NPP accident to be completed on these reactors;
- the safety reassessment of these reactors and the resulting improvements must be carried out in the light of the new-generation reactors, such as the EPR, the design of which meets significantly reinforced safety requirements.

ASN made a position statement on the objectives of this periodic safety review, that is to say the level of safety to be reached for continued operation of the reactors, and made additional requests in April 2016. EDF has supplemented its work programme and in 2018 it submitted to ASN the planned measures to meet these requests.

With the support of IRSN, ASN is continuing to examine the generic studies linked to this review. In 2019 and 2020, it will ask the Advisory Committee of Experts for its opinion on the safety case accident studies, the ability of the facilities to withstand internal and external hazards, the probabilistic safety studies, and the management of accidents with core melt. ASN will issue a position statement on the generic studies for this periodic safety review at the end of 2020.

In 2018, ASN more particularly obtained the opinion of its Advisory Committees of Experts on the management of ageing and obsolescence and on the mechanical strength of the reactor pressure vessels:
- after examination, ASN considers that the actual or planned steps to manage the ageing and obsolescence of the structures, systems and components of the 900 MWe reactors beyond their fourth periodic safety review and thereby contribute to maintaining their conformity, are satisfactory.
- the file substantiating the in-service behaviour of the irradiated zone of the reactor vessels for the ten years following their fourth periodic safety reviews was submitted by EDF in 2016. It was first presented to the Advisory Committee of Experts for Nuclear Pressure Equipment in November 2018, and must be presented again at the end of 2019, notably with regard to the thermomechanical loadings of the reactor vessels in order to rule on their ability to continue operating.

ASN regularly examines the reactor vessel files transmitted by EDF. The reactor vessel metal which is subjected to neutron radiation from the core undergo changes in its mechanical properties making it more brittle and therefore more sensitive to thermal shocks under pressure or to sudden rises in pressure when cold. The demonstration of the reactor vessel's resistance to sudden rupture takes this phenomenon into account, but must be revised periodically to take account of the development of knowledge.

The following steps were taken as from start-up to prevent any risk of rupture:

- a programme for monitoring the phenomenon of metal embrittlement due to irradiation: test pieces made of the same metal as the vessel were placed inside it and are used to perform mechanical tests.
- periodic inspections to verify the absence of defects or, if manufacturing defects are found, to check that they do not develop.

Thus the file concerning the in-service behaviour of the irradiated area of the 900 MWe reactor vessels for the ten years following their third ten-yearly outage inspections was presented to the Advisory

Committee of Experts for nuclear pressure equipment in June 2010. ASN considered that operation of these vessels for the period considered was acceptable, but has asked EDF to conduct further investigations and provide additional data to reinforce the guarantees obtained. ASN has more specifically reissued its request for 5-yearly inspection of the Tricastin 1 reactor vessel, which displays 20 defects under the liner and asked EDF to maintain or install heating of the safety injection system on the Tricastin 1, Fessenheim 2 and St Laurent B 1 reactors in order to limit vessel loadings in the event of an accident situation.

#### 14.2.4.1.2 Assessment and verification of nuclear power reactor safety for the period 2016-2018

**The Nuclear Power Plants (NPP) in operation**

ASN considers that the safety of EDF's NPPs was maintained at a satisfactory level during 2016-2018. On the whole, the number of significant events in 2018 was stable in relation to 2017. The verifications conducted by EDF regularly bring to light defects which affect several NPPs. Most of these defects are deviations related to the design of equipment, its installation or its maintenance and compromise its ability to perform its function in all the situations considered in the nuclear safety case.

**The conformity of the facilities**

As in previous years, ASN considers that the actual conformity of the facilities needs to be appreciably improved. This is more particularly the case with the seismic strength of the equipment. EDF must continue with the targeted inspections it has been gradually implementing for the past few years and which will allow regular detection of the equipment needing to be strengthened. Managing the conformity of the facilities in operation will be a major focus for ASN oversight in 2019, notably on the occasion of the fourth ten-yearly outage inspection of the Tricastin NPP reactor 1.

In 2018, EDF began a revision of its internal baseline requirements in order to improve deviations processing and ensure reactive information of ASN: this is a first step forwards. In 2018, ASN also noted that, by comparison with previous years, EDF placed greater emphasis on rapidly restoring the conformity of its facility after detecting a deviation.

In order to combat the risk of fraud, EDF has modified its inspection practices, making greater use of unannounced or cross inspections. In 2018, EDF also completed its review of the manufacturing files of the forged components produced by the Creusot Forge plant. The ASN examination of the deviations identified by this review did not reveal any new deviations in 2018 requiring repair or immediate replacement of any equipment item, but it nonetheless issued requests for additional justifications in order to back up the demonstrations provided by EDF. Examination of these additional justifications will continue in 2019.

**Maintenance**

EDF has taken steps to reduce the occurrence of maintenance quality defects: their number is however still too high. Some of them could have been avoided by taking greater account of operating experience feedback from other EDF reactors, including on the same site.

ASN however finds that most sites have successfully been able to carry out large-scale maintenance operations, such as the preparation for and performance of the ten-yearly outage inspections, which constitute a considerable drain on their human resources, notably those with the most experience, owing to the particularly intense maintenance phases.

ASN also considers that proactive measures must be taken by EDF to reinforce its maintenance programmes for certain equipment items. ASN in particular notes very high levels of fouling in certain internal structures of the steam generators in several reactors, which could impair their operating safety. These fouling levels are the result of maintenance that was insufficient to guarantee satisfactory cleanness. ASN considers that the in-service monitoring of the other equipment on the main primary system is carried out appropriately. In 2017, this notably led to the detection of a crack on the vessel bottom head penetration of Cattenom NPP reactor 3, with no change being observed in 2018.

With a view to the continued operation of its reactors, the "major overhaul" programme and in the light of the lessons learned from the accident at the Fukushima NPP, ASN considers that it is important for EDF to continue with the efforts it has already begun in order to remedy the difficulties encountered and improve its maintenance programmes.

ASN also observes shortcomings in the traceability and error-reduction measures concerning maintenance work. A number of anomalies are notably the result of incorrect application of a maintenance procedure, or even the inappropriate nature of the procedure itself. The workers still have to deal with constraints linked to work organisation, for which they are not responsible, such as insufficient preparation for certain activities, unplanned scheduling changes and problems with worksite coordination. The analyses carried out by the sites following significant events often lead to corrective measures that are no more than isolated awareness-raising sessions for staff, departments, or contractors identified as being responsible for the deviation. The analysis of the root causes must be taken further in order to identify any organisational weaknesses.

ASN regularly notes EDF's difficulty in ensuring appropriate and proportional monitoring of subcontracted activities, whether performed within the NPP itself or at the suppliers of goods and services. ASN however observes increased mobilisation by those responsible for monitoring outside contractors in the NPPs. It considers that EDF must further strengthen the role, the involvement and the competence of these persons, so that they can detect any inappropriate technical action at the earliest possible opportunity.

**Operation**

2018 was marked by difficulties encountered by EDF during post-outage reactor restarts. The scheduling, performance and analysis of the results of periodic tests are areas in which virtually all the sites need to improve. More particularly, ASN's inspectors on several occasions found incorrect conclusions regarding equipment availability following periodic testing. EDF has initiated improvement measures, the effects of which are not yet measurable.

The management of certain sensitive activities, such as temporary system configuration changes in order to carry out periodic tests, would appear to be progressing on certain sites. This progress, which must be placed in the context of the action plans being run by EDF for several years now, still remains to be consolidated.

In recent years, EDF has reinforced its organisation for managing hazard-related risks, such as the organisation put into place to detect and eliminate the risk of falling objects in the event of an earthquake (lighting, fire-fighting resources, etc.). However, ASN regularly observes that the steps taken by EDF to prevent hazards and mitigate their consequences need to be further improved. This is in particular the case with measures concerning the fire risk.

In addition, the inspections of the emergency organisation and resources confirmed that the organisation, preparedness and management principles for emergency situations covered by an On-site Emergency Plan (PUI) have been correctly assimilated.

**Continuation of reactor operations**

Finally, ASN notes the ambitious steps taken by EDF to enable its reactors to continue to operate. The steps planned as part of the fourth periodic safety review of the 900 MWe reactors will thus lead to significant improvements in the safety of the installations. ASN is however still waiting for additional demonstration data on certain subjects which, at this stage of the examination, could well lead to requests for significant additional measures. This is notably the case regarding seismic resistance, the efficiency of the systems recirculating the water present at the bottom of the reactor building sumps and the need or otherwise to increase the thickness of the basemat of certain containments. EDF deployed considerable engineering resources for this review. However, ASN found that the EDF engineering teams were saturated and this must be taken into account when preparing the other reviews.

**Personnel radiation protection and environmental protection**

In 2018, radiation protection was addressed differently by the various NPPs, notably with respect to radiological cleanness management within the facilities and the steps taken to prevent the risk of contamination. Faced with this situation, ASN is reinforcing its oversight of implementation of the action plans requested to correct these situations on the reactors concerned.

EDF's organisation for managing the detrimental effects and impact of NPPs on the environment needs to be improved on most sites and ASN considers that the licensee needs to raise its level of vigilance on these topics. Despite the action plan implemented by EDF to limit the incidents of liquid spillage into the environment, events leading to such spills were still too numerous in 2018. With regard to waste management, ASN observed progress by certain sites which had previously been under-performing, but still needs EDF to significantly.

#### 14.2.4.2 Research reactors

Each research reactor represents a particular case, for which ASN must adapt its oversight, while ensuring that the common safety practices and rules are applied. The last few years have seen the development of a more generic approach to the safety of these facilities, inspired by the rules applicable to power reactors, and more particularly the method of safety analysis by "operating conditions" (postulated initiating events) and the safety classification of the associated equipment. This approach is now used for the periodic safety reviews of the existing facilities and for the design of new reactors.

# 15. Article 15: Radiation protection

*Each Contracting Party shall take the appropriate steps to ensure that in all normal operational states the radiation exposure of the workers and the public caused by a nuclear installation shall be kept as low as reasonably achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits.*

## *15.1 Regulations and ASN requests*

The legal framework of nuclear activities has been extensively modified in recent years. The legislative system is now relatively complete and the publication of the application documents is well advanced, even if not as yet complete.

The European Commission has carried out work on merging into a single text several Euratom directives, including those concerning basic radiation protection standards, protection of patients against medical exposure and the regulation of high-level sources. The transposition of the new Euratom 2013/59 Directive, published on 5th December 2013, entailed legislative modifications to the Public Health, Labour and Environment Codes, notably through the publication of Ordinance 2016-128 of 10th February 2016 containing various nuclear provisions, Decree 2018-437 of 4th June 2018 concerning protection of workers against risks caused by ionising radiation, Decree 2018-438 of 4th June 2018 concerning protection against ionising radiation risks faced by certain workers and Decree 2018-434 of 4th June 2018 containing various nuclear provisions.

### 15.1.1 The Public Health Code and the general principles of radiation protection

Chapter III dealing with ionising radiation of Title III of Book III of the legislative part of the Public Health Code defines all “nuclear activities”, that is, all activities involving a risk of human exposure to ionising radiation resulting either from an artificial source, whether a substance or a device, or a natural source, when natural radionuclides are or have been processed because of their radioactive, fissile or fertile properties.

Article L. 1333-2 of the Public Health Code defines the general principles of radiation protection (justification, optimisation, limitation), which have been laid down at the international level by the International Commission on Radiological Protection – ICRP) and reiterated in Council Directive 2013/59/Euratom of 5th December 2013. These principles are recalled below and guide all regulatory activities for which ASN is responsible.

The Code institutes the Radiation Protection Inspectorate, set up and chaired by ASN, tasked with overseeing the application of its radiation protection provisions. The code also defines a system of administrative or criminal penalties.

#### 15.1.1.1 The justification principle

*“A nuclear activity may only be undertaken or exercised if justified by the individual or collective advantages it procures - particularly in health, social, economic or scientific terms – as compared with the risks inherent to the exposure to ionising radiation to which the individuals are likely to be subjected”.*

Assessment of the expected benefit of a nuclear activity and the corresponding health drawbacks may lead to prohibition of an activity for which the benefit does not seem to outweigh the risk.

#### 15.1.1.2 The optimisation principle

*"The level of exposure of individuals to ionising radiation resulting from a nuclear activity, the probability of such exposure occurring and the number of persons exposed must be maintained at a level that is as low as reasonably achievable, in view of the state of technical knowledge, economic and societal factors and, where applicable, the medical research objective".*

This principle, referred to as ALARA (as low as reasonably achievable), leads for example to a reduction in the discharge licences of the quantities of radionuclides permitted in radioactive effluents discharged from nuclear installations or mandatory monitoring of exposure at work stations in order to keep it to the strict minimum.

#### 15.1.1.3 The limitation principle

*"Exposure of a person to ionising radiation as a result of a nuclear activity cannot raise the sum of the doses received beyond limits set by the regulations, unless this person is exposed for medical purposes or for biomedical research."*

Strict limits are set for the exposure levels induced for the general population or for workers by nuclear activities (see § 15.1.2.1 and § 15.1.3.1). If these limits are exceeded, this situation is considered to be unacceptable and can lead to administrative or criminal penalties.

### 15.1.2 General protection of the population

In addition to the particular radiation protection measures taken for the individual authorisations concerning nuclear activities, for the benefit of the general public and workers, several more general measures incorporated into the Public Health Code help protect the public against the dangers of ionising radiation as a result of nuclear activities.

#### 15.1.2.1 Dose limits for the general public

The effective annual dose limit received by a member of the public as a result of nuclear activities is set at 1 mSv; the equivalent dose limits for the crystalline lens of the eye and for the skin are set at 15 mSv/year and 50 mSv/year respectively (average value for any 1 cm² area of skin). The method of calculating effective and equivalent doses and the methods used to estimate the dose impact on a population, are defined by the order of 1st September 2003.

#### 15.1.2.2 Radiological monitoring of the environment

##### 15.1.2.2.1 The objectives of radiological monitoring of the environment

The Environment Code requires that the licensees of nuclear facilities carry out radiological monitoring of the environment around their facility. The objectives of this monitoring of the various components of the environment (surface waters, ground waters, air, biological matrices: grass, milk, plants, fisheries products, etc.) are to:

- contribute to the knowledge of the radiological and radio-ecological state of the environment of the installation, and how it is developing;
- contribute to estimating the impact of the facility on health and the environment;
- detect any abnormal increase in radioactivity as early as possible;
- ensure that the facility is not malfunctioning;

- contribute to transparency and information of the public through the transmission of these data to the national environmental radioactivity monitoring network (RNM – see appendix 4, § 4.3).

##### 15.1.2.2.2 ASN duties concerning regulatory radiation protection monitoring

The Environment Code gives ASN the task of "*organising a permanent watch regarding radiation protection across the country*", of which environmental radiological monitoring forms an integral part.

In this capacity, ASN issues technical regulations, either of a general scope, if they apply to all BNI operators, or of a more individual scope, if they regulate a specific installation. ASN thus sets the minimum requirements for monitoring radioactivity in the environment and then verifies compliance with these requirements.

ASN also plays a role in public information, notably by ensuring that environmental information is made available to the public.

Finally, ASN helps the Ministry of Health to define technical provisions applicable to health monitoring of the radiological quality of waters intended for human consumption and for the accreditation of laboratories performing these health controls.

##### 15.1.2.2.3 Other monitoring players

The radiological state of the environment is monitored most closely in the vicinity of nuclear installations, but also across France as a whole. Various monitoring networks are thus deployed to carry out regular, precise measurements:

- environmental sampling networks (air, water, soil and food) analysed subsequently in the laboratory;
- air radioactivity remote-monitoring networks providing continuous, real-time transmission of their measurement results. They also have an alert function in the event of an unusual rise in the radioactivity level measured.

**BNI licensees**

In France, the licensees are responsible for monitoring the environment around their facilities, in accordance with their individual requirements (creation authorisation decree, discharge license orders or ASN resolutions concerning water intake and discharges) which define the measurements to be taken and at what frequency, regardless of any additional measures that can be adopted by the licensees for the purposes of their own monitoring.

The minimum content of this monitoring is defined in the "BNI Order" and in ASN Resolution 2013-DC-0360 of 16th July 2013, as amended, relative to the control of detrimental effects and the impact on health and the environment of French BNIs.

**IRSN**

In the vicinity of the nuclear facilities, IRSN has its own monitoring networks and conducts regular monitoring in addition to that carried out by the nuclear licensees (Andra, CEA, EDF, French Navy, Orano, etc.). The measurement results obtained are transmitted to the French national environmental radioactivity monitoring network (RNM)

In addition to monitoring in the vicinity of the facilities, broader monitoring is a means of finding out about the radiological state of the environment. This monitoring is performed by numerous stakeholders: IRSN, the Ministerial departments and services of the State responsible for health checks, as well as by other stakeholders belonging to non-governmental organisations (ACRO, CLI, ALQA, universities, etc.).

IRSN acquires data about French environmental radioactivity on the mainland and in the overseas territories, by means of radio-ecological surveys carried out at the request of the nuclear licensees, the authorities or representatives of civil society (CLI, municipalities, associations, etc.), or within the framework of its own study and research programmes.

To do this, IRSN uses two approaches:

- continuous on-site monitoring by self-contained systems (remote monitoring networks) with real-time transmission of results, including:
    - the recently refurbished Téléray network, based on 450 measurement detectors (see appendix 4, § 4.3);
    - the Hydrotéléray network, which comprises 7 monitoring stations located on the major rivers;
    - the OPERA continuous sampling network, with measurements in the laboratory.
- laboratory processing and measurement of samples taken in various compartments of the environment in the vicinity of or at a distance from facilities liable to discharge radionuclides.

The results of measurements are transmitted to the RNM, which enables an overview of the level of radioactivity across the country to be obtained in the various environmental compartments and foodstuffs. The measurements are made accessible to the public via various Internet platforms, including that of the RNM (http://www.mesure-radioactivite.fr/) and those of IRSN (http://teleray.irsn.fr).

- The environmental radiological monitoring data are periodically analysed by IRSN and made public either in the form of summaries, both national (radiological summaries) or regional (radiological findings and results of radiological monitoring in French Polynesia), or in the form of thematic reports (e.g. radiological findings on the remanence of artificial radioactivity).

###### 15.1.2.2.4 Radioactive waste and effluent

**BNI waste management**

The underlying principles for waste management are: limiting the quantity produced, sorting according to type and to level of activity, packaging immediately after production, storage guaranteeing the integrity of the packages, transportation then disposal.

In practice, waste management is more specifically checked during the review of the waste management studies for each site or facility, which describe the licensee's waste management objectives, notably the management routes for each type up to disposal. In addition, since 1st July 2015 (ASN resolution 2015-DC-0508 of 21st April 2015), the BNIs must have a waste zoning plan which clearly shows the boundaries of the zones in which nuclear waste could be produced, the methods for declassifying or reclassifying the waste zones and the traceability and record-keeping for those zones in which the structures and soils are liable to have been contaminated or activated. ASN Guide No. 23 clarifies certain aspects of application of this resolution. Since 1st July 2018 (ASN resolution 2017-DC-0587 of 23rd March 2017), the procedures for the packaging of radioactive waste and the conditions for acceptance of these waste packages in disposal BNIs have been more precisely regulated.

Finally, French regulations do not include the notion of a clearance level for waste.

**BNI discharges**

The Environment Code entrusts ASN with competence to define the requirements concerning BNI water intake and discharges.

When renewing or modifying these requirements, ASN sets limit values for emissions, water intake and discharge of effluents on the basis of the best available technologies in technically and economically acceptable conditions, taking into consideration the characteristics of the facility, its location and the local environmental conditions.

The approach to reduce BNI discharges at source aims to reduce their quantity. The optimisation efforts implemented by the licensees mean that, for "equivalent operation" the emissions are reduced, sometimes significantly. Setting and periodically revising discharge limit values should encourage the licensees to maintain their optimisation and discharge control efforts.

In its resolutions, ASN defines requirements concerning water intake and effluent discharge methods for each BNI and others which set their environmental discharge limits (resolutions requiring approval by the ministers responsible for nuclear safety for BNIs under construction and in service).

Since 1st July 2012, any BNI modification project that could cause a significant increase in its water intake or effluent discharges to the environment is now made available to the public.

#### 15.1.2.3 Protecting the population in the event of long-term exposure

Some sites are contaminated with radioactive materials due to a nuclear activity in the near or more distant past, or to an industrial activity using raw materials containing non-negligible quantities of natural radionuclides. The majority of these sites are listed in the inventory issued and periodically updated by the French National Radioactive Waste Management Agency (Andra) and can be consulted on its website www.Andra.fr.

A guide on the management of potentially polluted sites, the drafting of which was coordinated by ASN and the Ministry for Ecology, was published in December 2011 and describes how to deal with the various situations that could be encountered when rehabilitating sites (potentially) contaminated by radioactive substances.

Another Guide was published in 2016 concerning the management of soils contaminated by BNI activities.

### 15.1.3 Protection of workers

The Labour Code contains specific provisions for the protection of workers, whether or not salaried, liable to be exposed to ionising radiation. It transposes into French law the Euratom directives concerning the protection of external workers liable to be exposed to ionising radiation during the course of their work in limited access areas.

There are links between the Public Health Code, the Environment Code and the Labour Code, with regard to the provisions for the collective protection of workers within BNIs.

For all workers (salaried or otherwise) liable to be exposed during their professional activity, the Labour Code also sets provisions more specifically concerning:

- dose limits for workers;
- the technical rules for outfitting of working premises;
- the training and dosimetric and medical monitoring of workers;

- abnormal working situations (exceptional exposure);
- the functional organisation of radiation protection within the establishment (in particular the department with competence for radiation protection).

#### 15.1.3.1 Dose limits for workers

Limits are set for the exposure levels induced for workers by nuclear activities.

For the whole body, the effective dose exposure limit value is 20 mSv for twelve consecutive months. This dose limit is supplemented by specific limits for organs or tissues, called “dose equivalents”, which are set at:

- 500 mSv for the extremities and skin; for the skin, this limit applies to the average dose over a total surface of 1 $cm^2$, irrespective of the exposed surface;
- 20 mSv for the crystalline lens of the eye; this new limit value (previously 150 mSv) will only be applicable as of 1st July 2023. Interim provisions contain a cumulative limit value of 100 mSv for the period from 1st July 2018 to 30th June 2023, provided that the dose received during one year does not exceed 50 mSv.

In exceptional circumstances, these limit values may be exceeded under certain conditions; the exposure level may not however exceed 50 mSv over twelve months in terms of effective dose or dose equivalent for the crystalline lens of the eye, provided that the average annual dose received over 5 years does not exceed 20 mSv. There are also specific provisions for the eventuality of a radiological emergency situation.

The exposure limit values are supplemented by specific limits applicable:

- in the case of pregnancy, to exposure of the unborn child, which should remain below 1 mSv;
- for young people aged 16 to 18, an effective dose limit of 6 mSv, and equivalent dose limits of 150 mSv for the extremities and the skin and 15 mSv for the crystalline lens of the eye.

The Labour Code prohibits the employment of short-term contract and temporary contract staff for the performance of work in areas where the hourly effective dose is greater than 2 mSv.

If a short-term contract worker is exposed to ionising radiation and if at the end of his or her contract, this exposure exceeds the annual limit as calculated by comparison with the duration of the contract, the employer must propose an extension of the contract for a time such that the exposure observed at expiry of the extension is no higher than the annual limit value calculated by comparison with the total duration of the contract.

#### 15.1.3.2 Zoning

The regulations[5] set requirements for definition of monitored or limited access areas and also define health, safety and cleaning rules which must be applied in these areas.

[5] Order of 15th May 2006, amended, concerning the conditions for demarcation and signage of monitored and limited access areas and specially regulated or prohibited areas, owing to exposure to ionising radiation, as well as the health, safety and cleaning rules required in them.

The demarcation of regulated areas is defined on the basis of an evaluation of the risks and the level of exposure, whether external (effective or equivalent doses), or, as applicable, internal. The regulations set reference values.

#### 15.1.3.3 The radiation protection adviser (CRP)

The duties of the radiation protection adviser (CRP) are carried out under the responsibility of the employer. They provide advice and assist the employer on various subjects: they are notably consulted for the performance of the risk assessment, for demarcation of zones and for definition of the protection measures designed to reduce exposure to the level that is as low as reasonably achievable (optimisation principle). The CRP may be an individual within the facility or company, referred to as the "Radiation Protection Expert-Officer) (PCR) or a certified external organisation referred to as the "Organisation with Competence for Radiation Protection" (OCR). For BNIs, a "centre of expertise" recognised by ASN is set up.

The regulations[6] make provision for 3 levels of training and 5 activity sectors, including a "nuclear reactor" sector, covering all nuclear reactors, regardless of what they were designed for.

Training comprises a theoretical module and a practical module specific to each sector. The training organisations carrying out "PCR" training must be certified by an organisation accredited by the French Accreditation Committee (COFRAC).

#### 15.1.3.4 Dosimetry monitoring of workers

The external exposure monitoring system for persons working in facilities in which ionising radiation is used has been in place for several decades. It is based primarily on the mandatory wearing of passive dosimeters for workers liable to be exposed and enables compliance with the regulatory limits applicable to workers to be checked.

The data recorded indicate the cumulative exposure dose over a given period. They are collated in the SISERI[7] (https://siseri.irsn.fr/) system managed by IRSN and are published annually.

At the national level, the SISERI system consolidates the following data:

- passive external dosimetry, the results of which are supplied by the dosimetry organisations;
- operational external dosimetry, the results of which are sent in by the radiation protection advisers (CRP) for the BNIs;
- monitoring of internal exposure, the results of which are supplied by the medical biology laboratories or the occupational health services, and the internal doses calculated by the occupational physicians;
- other data concerning the monitoring of flight crews, radon exposure or naturally occurring radioactivity.

[6] Order of 6th December 2013 concerning the training of the radiation protection expert-officer and certification of the training organisations.

[7] Information taken from the 2017 report "Occupational exposure to ionising radiation in France". Date of publication: June 2018, IRSN. Reference PSE-SANTE 2018-000005.

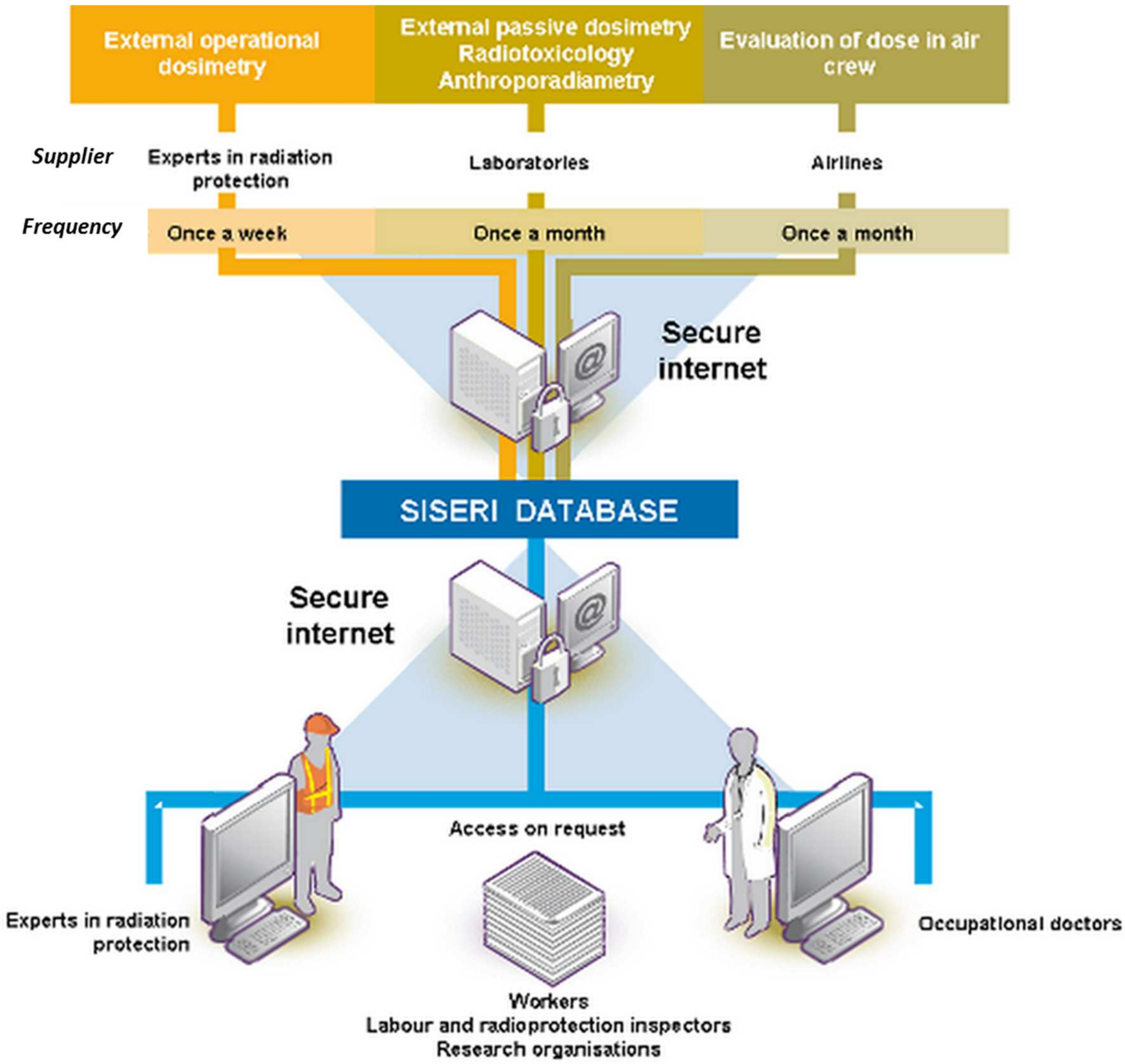


Figure 5: How the SISERI system works (source IRSN)

If one of the limit values is exceeded, the occupational physician and the employer are immediately informed. The occupational physician notifies the **employee** concerned.

#### 15.1.3.5 Verification of the effectiveness of the prevention means

The working equipment, the ionising radiation sources, the workplaces undergo initial and periodic verifications. The initial verifications and, as applicable, the periodic verifications are performed by accredited organisations, the centres of expertise, or by IRSN. The nature and frequency of the radiation protection technical checks are defined by the regulations. Periodic verifications are also performed by or under the supervision of the radiation protection adviser.

## *15.2 Measures taken for nuclear power reactors*

### 15.2.1 Radiation protection of workers

Occupational dosimetry must be optimised prior to performance of the operations. The doses received by workers can result from internal contamination or external exposure to radiation. In order to further optimise and reduce the doses received by exposed individuals, EDF launched the ALARA 1 policy in 1992, which was given fresh impetus in 2000. Considerable gains were then obtained, with the collective dose per year and per reactor falling from 2.4 man.Sv in 1992 to 0.67 man.Sv/ reactor in 2018.

With regard to the individual dose, the doses received by the most exposed workers have been significantly reduced. Over the period 2016 - 2018, no worker (EDF and contractor personnel) received an annual dose of between 16 and 20 mSv (nor were there any over the period 2013 – 2015). At the end of 2018, there was only a single worker whose annual dose very slightly exceeded 14 mSv (there were 2 at the end of 2015) and 160 workers whose annual dose is > 10 mSv (as compared with 266 at the end of 2015).

This dose optimisation approach is based on four fundamentals:

**Reduced contamination of systems**

Foreign experience feedback shows that the controlled injection of zinc into the primary system is a means of reducing the contamination of the systems. To date, this system has been implemented on research reactors which have replaced their steam generators and has demonstrated its effectiveness in reducing Dose Equivalent Rates (DeR) for the first operating cycles following replacement of these components. The advantage of continuously injecting zinc is still being studied and has yet to be demonstrated.

Since 2004, clean-out has been performed on the residual heat removal (RRA) and chemical and volume control (RCV) systems on those reactors where priority is given to reducing the source term. For the period 2016 – 2018, 7 further interventions took place (Fessenheim 1, Bugey 4, Paluel 1, Gravelines 5, Gravelines 6, Chinon 2, Saint-Laurent 2). A multi-year programme is updated every year, depending on the evolution of the radiological state of each reactor and the dosimetry gains assessed over 5 years, to confirm the priority interventions. Operating experience feedback from the reactors cleaned-up over the past 15 years shows a dosimetric gain confirming the benefits and effectiveness of this clean-up in order to reduce worker dosimetry.

**Preparation for interventions and dose optimisation**

The process, common to all nuclear sites (EDF and contractor staff) is based on the following key points: carry out a provisional dosimetry assessment (collective and individual dose) for each operation, analyse the optimisation of these operations on the basis of the dosimetry implications, set a dosimetry target not to be exceeded (collective and individual for each operation) resulting from this optimisation analysis, obtain operating experience feedback with analysis of deviations and best practices, to be used for future operations.

After an experimental phase and validation of an industrial prototype, the period 2016 – 2018 enabled all the sites to be fitted out with a centralised monitoring station (video monitoring of worksites, remote-transmission of radiological measurements and dosimetry data, remote-monitoring of equipment important for the protection of workers, etc.). The general adoption of this development now provides each site with a working conditions monitoring and control tool, thus helping to optimise worker dosimetry.

**Use and dissemination of experience feedback**

To limit the doses received by the workers, EDF set up alert thresholds in the operational doses management application common to all EDF nuclear sites. These thresholds are set at 13 mSv for the pre-alert and 18 mSv for the alert. If these values are reached, special consultation procedures involving workers, doctors and radiation protection specialists are triggered.

The most exposed disciplines are given specific follow-up which is bearing fruit, as the individual doses are falling significantly and the individual dosimetric average has been dropping continuously over the past fifteen years and stood at 0.9 man.mSv per worker in 2018 (2.17 in 2000).

**Activities involving a significant risk of exposure to radiation are subject to a specific process**

These specific activities comprise means of access to prohibited areas (dose equivalent rate higher than 100 mSv/h), access to limited stay areas (dose equivalent rate higher than 2 mSv/h), and gamma radiography operations. Specific organisations were designed and formally adopted and each site is periodically assessed by teams from a Nuclear Inspection unit (independent of the operating sites) with regard to its compliance with common baseline requirements defining the targets and performance to be achieved. These latter are thus classified according to a rating system which is particularly closely monitored by the DPN. Any significant event concerning gamma radiography operations and the means of access to prohibited areas is particularly closely monitored by the centralised engineering service and is the subject of a presentation by the site itself to the national risk prevention committee dealing with radiation protection. This committee is chaired by the Deputy Director of the DPN.

### 15.2.2 Radiation protection of the public

#### 15.2.2.1 Discharge of radioactive effluents

From the moment PWR operations started, EDF took steps to reduce and control discharges. EDF is therefore attempting to limit discharges, mainly by improving the effluent collection and treatment circuits and by reducing its production at source. These steps have led to an extremely significant reduction in the activity of liquid effluent discharges (except for tritium and carbon 14), for which the discharged activity has now reached a minimum level of about 0.2 GBq/reactor/year since 2008 (discharge activity (except tritium and carbon 14) divided by 100 since 1985 and divided by 10 since 1994). Discharges of tritium and carbon 14, which are directly correlated with the power output by the units, remains stable:

- at about 16 TBq/reactor/year for liquid tritium, 0.45 TBq/reactor/year for tritium gas;
- at about 10 GBq/reactor/year for liquid carbon 14 and 0.15 TBq/reactor/year for carbon 14 gas.

For 2017, the annual average discharge values of liquid and atmospheric radioactive effluents per reactor, all plant series included, were those given in the following table:

| Radioactive discharges | Discharges of liquid radioactive effluents (GBq per reactor) | Discharges of gaseous radioactive effluents (GBq per reactor) |
|---|---|---|
| Carbon 14 | 9.2 | 150 |
| Iodine | 0.004 | 0.015 |
| Tritium | 15 900 | 450 |
| FP-AP | 0.2 | 0.002 |
| Noble gases | Not applicable | 500 |

Table 4 : Average annual liquid and gaseous radioactive discharges per reactor

The dosimetric impact that can be attributed to radioactive effluent discharges from the sites today mainly concerns tritium and carbon 14. This is about one µSv/year and more than 2,000 times lower than the average dose that can be attributed to naturally occurring radiation alone in France (≈ 2,900 µSv/year on average). This impact is below the threshold of 10 µSv/year, a threshold below which a possible "health" risk is considered by the international organisations (ICRP, IAEA[8]) to be negligible. Figure 13 of § 4.1.3 in appendix 4 (Environmental monitoring) gives figures for liquid and gaseous discharge from NPPs.

#### 15.2.2.2 Environmental monitoring

Regulatory monitoring of the environment is performed in accordance with ASN resolution 2013-DC-0360 of 16th July 2013 concerning the control of detrimental effects and the impact of BNIs on health and the environment, modified by the Order of 5th December 2016, detailed in appendix 4. The environmental monitoring programme set up by EDF and established with the approval of ASN, is tailored to each nuclear facility and implemented under the responsibility of the licensee. It comprises a fixed programme of continuous and periodic measurements (daily to annual, representing more than 40,000 measurements per year for each NPP) directly related to the nature and frequency of the authorised discharges (see appendix 4).

At the initiative of the licensee, the regulation monitoring is supplemented by radio-ecological monitoring carried out every year on all nuclear sites in operation. This monitoring has been performed on the entire fleet since 1992 and gives an overview of the radiological state of the environment of the facilities, in terms

[8] AIEA Safety series No 89, International Basic Safety Standards (AIEA96), European Commission, Radiation Protection 113, Annals of ICRP - The scope of radiological protection regulation. 2006 Jack Valentin.

of both space and time. The sites also produce ten-yearly radio-ecological reports comparable to the "zero point" benchmark produced prior to commissioning of the first reactor of a site, which show that:

- the influence of the atmospheric radioactive effluent discharges from the sites on the terrestrial compartment (soil, whether or not cultivated, milk, plants, etc.) remains barely perceptible despite the high performance level of the analytical techniques used, including for tritium. Only the influence of carbon 14 discharges can be detected with a 1 to 3% average difference (or about the same order of magnitude as measurement uncertainties) with respect to areas not subject to the influence of discharges to the atmosphere.
- the influence of discharges from French sites on the continental aquatic and marine compartment results in occasional detection of 14C, 137Cs, 60Co and 58Co and 3H in some of the matrices monitored. With regard to the activity of the gamma-emitting radionuclides in the aquatic environmental matrices, it is interesting to note that this fell by a factor of 10 between the 1990s and 2000s and has stabilised since then. The downward trend in activity measured in aquatic plants is in direct correlation with the steps taken to optimise and reduce liquid effluent discharges. The measurements taken in the marine environment also show that because of the authorised radioactive effluents, the impact of the facilities is only perceptible in the near field.

The results of the analyses performed during the course of regulation monitoring of environmental radioactivity, in conjunction with the results of the yearly and ten-yearly radio-ecological monitoring analyses, contribute to demonstrating the very low impact of radioactive effluent discharges from the sites on the terrestrial and aquatic environments. They also confirm the general reduction in the activity of artificial gamma-emitting radionuclides measured in the environmental matrices monitored since the mid-90s.

Together with the fall in effluent discharges mentioned above, these results are the environmental reflection of the quality of operation on the sites and the benefit derived from the steps taken by EDF to reduce effluent discharges and their impacts on the environment.

## 15.3 Measures taken for research reactors

### 15.3.1 CEA reactors

Dedicated teams monitor the facilities, the CEA personnel and, outside normal working hours, provide an on-call duty service.

On each site, specialised teams are in charge of radiological monitoring of the personnel. The external and internal passive dosimetry results are transmitted to the SISERI system by the dosimetry organisations. Every employee intervening within a controlled area is also equipped with an individual operational dosimeter to ensure continuous and real-time monitoring of any doses received; the results from these dosimeters are transmitted to the SISERI system.

The employees of contractor companies are monitored by approved organisations, which issue them with passive dosimeters. This monitoring is supplemented by individual operational dosimeters that can be placed at the disposal of these employees by CEA.

On the basis of the principle of equivalence, CEA clarified the steps taken to organise the radiation protection of operations entrusted to outside contractors. For these operations with a risk of exposure to ionising radiation, the outside contractor appoints a radiation protection expert-officer (PCR), in compliance with the regulations. Moreover, during the operations in the facilities, the radiation protection of the contractor's staff is guaranteed by a certified radiation protection technician, provided by and acting under the responsibility of the contractor company.

The effectiveness of the system in place is proven by the record of doses received by the personnel of the facilities and the personnel of outside contractors for the years 2015-2017: over this period, the average collective dose at CEA was 0.2 M.Sv. For this same period, no CEA employee was exposed to an effective dose of more than 5 mSv. The average equivalent dose for a CEA worker is 0.11 mSv, and 0.09 mSv for an outside contractor worker (operational dosimetry).

Table 5 gives the external passive dosimetry results for all CEA employees subject to dosimetric monitoring.

Table 5: External passive dosimetry results for the period 2016-2018

| | 2016 | 2017 | 2018 |
|---|---|---|---|
| **Number of staff subject to dosimetric monitoring** | 6839 | 7027 | 7082 |
| **Dosimeters showing a dose < detection threshold** | 89 % | 91 % | 92 % |

The environmental monitoring programme is drawn up and performed on each site under ASN oversight.

For all the CEA research reactors, gaseous and liquid discharges remain low and in any case below the discharge licence limits.

### 15.3.2 The ILL high-flux reactor (HFR)

To ensure surveillance of the ILL and monitoring of the personnel, the radiation protection unit comprises 10 persons. Outside normal working hours, a duty service is provided on the ILL site.

The effectiveness of the overall radiological protection system in place is demonstrated by the dose history of BNI personnel, researchers and staff from outside contractors: over the past three years (2016, 2017 and 2018), no employee received an annual dose in excess of 2.1 mSv and the total dosimetry (personnel, researchers, contractors) over this period is below 0.05 m.Sv, for more than 2000 people wearing a dosimeter, or an average individual dose of less than 0.025 mSv.

For the years 2016, 2017 and 2018, gaseous releases remained below 18% of the carbon 14 authorisation, were about 6 to 12% of the tritium and noble gases discharge authorisation and about 1% for the other categories of radionuclides.

Liquid discharges were less than 15% of the authorised limits for tritium and less than 20% of the authorised limits for other radionuclide categories.

## *15.4 ASN analysis and oversight*

### 15.4.1 Exposure of workers

#### 15.4.1.1 ASN oversight

One of ASN's duties is to check compliance with the regulations relative to the protection of workers liable to be exposed to ionising radiation in BNIs. ASN focuses on all workers active on the sites, both in-house personnel and external contractor staff, during the entire operating cycle of the facility.

This oversight takes two main forms:

- performance of inspections:
  - specific to radiation protection, scheduled one to two times per year and per site;
  - during reactor outages in the nuclear power plants;
  - following ionising radiation exposure incidents;
  - in the head office departments in charge of radiation protection doctrine.
- examination of files concerning the radiation protection of workers, which can cover:
  - significant radiation protection events reported by the licensee;
  - design, maintenance or modification files with national implications, produced under the responsibility of the licensee;
  - documents produced by the licensee concerning application of the regulations;
  - the in-depth reviews carried out by IRSN at the request of ASN and the opinions submitted by the GPR.

#### 15.4.1.2 Nuclear power plants

Every year, ASN presents EDF with its assessment of the radiation protection situation on the sites. This report is a means of comparing ASN's analysis with that of the licensee and of identifying possible areas for progress.

Periodic meetings are also held to check the progress of technical or organisational projects being considered or actually being deployed.

ASN considers that radiation protection is addressed differently by the various NPPs, notably with respect to radiological cleanness management within the facilities and the steps taken to prevent the risk of contamination. Faced with this situation, ASN is reinforcing its oversight of implementation of the action plans requested to correct these situations on the reactors concerned.

Since 2011, ASN has carried out tightened inspections on the subject of protection of workers against ionising radiation. The Bugey, Cruas-Meysse, Saint-Alban/Saint-Maurice and Tricastin NPPs, located in the Rhone Valley, were the subject of a tightened inspection campaign in September and October 2018.

The size of the team (six to eight ASN inspectors and two to three IRSN experts) made it possible to control the organisation and management of radiation protection, take into account feedback, site management, application of the optimisation approach, control of radiological cleanliness and management of radioactive sources. Simulations were used to check the organisation for dealing with contaminated workers and processing atmospheric contamination detection alarms inside the reactor building. An unannounced night-time inspection of the steps taken to ensure the radiation protection of workers during a reactor outage was also carried out.

The inspectors observed that the teams on the sites had taken account of certain points raised by ASN in previous years and that good practices were implemented, in particular to improve the working conditions of the personnel. The ASN considers that improvements are needed in the process of optimising the dosimetry of interventions, the characterisation and analysis of gaps relating to radiation protection and the management of contaminated personnel.

In several NPPs, ASN observes the positive impact of allocating "zone managers" and the maintenance crews radiation protection supervision station during reactor outages.

ASN observes that the collective doses have reached a plateau of about 0.65 man.Sv per reactor, depending on the volume of maintenance work. In preparation for the project to renovate the major components of the NPPs, ASN considers that in its future reactor outage campaigns, EDF must boost its efforts to limit the expected rise in collective doses.

#### 15.4.1.3 Research reactors

The doses received by the workers in French research reactors in service are low and almost always below the value of 1 mSv/year. ASN is satisfied with the radiation protection of workers within the research reactors. Radiation protection within the research reactors could however be further improved with better preparation of the operations involving exposure of the personnel. Areas for improvement were also identified during inspections concerning demarcation in the field of certain zone boundaries.

### 15.4.2 Exposure of the population and the environment

The monitoring of discharges and the environment around nuclear reactors is the responsibility of the licensee. The discharge licensing decisions stipulate the minimum checks that have to be made by the licensee, in particular concerning effluents and environmental monitoring.

The results of regulatory measurements must be recorded in registers that are forwarded to ASN every month for control purposes. With regard to the environment, they are also sent every month to the national environmental radioactivity monitoring network (RNM) (see § appendix 4, § 4.3).

France has implemented a unique system to make available to the public on a dedicated website (www.mesure-radioactivite.fr) all the results of radioactivity measurements carried out in the environment by the various stakeholders (government departments, local authorities, non-governmental associations, public establishments and nuclear operators) who participate in environmental radioactivity monitoring. Each year, nearly 300,000 measurements are transmitted to the RNM, whose database currently contains more than 2.5 million measurement results.

In 2019, the 2015-2017[9] report on the radiological state of the French environment was published, presenting IRSN's analysis and interpretation of all environmental measurements made as part of the RNM. Based on these data, the radiological exposure of populations was also assessed, including doses to populations in the environment near nuclear power plants of about 1 microsievert per year (1 µSv/year), i.e. one-thousandth of the regulatory limit (1,000 µSv/year).

In addition, the licensees regularly send liquid and gaseous radioactive effluent samples to an independent laboratory for analysis. The results of these "cross-checks" are communicated to ASN.

Finally, ASN also carries out unannounced inspections with the assistance of independent laboratories, during which samples are taken from the discharges or from the environment, for the purpose of cross-checks. Since 2000, ASN carries out from 10 to 20 inspections with sampling per year.

#### 15.4.2.1 Monitoring of environmental discharges from NPPs

ASN updated the regulatory oversight of discharges and samples from several NPPs over the period 2016-2019. On all of these dossiers, ASN ensured that discharge limits were set for these sites according to the best available techniques and taking account of experience feedback from the NPPs in operation.

Each ASN individual decision setting out the sampling and discharge procedures contains around 100 generic requirements applicable to all French nuclear power plants. These requirements relate to sampling, gaseous, liquid and thermal discharges, and environmental monitoring.

Decision No. 2017-DC-0588 of the ASN of 6 April 2017, approved by the Order of 14 June 2017, brings these generic requirements together in a single text, improving the consistency of the requirements applicable to French nuclear power plants. It does not propose any major changes to the content of the currently applicable requirements. However, the content of some of the requirements currently contained in individual decisions may have changed, in particular to clarify the expectations of ASN or to add new provisions.

This decision, applicable since 1 January 2018, constitutes a minimum regulatory basis that ASN will extend in each individual decision, whenever additional requirements for the management of sampling and discharges are necessary in view of the specific characteristics of the site and its environment.

The tightened inspection campaigns carried out by ASN constitute a particular inspection format that offers a wider scope of control. They allow a global evaluation on a theme at the scale of a site and a geographical area. Since 2015, ASN has been carrying out this type of inspection once a year on the theme of environmental protection. After the Loire Valley, Rhône Valley, Chooz and Cattenom power plants, the Blayais, Golfech and Civaux nuclear power plants were subject to tightened inspections in March and April 2018.

A team of ASN inspectors, accompanied by IRSN experts, successively examined, according to a similar control programme of one and a half days, the organisation for the protection of the environment of each of these nuclear power plants.

The large size of the team mobilized (up to 16 ASN inspectors and three IRSN experts per site) made it possible to control discharge control, waste management and pollution prevention measures.

[9] https://www.irsn.fr/FR/expertise/rapports_expertise/Documents/environnement/IRSN-ENV_Bilan-Radiologique-France-2015-2017.pdf.

At each of the sites, the duration of the inspection facilitated large-scale exercises and scenarios. Thus, each of the sites tested, at the request of the ASN, its pollution prevention organisation as part of an exercise simulating a spill of hazardous substances reaching the stormwater collection network.

While the inspectors were able to note that EDF teams took into account some of the points raised by ASN in previous years, it appears from these inspections that a general improvement in the way the environmental protection issue is taken into account is expected. In addition, the ineffectiveness of the Civaux nuclear power plant's pollution containment strategy, observed during the spill exercise, led ASN to require EDF to strengthen its resources for managing pollution containment. The operator has therefore, at the end of the inspection campaign, drawn up an action plan, the implementation of which the ASN will continue to monitor.

#### 15.4.2.2 Research reactors

The reactors still in operation in France as at mid-2019 are situated on three sites: Saclay, Cadarache and Grenoble.

The liquid discharges from research reactors are managed in dedicated facilities. The facility which receives the effluents from a research reactor is determined according to the activity and nature of these effluents. The gaseous discharges from the reactors are discharged directly from the research reactor by vents. The gaseous discharge limits are controlled and these discharges are permanently monitored.

The discharges from CEA's research reactors are regulated by ASN resolutions covering the nuclear centre in which they are located. The relevant resolutions regulating discharges from these reactors are:

- for the Cadarache centre: ASN resolution 2017-DC-0597 of 11th July 2017,
- for the Saclay centre: ASN resolution 2009-DC-0156 of 15th September 2009.

For the RHF, the discharges are regulated by the Order of 3rd August 2007 authorising the Institut Max Von Laue-Paul Langevin (ILL) to continue with water intake and liquid and gaseous effluent discharges for operation of the Grenoble nuclear site (Isère *département*).

## 16. Article 16: Emergency preparedness

1. *Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency.*

   *For any new nuclear installation, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.*

2. *Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the States in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.*

3. *Contracting Parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency.*

### *16.1 General organisation for emergencies*

The organisation of the public authorities in the event of a nuclear or radiological incident or accident is defined by Prime Ministerial circular 5567/SG of 2nd January 2012 concerning the organisation of the Government response for the management of major emergencies, along with a range of texts concerning nuclear safety, radiation protection, public order and civil security.

Act 2004-811 of 13th August 2004 on the modernisation of civil security provides for an updated inventory of risks, an overhaul of operational planning, the performance of exercises involving the population, informing and training the population, an operational watch and an alert system. Several Decrees implementing this Act, codified in Articles L 741-1 to L 741-32 of the Domestic Security Code, more specifically concerning the ORSEC plans and off-site emergency plans (PPI), clarified it in 2005.

The subject of radiological emergencies is clarified in the interministerial Directive of 7th April 2005 on the action of the public authorities in the case of an event leading to a radiological emergency situation, which in particular describes the respective roles of the public authorities and the licensee.

The "Major nuclear or radiological accident" national response plan was drafted under the supervision of the General Secretariat for Defence and National Security (SGDSN), a department reporting to the Prime Minister. This plan, published in February 2014, describes the governmental organisation and enables radiological emergency situations of all types to be addressed. It supplements the existing local planning arrangements (PUI – on-site emergency plan and PPI – off-site emergency plan).

This national response plan takes account of changing modelling and measurement technology and is better able to anticipate the possible consequences of an accident, to mitigate them and measure their consequences more rapidly. It also includes elements of post-accident doctrine established by the steering committee for management of the post-accident phase of a nuclear accident or emergency situation (CODIRPA), the international nature of emergencies and the mutual assistance possibilities in the case of an event.

In 2015, the local implementation of this plan began in the French *départements*, under the supervision of the defence and security zone Prefects. It must take account of the diversity of local situations and will first of all entail updating of the existing planning measures in accordance with the method proposed by the guide issued by the Ministry of the Interior at the end of 2014.

Table 6: Positions of the various players in a radiological emergency situation

| | DECISION | ASSESSMENT | ACTION | COMMUNICATION |
|---|---|---|---|---|
| Public authorities | Government (CIC)<br>Prefect (COD) | - | Prefect (PCO)<br>Civil protection | Prefect (COD) |
| | ASN (Emergency Centre) and representative at Office of the Prefect | IRSN (CTC)<br>Météo France | IRSN<br>(mobile units) | ASN<br>IRSN |
| Licensees | National and local level | National and local level | Local level | National and local level |

*CIC: Interministerial Crisis Committee*
*COD: Departmental operations centre*
*PCO: Operational command post*
*CTC: Emergency Technical Centre*

Table 6 shows the positions of the public authorities (Government, ASN and technical experts) and the licensees in a radiological emergency situation. These players each operate in their respective fields of competence with regard to assessment, decision-making, action and communication, for which regular audio-conferences are held. The exchanges lead to decisions and orientations concerning the safety of the facility and the protection of the general public. Similarly, relations between the communication units and the spokespersons of the emergency centres ensure that the public and media are given coherent information.

**Trans-boundary coordination**

Given the potential repercussions of an accident on other countries, it is important that the information and response by the various countries concerned be as coordinated as possible. IAEA and the European Commission thus propose tools to the Member States for notification and assistance in the event of a radiological emergency. ASN made an active contribution to the production of these tools, more specifically the IAEA tool called USIE (Unified System for Information Exchange in Incidents and Emergencies), which is available in ASN's emergency centre and is tested on the occasion of each exercise.

France has signed the two international conventions on the early notification of a nuclear accident and on assistance in the event of a nuclear accident or radiological emergency, adopted by IAEA on 26th September 1986, and applies the Euratom decision of 14th December 1987 concerning community procedures for the rapid exchange of information in the event of a radiological emergency.

Two interministerial Directives of 30th May 2005 and 30th November 2005 transpose these texts into French law and mandate ASN as the competent national authority for application of these procedures. It is therefore up to ASN to notify the events without delay to the international institutions and member States, to rapidly provide pertinent information, in particular to border countries, to enable them to take the necessary population protection measures and, finally, to provide the ministers concerned with a copy of the notifications and the information transmitted or received.

**Bilateral relations**

Maintaining and strengthening bilateral relations with neighbouring and other European countries is one of ASN's major priorities.

ASN is continuing to develop bilateral relations in emergency management with its European counterparts, notably with Germany, Switzerland and Luxembourg. Delegations from Germany and Luxembourg were more particularly invited to observe a national exercise in the emergency centre in October 2017. In 2018, ASN also invited its German and Swiss counterparts to its emergency centre for a nuclear emergency exercise organised in the Fessenheim NPP, in order to test the alert and information chain for the departments, municipalities and border countries (Germany and Switzerland), activation of the emergency units and decision-making.

Conversely, ASN staff were invited to observe exercises for the response to a nuclear or radiological emergency in Finland and the United Kingdom in 2017, as well as in Japan and Taiwan in 2018.

**Multilateral relations**

ASN is taking part in the new IAEA committee (called EPReSC) for drafting of safety standards for emergency situations and is collaborating with the NEA for the organisation of international emergency exercises (INEX 5 in 2016) and participation in the Working Party on Nuclear Emergency Matters (WPNEM).

At the European level, ASN is a participant in the “Emergencies” working group reporting to the HERCA Association. This group is tasked with proposing harmonised European measures to protect the general public, on the one hand in the event of an accident in Europe and, on the other, in the event of a more remote accident, in the light of the lessons learned from the Fukushima Daiichi NPP accident. This group is also partly made up of members appointed by the WENRA association.

**The HERCA/WENRA approach**

In 2014, the HERCA and WENRA associations adopted a joint approach aiming to improve cross-border coordination of protection measures during the first phase of a nuclear accident. The approach recommends:

- in normal situations, exchanges between countries to promote improved mutual familiarity with and understanding of their emergency response organisations;
- in emergency situations:
    - ➢ if the emergency organisations receive sufficient information to be able to function normally during the first hours of an emergency situation, attempts are made to align the population protection measures in neighbouring countries with those decided on by the country in which the accident occurred;
    - ➢ in a situation, even if highly improbable, which would require urgent measures to protect the population but in which very little information is available, predetermined "reflex" measures to be implemented by the country in which the accident occurred.

In order to implement these principles, a minimum coordinated level of preparation is necessary. HERCA and WENRA thus consider that in Europe:

- evacuation should be prepared for the local population living in a radius of up to 5 km around the NPPs, with sheltering and ingestion of stable iodine tablets for persons living in a radius of up to 20 km around the nuclear power plants;
- an overall strategy should be defined to ensure the capability, if necessary, of extending population evacuation up to a 20 km radius, and sheltering and ingestion of stable iodine tablets up to a 100 km radius.

### 16.1.1 Organisation at the local level

In an emergency situation, the main parties involved and decision-makers are:

- the licensee of the affected nuclear facility, which deploys the response organisation and the resources defined in its on-site emergency plan (PUI, see § 16.1.3);
- the Prefect of the *département* in which the facility is situated, who takes the necessary decisions to protect the population, the environment and the property threatened by the accident. He or she works within the context of the PPI and the civil protection response organisation plans (ORSEC). He or she ensures that the populations and mayors are kept informed;
- ASN, which monitors the licensee's actions in terms of nuclear safety and radiation protection. In an emergency situation, it requests assessments from IRSN and assists the Prefect in managing the situation;
- IRSN, which deploys the experts from its mobile unit, the size of which can be modulated, in order to assist the public authorities with their decision-making. This implies deployment of resources in the field, but also the utilisation of monitoring networks and laboratories. The "environment mobile unit" provides technical coordination of environmental measurements, direct measurements of radioactivity of samples taken from the environment and the examination of packages damaged during a radioactive materials transport accident. The "mobile human resources" enable internal contamination measurements to be carried out on people. Finally, the fixed laboratories carry out assessments and analyses of exposure of individuals (radio-toxicological analyses, whole-body radiation measurement examinations, dosimetry reconstruction), and analyse samples taken from the environment;
- because of their local role, the mayors have an important part to play in anticipating and supporting the population protection measures. To this end, the mayor of a commune included within the scope of application of an off-site emergency (PPI) plan must draw up and implement a local safeguard plan to provide for, organise and structure the measures to accompany the Prefect's decisions. The mayor also plays a role in passing on information and heightening population awareness during the iodine tablet distribution campaigns.

### 16.1.2 Organisation at the national level

In the event of a major emergency requiring the coordination of numerous players, an interministerial crisis committee (CIC) is activated. The relevant departments of the Ministries concerned, together with ASN, work together to advise the Government, through the CIC, on the protective measures to be taken. They provide the information and advice to evaluate the state of the facility, the seriousness of the incident or accident, its possible developments, and the measures required to protect the general public and the environment to be assessed.

In performing its consultancy role, ASN draws on the services of IRSN, which carries out the diagnosis and prognosis regarding the safety of the facility and the potential or confirmed radiological consequences for the environment and the population. On the basis of these assessments, ASN proposes technical, health or medical measures to the authorities, with the aim of ensuring protection of the population and the environment, along with measures designed to return the affected facilities to a safe state. The role of ASN and IRSN is also to assist with communication by the authorities, by providing explanatory information about the situation, putting the risks into perspective and reporting on the environmental radioactivity measurement results.

The Prime Minister, who is responsible for managing any major emergency, activates the CIC and places it under the authority of the Minister for the Interior to coordinate governmental action.

The CIC may comprise representatives of the Ministries responsible for health (health protection mission), nuclear safety (national communication mission), foreign affairs (national alert point with the role of transmitting information to partner countries and the international organisations concerned), defence (through the defence nuclear safety authority (ASND)), the general directorate for civil protection and emergency management (which manages the interministerial emergency operational management centre and comprises a nuclear risk management support mission placed at the disposal of the Prefect), ASN (for management of radiological emergency situations), other Ministries and administrations or establishments concerned (such as IRSN, Météo-France), as well as the managers of the national nuclear licensees concerned (for example CEA, EDF and Orano).

### 16.1.3 The emergency plans

#### 16.1.3.1 The BNI emergency and contingency plans

The purpose of the on-site emergency plan (PUI), drawn up by the licensee, is to bring the facility to a controlled state and to mitigate the consequences of the accident. It describes the organisation and the means to be deployed on the site. It also includes the provisions for rapidly informing the public authorities. Pursuant to Article R.593-30 of the Environment Code, the PUI is one of the items to be included in the file sent by the licensee to ASN prior to commissioning of its facility. The licensee's obligations in terms of preparedness for and management of emergency situations are set out in the “BNI Order”.

The ASN “emergency” resolution of 13th June 2017 supplements the provisions of Title VII of the BNI Order of 7th February 2012 by specifying the obligations of the licensees regarding preparedness for and management of emergency situations, along with the ASN requirements regarding the content of the PUI. Most of the provisions of this resolution give official status to existing practices which were not incorporated into the regulations. This resolution also transposes certain reference levels established by the European Nuclear Regulators Association (WENRA) and takes account of the lessons learned from the Fukushima Daiichi accident (emergency management premises, means of communication, exercises simultaneously affecting several facilities). It requires that the emergency crew members take part in at least one simulation or exercise per year and specifies the information that the licensee must transmit to the authorities.

The off-site emergency plan (PPI) is established by the Prefect of the *département* concerned, pursuant to decree 2005-1158 of 13th September 2005, "to protect the populations, property and the environment, to cope with the specific risks associated with the existence of structures and facilities whose perimeter is localised and fixed. The PPI implements the orientations of civil protection policy regarding mobilisation of resources, information and alert, exercises and training". This Decree also clarifies the characteristics of the facilities or structures for which the Prefect is required to define a PPI.

Contingency plans such as the PPIs identify the population protection measures that mitigate the health and environmental consequences of a possible accident. The Prefect decides on the implementation of these actions on the basis of the predicted dose that would be received by a one-year old child situated in the open air when the accident occurs.

For the emergency phase, reference values are defined in Article D. 1333-84 of the Public Health Code:

- an effective dose of 10 millisieverts (mSv) for sheltering;
- an effective dose of 50 mSv for evacuation;
- an equivalent dose to the thyroid of 50 mSv for the administration of stable iodine.

The predicted doses are those that it is assumed will be received until releases into the environment are brought under control, generally calculated over a period of 24 hours. In the event of doubt concerning the duration of the releases, the duration adopted for the calculation does not exceed one week.

Furthermore, a reference vale of 100 mSv received for the duration of the radiological emergency and comprising all exposure routes is defined in Article R. 1333-82 of the Public Health Code. The purpose of this value is to allow effective implementation of the population protection strategy adopted, in accordance with the principles of justification and optimisation.

The PPIs currently make it possible to plan the public authorities' response in the first hours of the accident in order to protect the population living within a radius around the affected reactor which, until 2016, was 10 km and which has since then been raised to 20 km. On 3rd October 2016, the Ministry for the Interior published an instruction concerning the response to a major nuclear or radiological accident "Evolution of national doctrine for drafting or modifying PPIs around NPPs operated by EDF". In 2017, it published a guide intended for the offices of the Prefects in order to implement this instruction by updating the PPIs for the NPPs to take account of the changes, in particular the preparation for "immediate" evacuation within a 5km radius, the integration of consumption restrictions as of the emergency phase and the expansion of the PPI radius for NPPs to 20 km. These changes are also in line with the principles of the "HERCA-WENRA" approach, which aims to improve cross-border coordination of protection measures during the first phase of a nuclear accident.

The PPIs comprise a "reflex" phase which includes an immediate licensee alert of the populations within a 2 km radius around the facility, requiring them to take shelter and await instructions. The additional measures to be taken beyond the zone covered by the PPI are specified, as applicable, through a joint approach which can be based on the Orsec arrangements, taking account of the characteristics of the accident and the weather conditions. In 2018, half of the PPIs for the French NPPs were revised in line with these changes, with the final goal of revising all the PPIs for the French NPPs being set for mid-2019.

The Fukushima Daiichi NPP accident showed that a severe accident can have consequences that affect a radius of several tens of kilometres around an NPP. This thus requires the preparation and, as applicable, the implementation of measures beyond the PPI perimeter as part of the ORSEC planning process. ASN considers that it is today essential to continue with the harmonisation effort so that concrete results are achieved to ensure consistent population protection measures across Europe following an accident. Such an accident occurring in a European country could simultaneously affect several other countries, which reinforces the need for effective cross-border coordination.

ASN also assists the General Directorate for Civil Security and Emergency Management (DGSCGC) at the Ministry of the Interior, in order to supplement the PPIs with regard to aspects relating to post-accident management.

The PPI falls within the framework of the ORSEC system, which describes the protection measures implemented in large-scale emergencies. Consequently, beyond the perimeter established by the PPI, the modular and progressive *département* or zone ORSEC plan applies in full.

#### 16.1.3.2 The "Major nuclear or radiological accident" national response plan

ASN took part in drafting the "Major nuclear or radiological accident" national response plan under the supervision of the General Secretariat for Defence and National Security (SGDSN), a department reporting to the Prime Minister.

The local implementation of this plan in the French *départements* has been under way since 2015, under the supervision of the defence and security zone Prefects. It must take account of the diversity of local situations and will first of all entail updating of the existing planning measures in accordance with the method proposed by the guide issued by the Ministry of the Interior at the end of 2014.

#### 16.1.3.3 ASN's role in the preparation and monitoring of emergency plans

**Review of emergency plans for nuclear facilities or activities**

ASN reviews the on-site emergency plans (PUI) as part of the procedures to authorise the commissioning of BNIs or for licensing the possession and utilisation of high-level sealed sources (Articles R.1333-126 and R.1333-15 respectively of the Public Health Code), as well as the management plans for events linked to the transport of radioactive substances. ASN also reviews their updates.

**Participation in drafting of contingency plans**

Pursuant to the decrees of 13$^{th}$ September 2005 concerning the PPI and Orsec plans, the Prefect is responsible for drafting and approving the off-site emergency plan (PPI). ASN assists the Prefect and, with the help of its technical support organisation IRSN, analyses the technical data to be provided by the licensees, in particular the nature and scope of the consequences of an accident.

## *16.2 The duties of ASN in emergency situation*

In an emergency situation, the duties of ASN are (see Figure 6):

- to oversee the steps taken by the licensee and ensure that they are pertinent;
- to advise the authorities (Government and local representatives) regarding the population protection measures;
- to take part in the dissemination of information to the population and media;
- to act as competent authority within the framework of the international agreements on early notification and assistance.

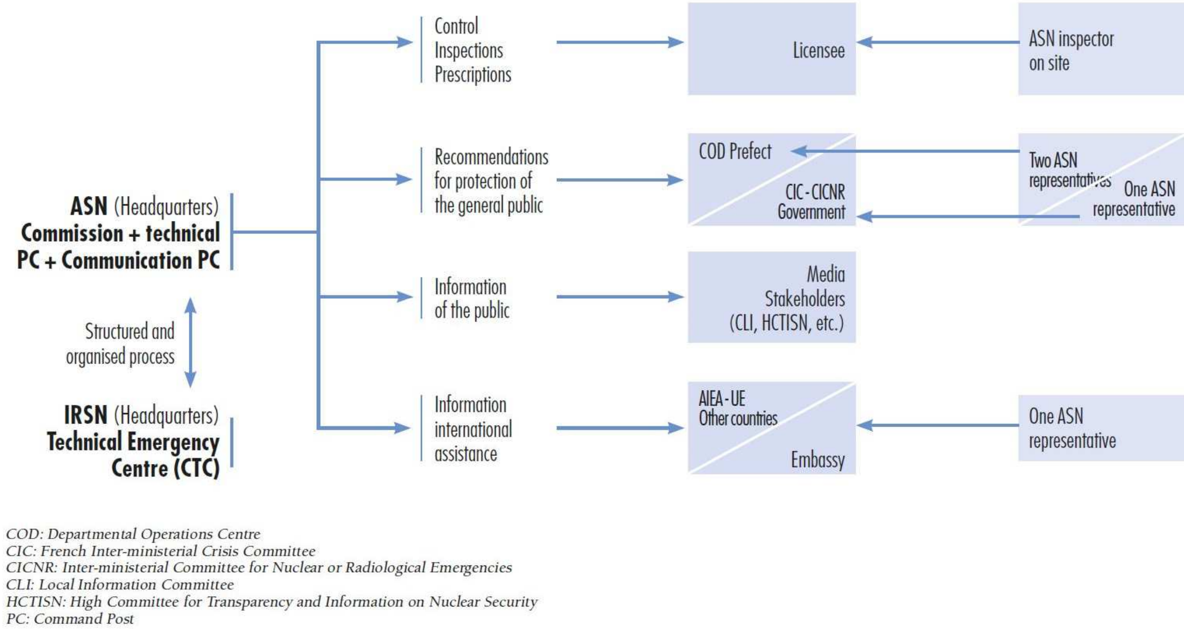


Figure 6: Role of ASN in a nuclear emergency situation

### 16.2.1 Checking the measures taken by the licensee

In the same way as in a normal situation, ASN acts as the regulatory authority in an accident situation. In this particular context, ASN checks that the licensee is fully exercising its responsibilities to control the accident, mitigate its consequences and inform the public authorities rapidly and regularly. On the basis of IRSN's assessments, ASN can at any time instruct the licensee to perform assessments or take the necessary measures, without substituting itself for the licensee in the technical operations.

### 16.2.2 Advising the Government and the Prefect

The Prefect's decision on the population protection measures to be taken in radiological emergency and post-accident situations depends on the effective or foreseeable consequences of the accident around the site. It is up to ASN to submit recommendations to the Government and the Prefect, incorporating the analysis carried out by IRSN. This analysis focuses on both the diagnosis of the situation (understanding the situation of the affected facility, consequences for humans and the environment) and the prognosis (evaluation of the possible developments, especially radioactive releases). This advice relates in particular to the public health protection measures to be implemented.

### 16.2.3 Dissemination of information

ASN is involved in several ways in the dissemination of information to:

- the media and the public: ASN contributes to information of the media, the public and the stakeholders in different ways (press releases, press conferences); it is important for this to be done in close cooperation with the other entities that are required to communicate (Prefect, licensee at local and national levels, etc.);
- institutional players: ASN keeps the Government and the SGDSN informed, the latter being responsible for informing the President of the Republic and the Prime Minister;
- foreign safety organisations.

### 16.2.4 Function of competent authority under the international conventions

The Environment Code requires that ASN acts as competent authority under the international agreements on early notification and assistance. As such, it collects and summarises information in order to send or receive the notifications and transmit the information required by these agreements to the international organisations (IAEA and European Union) and to the countries concerned by potential consequences on their territory.

### 16.2.5 ASN organisation

#### 16.2.5.1 Deployment of the ASN on-call team

In January 2018, ASN set up its 24/7 on-call system. This system aims to reinforce the robustness of ASN's organisation enabling it to deal with alerts, events and emergencies within its fields of competence.

It constitutes the first level of the ASN emergency organisation, which also provides for the general alert and mobilisation of staff to activate the various units in the emergency centre and carry out various local missions (support for the Prefect, on-site liaison, etc.).

The ASN on-call team comprises 15 members distributed among the head-office departments and the regional divisions, who carry out this mission for seven consecutive days.

The system deployed is proving satisfactory and the identified areas for improvement primarily concern staff training, the "reflex" sheets and the operation of the dedicated equipment.

#### 16.2.5.2 Preparedness for BNI accidents

ASN's alert system allows rapid mobilisation of its staff, to activate its emergency centre, and of the IRSN experts. This automatic system sends an alert signal to the staff equipped with appropriate reception devices, as soon as it is remotely triggered by the BNI licensee originating the alert. It also sends the alert to the staff of the DGSCGC, the interministerial emergency management operations centre (COGIC), Météo-France and the ministerial operational monitoring and alert centre of the Ministry for Ecological and Solidarity-based Transition.

In early 2019, ASN set up a new emergency organisation, the main characteristic of which is that it is designed to be modular. When a situation occurs and following the assessment made by the on-call team, several organisational response levels can be initiated, ranging from management by a single member of the on-call team, up to complete activation of the ASN emergency organisation.

The choice of the level of response is the responsibility of the head of the on-call team, in conjunction with the general management if necessary.

The organisation evolves over time and may lead to the mobilisation of staff that is occasional, intermittent or at regular intervals or, on the contrary, that is continuous and permanent, involving rotating shift changes.

The organisation set up by ASN in response to an alert or emergency situation involves the various ASN levels (division, emergency centre and departments, general management and Commission) as shown below.

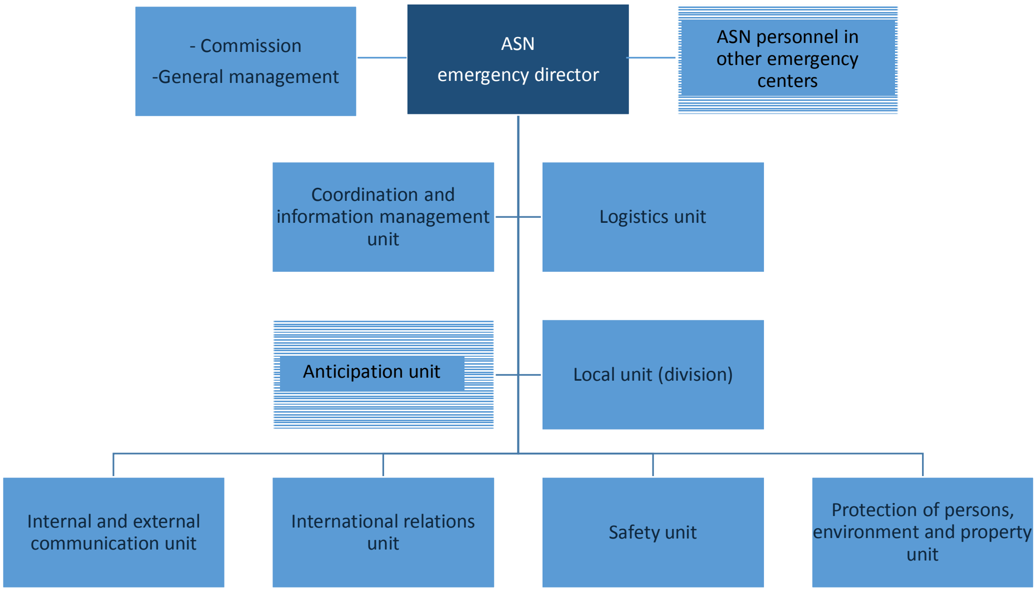


Figure 7: Diagram of the ASN emergency response organisation

Most of the units are located in the ASN emergency centre : staff are seconded in other emergency centres and the local unit is run by the staff of the regional division concerned.

The emergency centre is the principal point of coordination and management of alert and emergency situations. It provides premises and resources for coordinating the various missions and topics that need to be handled.

In nominal operating conditions, an emergency director oversees management of the emergency and the work-cycle of the various functional units:

- the role of the “coordination and information management” unit is to support the emergency director with management of information and coordination of the ASN emergency teams;
- the role of the “logistics” unit is to keep the emergency centre functioning;
- the role of the “safety” unit is to understand the event, anticipate how it develops and verify the appropriate nature of the steps taken by the licensee;
- the role of the “protection of persons, environment and property” unit is to produce an inventory (radiological, geographical, demographic, etc.) and propose a protection strategy;
- the role of the “internal and external communication” unit is to establish ASN’s communication strategy with its stakeholders;
- the role of the “international relations” unit is to carry out notification and assistance missions and act as the principal point of contact for informing international stakeholders;

- the role of the "anticipation" unit is to identify the various possible scenarios, the assessments to be carried out and the monitoring needed in order to understand the potential development of the situation as rapidly as possible;
- the role of the "local" unit is to support the Prefect in charge of operations and to represent ASN in dealings with the licensee.

This emergency centre is regularly tested during national emergency exercises and is activated for actual incidents or accidents. The emergency centre is connected not only to the public telephone network but also to several independent restricted-access networks that provide direct or specific secured lines to the main nuclear sites. ASN's PCT also has a videoconference system that is used chiefly to communicate with IRSN's emergency technical centre (CTC).

It also uses IT equipment tailored to its functions, in particular to transmit technical information from IRSN (continuous environmental radioactivity monitoring) and exchange information with the European Commission and the Member States (WebECURIE, USIE).

The lessons learned from the Fukushima Daiichi NPP accident also lead ASN to envisage sending one of its representatives, if necessary, to the French embassy in the country in which an accident occurs. IRSN may also be called on.

#### 16.2.5.3 Activation of the ASN emergency centre in real situations

In 2017, the national emergency centre was activated on 4 occasions, for four real situations. These concerned two intrusions by Greenpeace on the Cattenom and Cruas-Meysse NPPs and two PUI activations on the Bugey NPP. The first activation, as a result of a fire on a roof in a controlled area during a worksite, had no consequences on the safety of the facilities or any environmental impact, as the fire was rapidly extinguished and this was therefore rated level 0 on the INES scale. The second event concerned blockage of a valve on reactor 2, entailing manual shutdown of the reactor. The licensee implemented its incident management procedures, enabling a controlled state to be restored in a few hours. This event, rated level 1 on the INES scale, had no environmental impact. Following each of these events, ASN carried out inspections which confirmed that the licensee had taken the necessary steps. Lessons were learned from these events.

In 2018, the national emergency centre was activated 11 times, for two real situations and nine national exercises, one of which concerned a national defence nuclear facility, jointly with ASND. An incident concerned a fire which broke out in the Onet Technologies Nuclear Decommissioning – OTND plant in Pierrelatte, where low-level waste is stored and processed. ASN activated its emergency centre in order to support the Regional Directorate for the Environment, Planning and Housing (DREAL) and the office of the Prefect. The fire was rapidly extinguished and the smoke remained contained, as the facility is equipped with very high efficiency filters. The measurements taken in the following days confirmed that no releases outside the facility had taken place. The second event concerned a fire on a transformer of Nogent-sur-Seine NPP reactor 2, which was shut down for maintenance with core unloaded, and led to the loss of the off-site power supply. The only electricity generating set available then provided the facilities with electricity, notably the pool cooling systems. The incident ended several hours later, with off-site electrical power being restored.

## 16.3 Role and organisation of the reactor licensees

### 16.3.1 Role and organisation of EDF

#### 16.3.1.1 Organisation

The emergency organisation of the EDF nuclear fleet is designed to take account of emergency situations, in order to prevent all radioactive releases into the environment or, failing which, mitigate them. It falls within the framework of Title VII of the Order of 7th February 2012 setting the general rules concerning BNIs.

It is based on two levels:

- **the local level** on each site under the supervision of the unit manager or his/her representative. It is structured into teams (or command posts - PC) covering the four broad areas necessary for emergency management (appraisal, decision, action and communication).
- **the national emergency organisation (ONC),** which supports the local level with the provision of specialists from the EDF head office departments.

It comprises human and material resources that can be mobilised 24/7, when called by an NPP.

**At local level**

On each of the 19 sites of the NPP fleet, about 70 persons can be mobilised within the hour.

The operating team in charge of the affected reactor constitutes the local command post (PCL), under the responsibility of the shift operations supervisor.

The local strategic management command post (PCD) is assisted by two expert appraisal teams:

- the local emergency response team (ELC), in charge of analysing the state of the facility and predicting developments;
- the controls command post (PCC), responsible for assessing the consequences of the accident on the population and the environment.

These two teams – ELC and PCC – inform the national technical teams (EDF and IRSN) and keep the local PCD regularly informed of events that could change the emergency management strategy.

The resources command post (PCM) is responsible for all site intervention and logistics actions:

- personnel protection and the management of assembly points;
- implementation of telecommunications for all the PCs;
- organisation of work and specific tasks on equipment;
- logistical support to external emergency services and to emergency-response teams.

It is the responsibility of the director of the PCD to assess the seriousness of the event, based on predetermined criteria for triggering the PUI and determining its level.

**At national level**

The national emergency organisation must be operational in its Paris and Lyon premises within two hours. It mobilises about 50 people and alerts 300 others. It comprises a support unit for the reactor designer, Framatome.

The national strategic management command post (PCD-N) is directed by the DPN on-call manager. It coordinates the actions taken by EDF's emergency-response structure as a whole, advises the NPP management concerned by the event and provides information to the EDF Chair, to the public authorities and to ASN at the national level.

It is supported by a national emergency technical team (ETC-N) which has two roles:

- provide the PCD-N with a diagnosis and prognosis of the situation of the site;
- propose opinions and recommendations to the site for management of the facility and an assessment of the environmental consequences.

The skills and capabilities of the persons and organisations involved are maintained by training and by performing periodic exercises. The programme of exercises performed on the EDF fleet every year includes at least 5 exercises for each site and ten or so exercises involving the national level, four of which are conducted in cooperation with the authorities, ASN and IRSN.

Two major changes are currently being deployed to reinforce the robustness of the emergency preparedness organisation:

- the construction of local emergency management centres (CCL) on each site, to replace the existing emergency management rooms, is scheduled by 2024. The CCL the Flamanville site is being completed. These CCL protect the emergency teams from external hazards and the possible presence of radioactivity on the site.
- the deployment of a minimum staff for the operating teams which, combined with the installation of equipment able to withstand the major hazards, makes it possible to deal with the consequences of an external hazard isolating the site, without off-site reinforcements, for a period that could eventually be up to 24 hours. Sessions to prepare for high-stress situation management are currently being deployed for the team managers.

#### 16.3.1.2 Setting up of the Nuclear Rapid Intervention Force (FARN)

The FARN is a national EDF entity which is part of EDF's emergency organisation and capable of rapidly providing material and human aid to a site in difficulty, if so decided by the national emergency Director (PCD-N). Since 1st January 2016, the FARN has been fully operational for the entire EDF NPP fleet.

It is based on four sites and has a national headquarters. It consists of professionals from the NPPs trained in emergency situations, who practice for 50% of their time. Its training programme comprises a minimum of five annual exercises, mobilising about a hundred people on the EDF nuclear NPP sites for one week, plus about ten command post exercises.

In accordance with the ASN requirements, the FARN can:

- intervene within 24h hours, following on from and assisting the crews on the site concerned, where the access infrastructures could be partially destroyed;
- restore access to the site, in conjunction with the authorities;

- work autonomously for several days on a partially destroyed site (non-seismic tertiary buildings, for example);
- provide permanent liaison with the site management and teams.

### 16.3.2 Role and organisation of the CEA

If an emergency occurs at a facility operated by the CEA, an emergency response organisation is set up to supplement the arrangements made by the public authorities (see § 16.1). CEA plays a role in it at local and national levels.

The site affected by the emergency (local level):

- manages the response inside the facility;
- ensures communication with the local media for the site affected by the emergency, in collaboration with the office of the Prefect;
- is responsible for relations with the office of the Prefect and with the IRSN emergency technical centre.

The CEA administration (central level):

- directs CEA's response at national level;
- is responsible for communication with the national media;
- is responsible for relations with the public authorities at national level.

To fulfil their role, the local and central levels are assisted by the local (PCD-L) and central (CCC - emergency coordination centre) strategic management command posts.

- the PCD-L is under the responsibility of the director of the centre or his representative. It comprises a decision-making unit, a local technical emergency team (ETC-L), a control team, an operational team, a communications unit and a press unit;
- the CCC is under the responsibility of the general administrator of the centre or his representative. It comprises a decision-making unit, a central emergency technical team (ETC-C), a communications unit and a press unit.

The communication and press units, in agreement with the PCD-L or the CCC, prepare press releases, answer external calls and manage interviews.

It is the responsibility of the director of the site or his representative to assess the seriousness of the event, based on predetermined criteria for triggering the PUI and determining its level.

### 16.3.3 The role and organisation of the Institut Laue-Langevin (ILL)

If an emergency occurs at a facility operated by ILL, an emergency response organisation is set up to supplement the arrangements made by the public authorities (see § 16.1).

ILL plays a role at local and national levels.

The site experiencing the emergency:

- manages the response inside the facility;
- ensures communication with the media for the site affected by the emergency, in collaboration with the office of the Prefect;

- is responsible for relations with the office of the Prefect and with the IRSN emergency technical centre;
- is responsible for relations with the public authorities at national level.

To perform these duties, ILL relies on its strategic management command post, the PCD.

- the PCD is placed under the responsibility of the ILL Director and the Head of the Reactor division, or their representatives. It comprises a decision-making unit;
- the PCD calls on the services of an emergency technical team (ETT), a technical command post (PCT), a communications unit (communication delegate and media PCD). The ETT itself comprises a movements team (ETT Movement), an environment team (ETT Environment) and a radiation protection team (ETT RP).

The communication delegate, with the agreement of the PCD, drafts the press releases and handles interviews, while the PC Communication answers outside queries.

It is the responsibility of the Head of the Reactor Division or their representative to assess the seriousness of the event, based on predetermined criteria for triggering the PUI, and to determine its level.

The ILL is equipped with an emergency control station (PCS) which remains functional even in the event of the seismic, flooding and chemical hazards considered for the "hardened safety core".

## *16.4 Emergency exercises*

### 16.4.1 National nuclear emergency exercises

Jointly with the SGDSN, DGSCGC and ASND, ASN prepares the annual programme of national nuclear and radiological emergency exercises concerning BNIs and radioactive substances transport operations. This programme is announced to the Prefects by means of an interministerial instruction and takes account of the lessons learned from actual situations (national and international) and the exercises held the previous year.

In addition to the national exercises, the Prefects are asked to hold local exercises on the sites within their *départements*, in order to enhance preparedness for radiological emergency situations and more specifically test the time needed to deploy the players involved.

The exercises enable those involved to build on knowledge and experience in the management of emergency situations, in particular for the 300 or so persons mobilised in the field for each exercise.

They are able to measure the degree of preparedness of each Prefect's office and the other stakeholders involved and:

- ensure that the plans and procedures they contain for alerting and early notification of international organisations are kept up to date and are well-known to all the managers and responders;
- allow training of those liable to be involved;
- implement the various aspects of the emergency organisation, along with the procedures stipulated in the various plans and baseline requirements: national plan, interministerial requirements, contingency plans and local safeguard plans;
- contribute to informing the media and the populations;

- develop a pedagogical approach aimed at civil society, so that everyone can make a contribution to their own safety by adopting appropriate safeguard behaviour.

Some of the emergency exercise objectives are mentioned in the interministerial instruction on exercises:

- test the regional implementation of the national plan for response to a major nuclear or radiological accident, in particular in all the départements which do not contain a nuclear facility (half-day “transport” exercises);
- prepare the offices of the Prefect for implementing public protection measures or post-accident actions, by extending slow-development accident exercises with a phase focusing on civil security;
- test the ability of the entities involved to provide the interministerial level with information linked to the national plan for response to a major nuclear or radiological accident, on the occasion of the SECNUC major exercise;
- involve the Prefects of the defence and security zones in certain exercises.

ASN is also heavily involved in the preparation and performance of other emergency exercises that have a nuclear safety component and are organised by other players such as:

- its counterparts in charge of nuclear security (defence and security high official – HFDS – at the Ministry for energy) or defence-related installations (ASND);
- international bodies (IAEA, European Commission, NEA);
- the Ministries (Health, Interior, etc.).

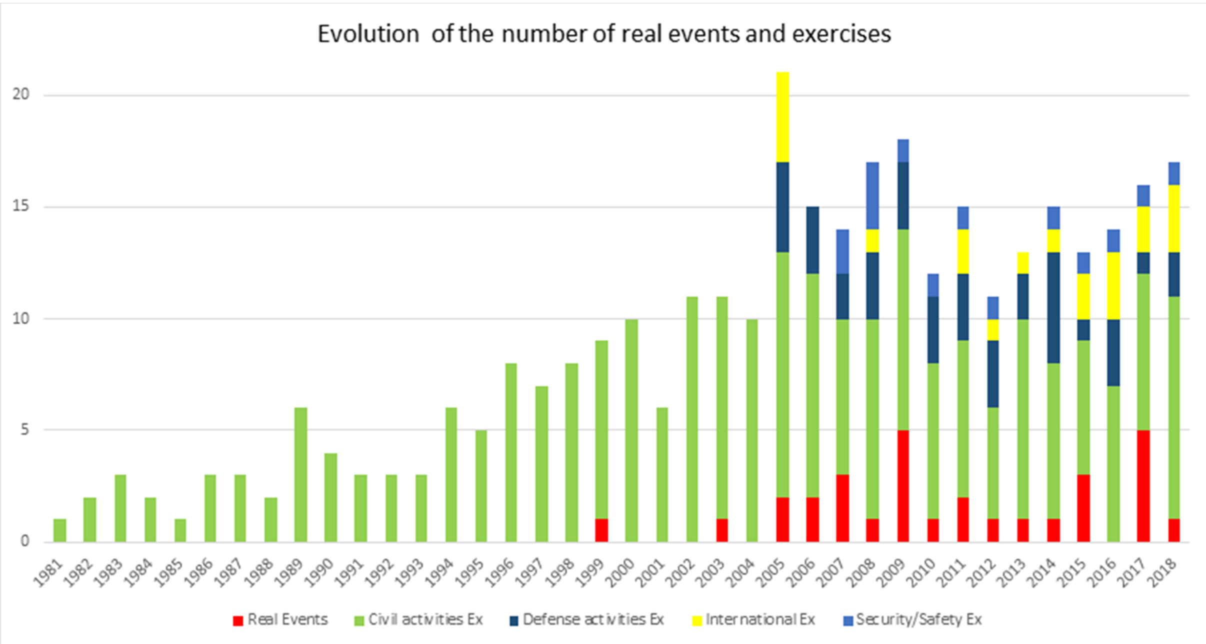


Figure 8: Number of exercises and emergency situations

Evaluation meetings are organised immediately after each exercise in each emergency centre and at ASN a few weeks after the exercise. Along with the other players, ASN endeavours to identify the best practices and the areas for improvement brought to light during these exercises. Experience feedback debriefing meetings are also held to build on the lessons learned from actual situations which have occurred.

Every year, ASN also brings all the stakeholders together to learn the lessons from the exercises in order to improve the response organisation as a whole. These meetings enable the stakeholders to share their experience through a participative approach. They more specifically revealed the importance of having scenarios that were as realistic as possible, in real meteorological conditions and that were technically complex enough to be able to provide useful experience feedback.

The exercises and the actual situations which occurred demonstrated the importance of communication in emergency situations, particularly to inform the public and foreign authorities sufficiently early and avoid the spread of rumours that could lead to movements of panic among the population, both in France and abroad.

### 16.4.2 International exercises and cooperation

ASN and its technical support organisation, IRSN, maintain international relations in order to discuss best practices observed during exercises held in other countries. From 2016 to 2019, ASN – sometimes accompanied by its technical support organisation, IRSN - therefore:

- took part in the INEX 5 international exercise in 2016 , organised under the auspices of the NEA and one of the main goals of which was transboundary coordination of population protection measures. On this subject, ASN focused more particularly on discussions with its German counterparts (BMU);
- received foreign delegations as observers of exercised organised by France, more particularly during an exercise held in 2017 at the Cattenom NPP, and in 2018 at the Fessenheim NPP;
- took part in 2017 and 2018 as observer of exercises organised abroad (United Kingdom, Finland, Japan, Taiwan);
- took part in the ConvEx exercises organised by the IAEA and ECUREX, under the auspices of the European Commission.

ASN is a member of the IAEA’s National Competent Authorities Co-ordination Group (NCACG) and notably participated in the work to implement an action plan by competent authorities to improve international information exchanges in the event of a radiological emergency. ASN also plays an active part in the “ConvEx” exercises held by IAEA pursuant to two international conventions, one on notification and the other on assistance, in the event of a radiological or nuclear emergency.

In addition, with regard to international assistance, ASN has set up a data bank listing all the national technical and human resources available in the event of an accident or radiological emergency and, since August 2008, has been one of the competent authorities which has registered the French means of international assistance with the Response Assistance Network (RANET). ASN is involved in defining the strategy for international assistance needs and resources, and in the development of RANET.

## *16.5 Preparing public protection measures*

The population protection measures that can be taken during the emergency phase, along with the first steps taken in the post-accident phase aim to protect the populations from exposure to ionising radiation and any chemical and toxic substances that may be present in the releases. These actions are part of the PPI.

### 16.5.1 General protection measures

In the event of a severe accident liable to lead to releases, a number of preventive measures can be considered by the Prefect in order to protect the population:

- sheltering and waiting for instructions: when alerted by a siren, the persons concerned take shelter at home or in a building - with all openings completely closed - and wait for instructions from the Prefect over the radio;
- taking stable iodine tablets;
- evacuation: the populations are then asked to prepare a bag, secure their home, leave it and go to the nearest assembly point.
- restrictions or a ban on the consumption or sale of foodstuffs.

These actions form part of a population protection strategy, the effectiveness of which must be evaluated and which could possibly be redirected on the basis of the principles of justification and optimisation.

### 16.5.2 Iodine tablet pre-distribution campaigns

Taking stable iodine tablets is a means of saturating the thyroid gland and protecting against the carcinogenic effects of radioactive iodines.

The circular of 27th May 2009 defines the principles governing the respective responsibilities of a BNI licensee and of the State with regard to the distribution of iodine. The licensee has responsibility for the safety of its facilities. This circular requires that the licensee finance the public information campaigns within the perimeter of the PPI and carry out permanent preventive distribution of the stable iodine tablets, free of charge, through the network of pharmacies.

In 2016, a new national campaign for the distribution of iodine tablets (as the existing tablets were nearing their expiry date), supervised by ASN, was carried out and concerned the populations situated in the zone covered by the PPIs around the NPPs operated by EDF and other nuclear facilities liable to release radioactive iodine in the event of a severe accident (Saclay site, Cadarache site, ILL in Grenoble for example). The aim of this distribution was to ensure that as high a proportion of the population as possible is covered, but also to make the populations and the local elected officials (mayors) aware of the potential risk and the instructions to be followed when necessary, through specific communication media and local information meetings initiated in the second half of 2015. Owing to the extension of the PPI zone radius from 10 km to 20 km at the end of 2016, a campaign of pre-distribution of stable iodine tablets to the population concerned by this extension is scheduled for mid-2019.

Outside the area covered by the PPI, stocks of tablets are created to cover the rest of the country. In this respect, the Ministries in charge of health and the interior decided to create stocks of iodine tablets, positioned and managed by the health emergency preparation and response organisation (EPRUS). Each Prefect organises the procedures for distribution to the population in their own *département*, relying in particular on the mayors for this. This arrangement is described in a circular dated 11th July 2011. Pursuant to this circular, the Prefects have drawn up plans to distribute iodine tablets in a radiological emergency situation, which can involve exercises being held for the local implementation of the major nuclear or radiological accident national response plan.

### 16.5.3 Care for contaminated persons

In the case of a radiological emergency situation, a large number of persons could be contaminated by radionuclides. This contamination could make it difficult for the emergency response teams to provide the necessary care.

Circular 800/SGDN/PSE/PPS of 18th February 2011 specifies national doctrine for the use of emergency response and care resources in the face of a terrorist act involving radioactive substances. These provisions, which also apply to a nuclear or radiological accident, aim to implement a unified nationwide methodology for the use of resources, in order to optimise efficiency. They would need to be adapted to the specific situations encountered.

The "Medical intervention in the case of a nuclear or radiological event" guide, published in 2008 and the drafting of which was coordinated by ASN, accompanies circular DHOS/HFD/DGSNR n° 2002/277 of 2nd May 2002 on the organisation of medical care in the case of a nuclear or radiological accident, bringing together all useful information for the medical respondents in charge of collecting and transporting the injured as well as for the hospital personnel providing treatment in the health care facilities. Under the supervision of the SGDSN, a working group comprising the authors of this guide was set up at the end of 2015 to begin its revision, in order to take account of a number of changes to practices that have taken place since 2008.

## *16.6 Understanding the long-term consequences*

The "post-accident" phase concerns the handling over a period of time of the consequences of long-term contamination of the environment by radioactive substances following a nuclear accident. It includes dealing with various consequences (economic, health, social), by their very nature complex, in the short, medium or even long term, with a view to restoring a situation considered to be acceptable.

The conditions of reimbursement for the damage resulting from a nuclear accident are currently stipulated by Act 68-943 of 30th October 1968, amended, concerning civil liability in the field of nuclear energy. France has also ratified the protocols signed on 12th February 2004, reinforcing the Paris convention of 29th July 1960 and the Brussels convention of 31st January 1963 concerning civil liability in the field of nuclear energy. These protocols and the measures necessary for their implementation are now codified in the Environment Code (Section I of Chapter VII of Title IX of Book V). The "TECV Act" sets the entry into force in February 2016 of these provisions and of new liability thresholds set by the two protocols, without waiting for their ratification by all the signatory States.

Pursuant to the interministerial directive of 7th April 2005, and in association with the ministerial departments involved, ASN was tasked with establishing the framework and defining, preparing and taking part in implementing the necessary provisions in response to post-accident situations following a nuclear accident. It therefore created the Steering committee for managing the post-accident phase of a nuclear accident or radiological emergency situation (CODIRPA) in June 2005. Post-accident management of a nuclear accident is a complex subject involving numerous aspects and players. The technical points to be considered by the CODIRPA are drawn up by IRSN in consultation with ASN.

The elements of the doctrine drafted by the CODIRPA, covering exit from the emergency phase and the transitional and long-term phases, were transmitted by ASN to the Prime Minister in November 2012.

These elements are published on www.asn.fr and widely disseminated at the local, national and international levels.

In the event of the release of radioactive substances into the environment, measures are decided on to prepare for management of the post-accident phase. They are based on the definition of area zoning to be implemented once the releases cease on exiting the emergency phase and include:

- a population protection zone (ZPP) within which action is required to reduce both the exposure of the populations to ambient radioactivity and the consumption of contaminated foodstuffs, as far as is reasonably possible (for example a ban on consumption of produce from the garden, restrictions on access to wooded areas, ventilation and cleaning of homes, etc.);
- a heightened territorial surveillance zone (ZST), which is larger and more concerned with economic management of the regions, within which specific surveillance of foodstuffs and agricultural produce will be implemented;
- as necessary, within the ZPP, an evacuation perimeter defined according to the ambient radioactivity (external exposure); the residents must be evacuated for a length of time that will vary according to the level of exposure in their living environment.

At the end of 2014, the new duties of the CODIRPA, officially laid out in a letter from the Prime Minister on 29th October 2014, giving ASN a new five-year mandate, focused on watching over, supporting and analysing the various post-accident preparation processes, with the aim of periodically proposing updates to the doctrine.

Three working groups were set up in 2014, one concerning long-duration releases doctrine, another concerning the involvement of the regional stakeholders in preparing for post-accident management and the third the involvement of the health professionals. The working group on long-duration releases submitted its report in 2015.

In relation to the experience feedback from the Fukushima Daiichi NPP accident, a new working group was set up in 2015 on waste management in a post-accident situation, involving members of the CODIRPA and of the National Radioactive Materials and Waste Management Plan (PNGMDR). Subjects for which more in-depth examination of doctrine should be envisaged were then identified. These mainly concerned the management of manufactured products, management of water and marine environments, and radiological measurements in a post-accident situation.

Work is being done to define a new doctrine taking account of the scale of the accident and the results of the measurements. This doctrine would recommend implementing progressive post-accident zoning, adjusted according to the measurement results, with the elimination of the predetermined public protection zone (ZPP).

# F – Safety of facilities

## 17. Article 17: Siting

*Each Contracting Party shall take the appropriate steps to ensure that the appropriate procedures are established and implemented with a view to:*

*i) evaluating all relevant site-related factors likely to affect the safety of a nuclear installation during its projected lifetime;*

*ii) evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;*

*iii) re-evaluating as necessary all relevant factors mentioned in sub-paragraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation,*

*iv) consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation, and providing the necessary information to such Contracting Parties on request so that they can evaluate and make their own assessment of the likely safety impact of the nuclear installation on their own territory.*

### *17.1 ASN Requests*

#### 17.1.1 Evaluation of relevant site-related factors

§ 7.2 specifies the different authorisation procedures in effect for the creation, commissioning, modification, shutdown and decommissioning of a BNI.

Well before applying for a BNI creation authorisation, the licensee must inform the administration of the site(s) on which it plans building this installation. With the support of IRSN, ASN assesses the safety-related characteristics of the site: seismicity, hydrogeology, industrial environment, cold water sources (heatsinks), etc. The characterisation of the risks associated with the site and the design of the installations to counter these risks are the subject of basic safety rules (see appendix 2 § 2.3).

The safety options, which more specifically include the accident and hazard situations considered in the design and the methods of dealing with them, must then be presented in the preliminary version of the safety analysis report.

The stress tests performed following the Fukushima Daiichi NPP accident concerned all French nuclear facilities (see § 14.2.1.6). These tests notably supplemented the initial assessments with a characterisation of the extreme natural phenomena and their effects on the safety of the installations.

#### 17.1.2 Evaluation of the impact of a BNI on the local population and the environment

As indicated in § 7.2.2, the BNI creation authorisation application is accompanied by a file comprising a number of items, including the impact assessment and the risk control assessment.

#### 17.1.3 Reassessment of the relevant factors

The external hazards are reassessed as part of the periodic safety reviews conducted every 10 years, to take account of changing knowledge.

Moreover, the external hazards beyond the initial design-basis, particularly earthquakes and flooding, were the subject of a targeted review as part of the stress tests (see § 14.2.1.6).

### 17.1.4 Consultation of neighbouring countries

In accordance with the regulations, authorisation to create a BNI cannot be granted until the European Commission, more particularly including the neighbouring countries, has been consulted (see § 7.2.5).

With regard to the stress tests and the corresponding targeted inspections campaign, ASN involved civil society. Foreign experts participated in the European stress tests review, in inspections and in meetings of the Advisory Committees of Experts (GPE).

### 17.1.5 Public consultation

Pursuant to Articles L. 121-1 et seq. of the Environment Code, the creation of a BNI is subject to the public debate procedure when it involves a new nuclear power production site, or if the new site (not nuclear power production) corresponds to an investment of more than €300 M. The public debate focuses on the appropriateness, the objectives and the characteristics of the project. Moreover, as mentioned in § 7.2.3, the BNI creation authorisation and decommissioning decree are granted following a public inquiry.

Pursuant to Article L. 123-19-1 et seq. of the Environment Code, ASN collects the observations of the public regarding its draft regulations.

With regard to the stress tests and the targeted inspections campaign, ASN involved the CLIs (see § 8.3.5) in the inspections and members of the HCTISN (see § 8.3.2) in the meetings of the GPE.

## *17.2 Measures taken for nuclear power reactors*

The safety analysis reports (RDS) comprise a specific “site and environment” chapter, dealing with topics concerning the safety-related characteristics of the sites.

These topics enable the relevant site-related factors that could affect the safety of the installation to be identified and the impact of the installation on safety, individuals, society and the environment to be assessed.

These topics take into account the requirements of the basic safety rules (RFS) concerned (see appendix 2, § 2.3.1): site geology (RFS 1.3.c), seismic conditions (RFS 2001-01), climatic risks and risks relating to the industrial environment and communication routes (RFS 1.2.d). They also take into account the requirements of the guide on protection against the external flood risk for nuclear facilities published by ASN in 2013 (see § 17.4.1.1.2).

These topics are reassessed at each periodic safety review and the chapters of the safety analysis report (RDS) are updated accordingly.

The stress tests assessed the robustness of the facilities beyond the hazards defined in the RDS, more particularly for earthquakes, external flooding and climatic hazards. The risk associated with the industrial environment was also reviewed.

### 17.2.1 External events – Earthquake

An "envelope" design-basis earthquake (DBE) for the sites of the plant series, was taken into consideration for the standardised design of the nuclear island. In addition, the other buildings and facilities needed for operation of the plant, including the heat sink and the intake channel, were specifically designed for each individual site.

The deterministic approach used to define the seismic loads to be considered in the reviews of a facility or in the design of new facilities includes determining the maximum historically probable earthquake (MHPE) and the safe shutdown earthquake (SSE) by adding an additional degree of intensity. A check is then run to ensure that the NPP can be restored to and maintained in safe shutdown conditions after an earthquake corresponding to an intensity at least equivalent to that of the safe shutdown earthquake (SSE), in accordance with basic safety rule RFS 2001-01.

**Methodology used to evaluate the safe shutdown earthquake during the periodic safety reviews**

The periodic safety reviews are an opportunity for an in-depth examination of compliance with the seismic requirements in force and for a reassessment of the SSE in the light of the most recent data and changing knowledge.

Reinforcements may be decided on, not only on the basis of a reassessment of the seismic hazard, but also on the basis of developments in paraseismic engineering (calculation methods and means).

**Identification of systems, structures and components which must remain available after an earthquake**

Depending on the role items of equipment play in safety, they are placed in safety classes that comprise seismic classification requirements defined by the regulations or the basic safety rules. The seismic classification requires justification of the equipment's ability to perform its functions during and after the earthquake, either by calculation, or by testing on a vibrating table, or through case-by-case analysis.

EDF points out in its stress test reports that it set seismic classification requirements in particular for the items important for safety ("EIP seismic classified") and for the post-accident surveillance measures (SPA).

**Assessment of the safety margins in the stress tests**

EDF reviewed the margins concerning the ability of elements important for protection to withstand external hazards (more particularly earthquake and flooding).

In addition, EDF carried out the seismic inspection of a representative sample of the equipment needed to operate the plant unit in the event of total loss of off-site and on-site power supplies, whether seismic-classified or not, for all the NPPs in service.

EDF defined a Hardened Safety Core for its facilities, consisting of new and existing SSCs (Systems, Structures and Components), which must withstand major hazards (beyond the plant's design basis) in situations of total loss of heatsink and total loss of power supplies. EDF has defined extreme seismic hazard levels (hardened safety core earthquake) for all the sites in operation. An examination of these hazard levels was presented to the Advisory Committee in 2016 and ASN transmitted requests for additional information to EDF in 2016 and 2018. These requests are currently being considered by EDF.

The new structures and equipment are currently being deployed and the existing structures and equipment in the Hardened Safety Core are being reinforced, in order to significantly increase the eventual robustness of the nuclear power plants.

**Main operating provisions**

So that, following an earthquake, appropriate steps can be taken rapidly to bring the NPP reactors to and maintain them in the safest shutdown state, or to continue operation, basic safety rule RFS I.3.b recommends installing seismic instrumentation for pressurised water reactors. The action to be taken depends on the level of the earthquake with respect to an inspection threshold (SDI):

- if the SDI threshold is exceeded, the reactors must go to the shutdown state defined. The resumption of operation may only be initiated with the approval of ASN;
- otherwise, operation may continue, but with visual inspection of structures and equipment.

The results of the conformity checks performed on the 19 NPP sites reveal no findings that could call into question the requirements of RFS I.3b.

**"Seismic interaction" approach**

The purpose of the “seismic interaction approach”, the purpose of which is to prevent damage to an item needed in the event of an earthquake by an item or structure not seismic classified, was initiated in the 1990s for the CP0, CPY, P4 and P’4 plant series and incorporated into the design of the N4 Plant series. It is implemented by a specific analysis as part of the design of each modification.

In response to the ASN requirement concerning the measures to be taken to prevent damage by other equipment to items which must remain available following an earthquake for reasons of safety, EDF decided to reinforce its organisation to control hazard risks during operation. The EDF guide dealing with "seismic interaction" in the NPPs is applicable. It defines the organisational measures to be put in place on the sites and details the roles and responsibilities of the players and the preventive measures to be implemented.

The training of "seismic interaction" coordinators is part of the approach. Similarly, specific training for the sector correspondents and awareness-raising for all personnel are now included in the DPR training curriculum.

The lists of “hazard-target” pairs are regularly updated.

**Loss of off-site electrical power supplies**

For the reference accidents, the safety analysis report examines the simultaneous occurrence of a major earthquake and the loss of off-site power supplies, which were not designed to withstand it.

For the design extension conditions, it also examines the total loss of on-site and off-site power to a reactor on the site. If it proves impossible to start or connect the reactor’s emergency diesel generator sets, it is possible to connect a non-seismic classified back-up diesel generator (GUS) or Combustion Turbine (TAC) available on each site, a diesel generator of a neighbouring reactor (SSE classified) or, eventually, the ultimate back-up diesel generator set (DUS designed for the hardened safety core earthquake (SND)).

In response to the ASN requirements, the DUS is an additional electrical power supply means able to power the systems and components of the hardened safety core, the design principles of which were transmitted by EDF to ASN at the beginning of 2013 and for which deployment work is currently ongoing.

**Conditions of site access following an earthquake**

In the event of major disruption to roads and structures, the emergency response organisation calls on the public authorities who, in addition to triggering the off-site emergency plan (PPI) if necessary, take special measures to restore access to the site, so that the on-call duty personnel can intervene.

The stocks of fuel and oil and their replenishment under all circumstances are guaranteed in order to ensure autonomy in accordance with the following organisational arrangements:

- minimum oil autonomy of 15 days for the 1300 MWe and 1450 MWe plant series, and of 4.5 days for the 900 MWe plant series. In addition, an oil supply contract is intended to cover the needs of a nuclear power plant in the case of "long-term" (15 days) operation of the emergency diesel generator sets,
- minimum fuel autonomy of 72 hours with a supply contract based on a minimum dedicated stock and, beyond this, by requisition (action sheet N°12 of the Governmental plan),
- resupply of fuel and lubricant by the FARN (nuclear rapid intervention force): this capability was validated during FARN tests carried out at the Chinon NPP in September 2015.

**Earthquake-induced fire risk**

The buildings have fire protections designed in accordance with the principle of defence in depth and are subject to seismic resistance requirements. These provisions are originally designed to withstand the OBE (operating-basis earthquake) (excluding the N4 plant series, originally designed for the design-basis earthquake (DBE).

In response to an ASN requirement, EDF initiated a study of the SSE (safe shutdown earthquake) resistance of these provisions contributing to nuclear safety in terms of the fire risk, which led to a currently ongoing programme of work to reinforce items for which SSE resistance is not guaranteed.

**Earthquake-induced explosion risk**

As part of the periodic safety reviews, application of the SSE design requirement to the hydrogen systems and inclusion of the "seismic interaction" approach with regard to potential hazards for lines situated in the nuclear island except for the reactor building, is in progress on the 900 MWe, 1300 MWe and N4 plant series.

In response to the ASN requirement, EDF is implementing this new requirement on the various plant series, in accordance with the schedule of periodic safety reviews.

**Seismic level leading to non-design-basis flooding**

As part of the stress tests, the assessment made by EDF of the water reserves located above the site and which are not considered to be robust to the SSE, did not reveal any risk not already covered by the existing or planned protection measures.

For those sites on which the external flooding risk created by an earthquake exceeding the design basis for the facility cannot be ruled out, EDF carried out a study to determine if there is a real risk of the nuclear island platform being submerged. Additional protection measures are currently being deployed on the sites in accordance with ASN requirements.

### 17.2.2 External events - Flooding

Flooding is a risk that is taken into account in the design of the facilities and reassessed during the periodic safety reviews or further to certain exceptional events.

**Floods for which the facilities are designed**

For the sizing of protection against flooding, the design utilised basic safety rule RFS I.2.e[10] which more particularly defines an approach for determining the water levels to be considered when designing the facilities.

In 2013 ASN published a new guide on protection against the external flood risk for nuclear facilities (see § 17.4.1.1.2). This guide supersedes RFS 1.2.e. It details the recommendations for assessing and quantifying the risks of external flooding faced by these facilities and for defining the appropriate means of dealing with them.

**Measures to protect facilities from the flooding risk integrated into the design process**

EDF has conducted a safety analysis for each site, drawing up a list of the systems and equipment needed to reach and maintain a safe state.

In order to reach a conclusion on the absence of water in the premises housing the equipment to be protected in the event of flooding, EDF has adopted a two-step approach:

- comparison of the water height liable to be reached at the various possible water entry points;
- indication of the material and operating measures aimed at protecting the facility against this water entry.

Material provisions

The material provisions concern the civil engineering, the specific equipment (electrical, I&C, mechanical, etc.), as well as modifications to existing hardware.

The work for protecting the facilities against flooding and integrating the lessons learned from the Blayais NPP event of December 1999 was completed at the end of 2014.

Operating measures

On the occasion of the stress tests, EDF also presented its operational measures for each site, aimed at protecting the facility against the flood level for which it was designed. They include:

- warning systems in the event of a foreseeable hazard that could lead to flooding of the site.
- agreements with organisations within or outside EDF;
- special operating rules in the event of flooding;
- local procedures.

In response to an ASN requirement, measures for coping with isolation in the event of flooding have been implemented on certain sites.

**Conformity of facilities with the current baseline safety requirements**

[10] Basic safety rule 1.2.e. of 12/04/1984 concerning protection against the external flooding risk.

The work to restore conformity of the protected volume and deployment of the organisations and resources to maintain its effectiveness over time were carried out within the deadlines set by ASN.

At national level, these measures resulted in the holding of a protected volume conformity check and updating of the protected volume management rules (see the definition in § 17.4.1.1.2) for the sites.

**Evaluation of safety margins**

During the stress tests, and for each site, EDF presented the margins between the flood level reached and the level of the protections provided with the current design.

During the stress tests, EDF defined augmented scenarios also taking into account the flooding induced by a beyond design-basis earthquake and the structures present on or above the platform and liable to constitute potential sources of flooding following an earthquake of intensity exceeding the SSE, if the structure is not considered robust to a beyond design-basis earthquake.

The approach implemented thus led EDF to define augmented hazards covering all the phenomena that could lead to or contribute to flooding and examine additional scenarios for certain sites. These extreme flooding hazard levels were defined for all the sites in operation.

EDF thus calculated the water level resulting from these augmented scenarios, highlighting the protection measures implemented on the site for protection against design-basis hazards. Where applicable, these studies led to identification of the additional measures that need to be taken.

This approach adopted by EDF offers the facilities a high degree of protection against the risk of flooding.

### 17.2.3 External events – Extreme climatic conditions

From the outset, the design of the EDF reactors has included protection against external hazards considered to be plausible.

The reassessments conducted on the occasion of the successive periodic safety reviews and notably the integration of lessons learned, changing knowledge and the rules applicable to similar facilities, subsequently led to an improvement in how the various hazards are addressed, in particular those linked to climatic conditions.

Further to the Fukushima Daiichi accident in March 2011, EDF's stress test reports (RECS) demonstrated the robustness of its facilities and defined a Hardened Safety Core of additional material and organisational measures to deal with the following extreme climatic hazards:

- tornado: depending on the geographical area, the tornado level selected corresponds to a tornado of level EF4 (Oceanic zone) or EF3 (Rest of France zone).
- natural phenomena related to flooding:
  - extreme wind: laminar flow winds, with peak speeds of 200 km/h,
  - lightning: extreme lightning level, with an intensity of 300 kA, corresponding to the local physical maximum,
  - hail: risk of hailstones of up to 5 cm in diameter.

As of the 4th periodic safety review of the 900 MWe plant series, EDF considers the safety reference levels published by WENRA in 2014 (inclusion of an aggravating factor, operator delay) in order to comply with the safety requirements for the hazard studies in the most advanced European standards for existing reactors. In practice, the analysis leads to the performance of sensitivity studies, considering a worst case combination of the hazard with a failure of active equipment able to prevent the hazard or mitigate its consequences, and studies of sensitivity to the response time of the operator to verify that there is no cliff-edge effect.

When technically pertinent, EDF also carried out sensitivity studies on the behaviour of the installation in response to climatic hazard levels corresponding to annual occurrences of less than $10^{-4}$. In practice, the climatic hazard for which, given the current state of knowledge, it is possible to define such a level of occurrence, are heat waves, extreme cold, extreme winds and tornadoes.

All of the studies performed were able to define modifications to the installations to reinforce protection against the reassessed hazard levels (e.g.: improved ventilation of electrical premises) and demonstrated robustness of the installations to hazards in accordance with the most advanced international recommendations.

EDF has also set up a climate watch.

## *17.3 Measures taken for research reactors*

### 17.3.1 CEA reactors

The Safety Analysis Reports (RDS) comprise a dedicated "Site and Environment" chapter which covers the same topics as for nuclear power reactors.

These topics take into account the regulatory requirements concerned.

These topics are reassessed at each periodic safety review and the chapters of the safety analysis report (RDS) are updated accordingly.

As part of the experience feedback following the Fukushima accident, the robustness of the installations beyond the requirements of the RDS was assessed, particularly for earthquakes, external flooding and climatic hazards as shown by the lessons learned from Fukushima. The risk associated with the industrial environment was reassessed.

As a general rule, these assessments have shown the research reactors to display good robustness to these extreme hazards. More specifically, the susceptibility of the sites to flooding is extremely low. Research reactors, which have much lower power levels than power reactors, are also very resistant to electrical power supply and heat sink losses. They enjoy a considerable time margin before intervention is necessary.

### 17.3.2 The ILL high-flux reactor (HFR)

The safety report describes all the external hazards that are taken into consideration in the design of the equipment items that are required according to the operating situations. The ILL stress tests analyse the impact of concurrent extreme hazards. The ILL defined and carried out the work needed to improve the robustness of the facility in extreme conditions.

## *17.4 ASN analysis*

### 17.4.1 Nuclear power reactors

As part of the fourth PSR of 900 MWe reactors, the third PSR of 1300 MWe reactors and the second PSR of N4 reactors, the standards for the protection of nuclear power plants against natural hazards and the heat sink were examined.

As a general rule, the licensee has taken operating measures aiming to protect the sites against extreme meteorological conditions, more specifically including warning systems for predictable hazards and particular organisational and material prevention and protection measures.

#### 17.4.1.1 Change in the design basis for natural and human risks following the stress tests

For the different risks considered for each site, the licensee has highlighted the margins with respect to the risks considered in the design and those going beyond the baseline requirement. It has decided, where applicable, on any additional measures to be taken. The licensee has also studied several situations which it considers to be representative for evaluating the cliff-edge effects.

As part of this approach, new requirements have been set out for reactors in operation or under construction with the aim of reinforcing their robustness to such phenomena. The main requirements and requests that cut across Articles 17, 18 and 19 of the Convention are described in chapter 6 and detailed below.

ASN is also preparing the transposition into the national regulatory framework of the external hazard reference levels which WENRA has added or modified.

##### 17.4.1.1.1 Earthquakes

**Earthquake hazard**

With regard to earthquakes, the methodology currently used to determine the seismic risk in France is mainly deterministic and complies with the methodology and criteria prescribed by the IAEA.

ASN considers that the seismic hazard assessments determined by EDF are acceptable, with the exception of those concerning the sites of Saint-Alban/Saint-Maurice, Fessenheim, Chinon and Chooz which are insufficient in the light of current knowledge. ASN therefore asked EDF:

- to reassess the seismic spectra for the Saint-Alban/Saint-Maurice, Fessenheim, Chinon and Chooz sites in order to take account of the uncertainties;
- to define a programme of work to verify the strength of the equipment and civil engineering structures and make any necessary seismic reinforcements for the periodic safety reviews.

ASN considers that the exercise conducted on the earthquake PSA (probabilistic safety assessment) applied to the Saint-Alban NPP is interesting and needs to be continued and extended to the other NPPs during the periodic safety reviews. This PSA identifies the initiating events and equipment items that contribute predominantly to the risk of core melt. Additional analyses are necessary, notably for the seismic hazard evaluation and the definition of the various equipment and structure failure modes, as well as the extent of the equipment that must be covered by fragility curves taking account of these various failure modes. EDF must also provide elements to substantiate the applicability to the French reactors of the American approach developed by the EPRI.

**Secondary effects of earthquakes**

The secondary (indirect) effects of earthquakes were examined during the periodic safety reviews and through additional studies as part of the stress tests which focused on:

- the "seismic interaction" approach (see § 17.2.1);
- loss of off-site electrical power supplies;
- conditions of access to the site following an earthquake;

- the fire and explosion risks induced by an earthquake, as well as the flooding risk induced by an earthquake.

**Seismic instrumentation**

The conditions of operation of the seismic instrumentation installed on the sites were checked by ASN during the targeted inspections carried out in 2011 and were the subject of a request as part of the European peer review.

**Other requests**

The licensee presented ASN with an inventory designed to verify the effective resistance of the premises to the SSE, along with the envisaged modifications. Compensatory measures have been defined to ensure the SSE resistance of the premises on the Civaux, Cruas and Flamanville sites.

On the basis of the in-depth experience feedback from the Fukushima Daiichi NPP accident, ASN plans to review the baseline safety requirements of the nuclear facilities, particularly with regard to the earthquake aspects.

#### 17.4.1.1.2 Flooding

Following the flooding of the Blayais site in 1999, EDF put in place a protected volume[11] on all the sites. The conformity of this protected volume was specifically inspected by ASN during the targeted inspections conducted in 2011, resulting in requests from ASN. In the spring of 2012, the licensee sent ASN an overall analysis of the replies to the observations made by ASN, which ASN judged to be satisfactory. ASN has set the following requirements:

- work to integrate experience feedback from the Blayais flood in 1999 for the Blayais, Bugey, Cruas, Dampierre, Gravelines, Penly, Saint-Laurent-des-Eaux and Tricastin sites (requirement ECS-04). The scheduled modifications completion date of 31st December 2014 was met by EDF;
- restoring conformity of the protected volume and implementation of the appropriate organisation and resources to ensure that the effectiveness of the protected volume stipulated in the safety case (requirement ECS-05) is maintained over time. Work to restore conformity was completed on 30th June 2012;
- verification of the resistance of the emergency situation management rooms to the flood safety level (CMS) and performance of any modifications as necessary (requirement ECS-30). The licensee presented ASN with an inventory aimed at verifying the effective resistance of the rooms to this hazard, along with the planned modifications. EDF met the 31st December 2013 deadline for completion of the modifications.

Apart from the requirement for a hardened safety core (see § 6.2.1.2, requirement ECS-01), ASN also sent EDF a specific requirement for the protection of the facilities against flooding beyond baseline safety requirements, to reinforce the robustness of its facilities and prevent cliff-edge effects associated with heavy rainfall or the failure of equipment on the site under the effect of a stronger than design-basis earthquake (requirement ECS-06). This requirement notably concerns the raising of the protected volume

[11] The protected volume perimeter, which encompasses the buildings containing the equipment guaranteeing the safety of the reactors, has been defined by EDF so as to guarantee that water ingress from outside this perimeter does not lead to flooding of the premises situated within this perimeter. In concrete terms, the protected volume consists of civil engineering structures and devices for blocking off the openings in these walls (doors, openings, etc.) which can be potential water ingress points in the event of flooding).

in order to prevent the occurrence of total loss of heat sink or electrical power supply situations for scenarios beyond design-basis (beyond design-basis rainfall, flooding induced by the failure of on-site equipment as a result of an earthquake, etc.). EDF has carried out all the corresponding modifications.

In 2013, ASN published a guide on protection against the external flood risk for nuclear facilities. This guide supersedes RFS I.2.e. It takes account of the lessons learned from the flooding of the Le Blayais site in 1999. It details the recommendations for assessing and quantifying the risks of external flooding faced by these facilities and for defining the appropriate means of protection for dealing with them. The hazards to take into consideration are defined on the basis of an in-depth assessment of knowledge in the various areas concerned, hydrology and meteorology in particular (11 different hazards considered). It is based on deterministic methods, incorporating allowances and combinations integrated into the hazards, taking account of a "probabilistic" overshoot target of $10^{-4}$ per year. In 2014, ASN stated its position on the principles for application of this guide to the existing reactors.

##### 17.4.1.1.3 Other natural risks

Within the framework of the stress tests, the licensee also studied the margins in the event of extreme meteorological conditions such as wind, lightning, hail, and their combination, in the event of loss of the heat sink and electrical power supplies. Analysis of the studies led ASN to set requirements and make additional demands concerning the additional information needed for the evaluations of margins and the reinforcement of the robustness of facilities beyond their current design basis.

In addition, for the fourth periodic safety review of the 900 MWe reactors, the third periodic safety review of the 1300 MWe reactors and the second periodic safety review of the N4 reactors, the baseline protection requirements for the NPPs against natural hazards were examined.

##### 17.4.1.1.4 Risks associated with other industrial activities

At the end of the stress tests, ASN asked EDF to take account of the risk created by the activities situated near the nuclear facilities in the extreme situations studied in the stress tests, liaising with the neighbouring licensees responsible for these activities.

#### 17.4.1.2 Flamanville reactor No. 3 (EPR)

Flamanville reactor No.3 was included in the scope of the stress tests in accordance with specifications identical to those for reactors in operation. This review led to a range of specific requirements being issued. The check on compliance with these requirements is being examined for the commissioning authorisation application for this reactor.

### 17.4.2 Research reactors

The French research reactors are spread over three sites in France: Cadarache, Saclay and Grenoble. The extreme meteorological conditions were assessed for each of these sites and warning systems for predictable hazards, along with specific organisational and material prevention and protection measures are implemented.

At CEA, the reference hazards are defined on the sites, in the facility's general safety presentation (PGSE). The various natural hazards, as well as the entropic hazards, are defined in it and reassessed at each update. The updates of the PGSE for the Cadarache and Saclay centres were transmitted by CEA in 2017. The reference hazard assessments for each site are thus being reviewed by ASN.

The Saclay site was also the subject of recent attention with respect to its urban development. A metro line with station are planned near the site, which led CEA to examine the risks induced by this new infrastructure on the BNIs, and vice-versa. The project was considered to be compatible with the activities of the Saclay centre.

In 2018, the ILL completed the installation of backup systems and the reinforcement of its facility. This work is in response to ASN requirements or commitments made in the wake of the Fukushima Daiichi accident.

With regard to the urban development problems, the RHF – which is located in the city of Grenoble – was the subject of particularly robust measures as a result of the stress tests. The emergency management room was more particularly designed so that it would remain accessible and functional following an extreme hazard.

# 18. Article 18: Design and construction

*Each Contracting Party shall take the appropriate steps to ensure that:*

*i) the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defence in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur;*

*ii) the technologies used in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;*

*iii) the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration given to human factors and the man-machine interface.*

## *18.1 The defence in depth concept*

The BNI Order includes regulatory requirements concerning the safety case and notably the principle of defence in depth.

### 18.1.1 ASN requests

The design of nuclear facilities is based on the principle of defence in depth, which leads to the implementation of successive defence levels (intrinsic characteristics, material provisions and procedures), intended to prevent incidents and accidents then, if the preventive measures fail, to mitigate their consequences.

The defence in depth principle, the implementation of which is among the requirements of the BNI Order, is an integral part of the safety case.

In the extreme situations analysed in the stress tests, the approach presupposes successive loss of the lines of defence by applying a deterministic approach. The aim was to assess the robustness and adequacy of the measures taken on the facilities and to identify the possible means of improving safety.

### 18.1.2 Measures taken for nuclear power reactors

The safety of the nuclear power reactors in operation and under construction is based on the principle of defence in depth, which consists in implementing five successive and sufficiently independent levels of defence, the first four of which are the responsibility of the licensee:

1. the first level aims to prevent operating anomalies and system failures through the quality of design and manufacturing;
2. the second level consists in detecting incidents and taking steps that will firstly prevent them from leading to an accident, and secondly restore a situation of normal operation or, failing which, place and maintain the facility within the authorised operating range;
3. the purpose of the third level is to control accidents that could not be avoided or, failing which, prevent the situation from worsening by regaining control of the facility in order to return it to and maintain it in a safe condition;
4. the fourth level consists in managing accident situations that could not be controlled so as to mitigate the consequences, especially for persons and the environment.

5. In the case of a malfunction or ineffectiveness of the above-mentioned provisions, the fifth level includes measures to protect the public in the event of significant releases. This fifth level comes primarily under the responsibility of the public authorities.

**The concept of defence in depth - Measures taken for the EPR**

The safety of the EPR reactors is based on the five levels mentioned above, with the design incorporating severe accidents (notably including a zone which, if necessary, enables the corium to spread out and cool) and improvement of the installation's ability to withstand external hazards (including airplane crash).

A very high level of safety is sought for the EPR reactor, with the aim of reducing:

- the doses received by the workers,
- equipment failures,
- the frequency of core melt (significantly),
- releases resulting from accident situations.

At the design stage, the approach for verifying design consistency with the principle of defence in depth was presented in the preliminary safety analysis report (RPS) transmitted to ASN in support of the reactor creation authorisation application, then substantiated in the commissioning application file.

### 18.1.3 Measures taken for research reactors

The design of the RJH and of ITER is based on the defence in depth concept.

The RJH design for defence in depth incorporates severe accidents. Outlets with appropriate filters to mitigate the consequences of a severe accident are incorporated by design.

### 18.1.4 ASN analysis and oversight

The defence in depth concept is applied to all the nuclear facilities by implementing means to detect or counter certain failures of systems that guarantee the safety of the installations. The safety analysis must demonstrate the effectiveness of these systems in both normal operating situations and accident situations. These various systems are inspected by ASN at regular intervals.

The safety approach was reinforced in the stress tests by taking into consideration extreme natural phenomena and accidents that could affect several reactors on the same site.

The safety approach applied by the licensees remains on the whole satisfactory, with certain areas for improvement identified on a case-by-case basis according to the facilities concerned.

#### 18.1.4.1 The nuclear power reactors

**The EPR type Flamanville reactor N°3**

The safety approach implemented at the design stage is based on the concept of defence in depth such as it is presented in the INSAG (International Nuclear Safety Advisory Group) documents. The main measures taken to implement it were described in the preliminary safety analysis report (RPS) which was submitted in support of the creation authorisation application for this installation. The examination of the detailed design of this reactor, and in particular the review by ASN and its technical support organisation of the concrete measures for implementing this concept, continued after delivery of this authorisation in April 2007.

This reactor was also included within the scope of the stress tests.

EDF submitted its commissioning authorisation application for this installation in spring 2015; this application notably includes the safety analysis report (update of the preliminary safety analysis report (RPS)). ASN and its technical support organisation are currently examining this application (see § 18.3.4.1). The Advisory Committee for nuclear reactors was consulted regarding the Flamanville EPR reactor safety case on 4th and 5th July 2018.

##### 18.1.4.2 Research reactors

The defence in depth concepts are applied to the RJH and ITER reactors in the same way as for nuclear power reactors, with an approach that is proportionate to the issues: all steps are taken at the design stage to prevent and detect the occurrence of an accident. As with the nuclear power reactors, even though all steps are taken to avoid an accident, the 4th level of defence in depth is also integrated into the design to mitigate the consequences of any severe accident.

## *18.2 Qualification of the technologies used*

### 18.2.1 ASN requests

The qualification of the elements important for protection (EIP), stipulated in the BNI Order, must be proportionate to the issues, aiming in particular to guarantee their ability to perform their functions in the situations where they are needed. Appropriate design, construction, tests, inspection and maintenance provisions must be implemented to enable this qualification to be maintained over time.

Nuclear pressure equipment (NPE) is subject to an individual conformity assessment whereby the conformity of these equipment items with all the regulatory requirements and their fitness to be used is assessed with respect to the anticipated operating loads.

Nuclear pressure equipment is subject to both the BNI system and that for products and equipment involving risks. With regard to the regulations applicable to NPE as products and equipment involving risks, the applicable texts are specified in table 2 of § 7.1.3.

NPE items are designed and produced by a manufacturer under its responsibility. The manufacturer is obliged to comply with the essential safety and radiation protection requirements stipulated by the regulations and to have the conformity of the item of equipment assessed. This conformity assessment concerns both equipment intended for the new basic nuclear installations such as the Flamanville 3 EPR, the RJH, or the ITER nuclear fusion reactor, and spare equipment items such as replacement steam generators, for installations in service.

### 18.2.2 Measures taken for nuclear power reactors

**Equipment qualification**

As a general rule, the qualification of each equipment item is defined following rules and requirements that depend on its "safety classification, that is to say its importance for safety and the types of loads it must withstand.

For electrical safety equipment, three qualification categories representing “envelope” conditions have been defined, depending on their function in a normal or accident situation and their location (inside or outside the containment).

It is important to be able to check the sustainability of these qualifications over time during operation. This aspect is considered in the conformity reports which are produced on the occasion of the periodic safety reviews.

**Pre-service inspection and periodic requalification of main primary and secondary systems**

The main primary and secondary cooling systems of the PWRs are subject to a pre-service inspection and a periodic ten-yearly requalification. This latter comprises inspection of the equipment, non-destructive examinations, pressurised hydrotesting and verification of the operation of the over-pressure protection accessories.

New applications have been developed and qualified to meet new needs and requirements, more particularly concerning the pre-service inspection of the Flamanville N°3 EPR type reactor.

### 18.2.3 Measures taken for research reactors

The safety analysis methodology applied for all the research reactor licensees leads to a safety classification of the components that are required to perform a safety function and which must be qualified. This classification determines the requirement level for manufacture, operation and monitoring alike.

Furthermore, the periodic safety reviews can lead to upgrading work in various areas, in particular for certain equipment items.

### 18.2.4 ASN analysis and oversight

#### 18.2.4.1 Assessment of nuclear pressure equipment (NPE) conformity

ASN assesses the conformity with the regulatory requirements of the NPE most important for safety, referred to as "level N1" equipment, such as the reactor pressure vessel or the power reactor steam generators. ASN can be assisted in this task by an approved organisation. This latter is then mandated by ASN to perform some of the inspections on the level 1 equipment.

The ASN-approved organisations assess the conformity of the level N2 and N3 nuclear pressure equipment with the regulatory requirements. The approved organisations are contacted directly by the manufacturers.

The oversight by ASN and the approved organisations is carried out at the different stages of the design and manufacture of the NPE. It takes the form of an examination of the technical documentation of each equipment item and inspections in the workshops of the manufacturers, as well as at their suppliers and subcontractors.

#### 18.2.4.2 The EPR type Flamanville reactor N°3

##### 18.2.4.2.1 Qualification of nuclear pressure equipment (NPE)

In accordance with the principles described earlier, ASN and the approved organisations assess the conformity of the NPE for the Flamanville 3 reactor on the construction site or on the manufacturer's premises. This oversight takes the form of an examination of the technical documentation of each equipment item and inspections in the workshops of the manufacturers, as well as at their suppliers and subcontractors.

In addition, ASN and STÜK, the Finnish nuclear regulator, are in regular contact with each other to share experience about the manufacture of NPE items.

Over the last two years, ASN has continued its assessment of the conformity of the NPE of the EPR reactor's primary and secondary cooling systems.

In 2018, the approved organisations carried out 7,704 design and manufacturing inspections on the NPE intended for the Flamanville EPR. These inspections are performed under ASN supervision.

**EPR reactor pressure vessel**

On 7th April 2015, ASN released information concerning an anomaly in the composition of the steel in the centre of the Flamanville 3 EPR vessel closure head and bottom head. This anomaly is linked to the presence of a high carbon concentration which results in mechanical properties that are not as good as initially specified.

Together with EDF, Framatome initiated a test programme to demonstrate that the mechanical strength of the steel is sufficient in all operating situations, including accident situations. Framatome transmitted its technical conclusions to ASN in December 2016.

Based on an assessment of the files transmitted by Framatome and the additional technical data supplied by EDF, carried out by its nuclear pressure equipment department and its technical support organisation, IRSN, on the basis of the opinions of its Advisory Committee for nuclear pressure equipment and of the High Council for the Prevention of Technological Risks, as well as the observations collected during the course of the public consultation, ASN issued its opinion on this anomaly on 10th October 2017. It indicated that, with certain reservations, it considered that this anomaly did not compromise the commissioning of the reactor pressure vessel.

As the commissioning and operation of the Flamanville EPR reactor pressure vessel also requires ASN authorisation, notably with regard to compliance with other requirements applicable to the reactor pressure vessel as a whole, Framatome submitted an application in this respect on 13th July 2018, which was then supplemented following requests from ASN. ASN reviewed this application, drawing on the conclusions of its 2017 opinion and it also verified compliance with the technical and regulatory requirements other than those concerning the chemical composition of the steel of the reactor vessel closure and bottom heads.

On the basis of the conclusions of this review, ASN authorised the commissioning and operation of the Flamanville EPR reactor pressure vessel on 9th October 2018, subject to the performance of a test programme to monitor thermal ageing, plus specific inspections during operation of the facility. As the current state of knowledge does not enable the feasibility of these inspections to be confirmed for the vessel closure head, ASN set a service life limit of the end of 2024 for the existing vessel closure head.

**Secondary piping**

At the beginning of 2017, EDF informed ASN of deviations that had occurred during welding of the main steam pipes (VVP system) for the Flamanville EPR reactor.

It should be recalled that for these pipes, EDF had adopted a "break preclusion" approach, which implies tightened design, manufacturing and in-service monitoring requirements such as to consider that a break of these pipes is extremely improbable. This choice means that the licensee does not need to study the consequences of a break on these pipes in the facility's nuclear safety case.

In order to achieve the expected high standard of manufacturing quality, the licensee (EDF) and the manufacturer (Framatome) defined tightened requirements, more specifically with respect to the mechanical properties. However, these tightened requirements were not specified to the subcontractor responsible for these welding operations. The inspections carried out during production showed that, for some of these welds, not all of these requirements had been met.

In addition, in March 2018, EDF identified a number of flaws during the pre-service inspection of these pipes, as required by the regulations prior to commissioning. These flaws should have been detected by the manufacturer on completion of manufacturing. This finding led EDF to implement a verification programme for all the welds on the main secondary systems, which include the VVP pipes. These new checks revealed flaws requiring repair. ASN verified the performance of these new inspections by EDF.

All of these deviations, as well as the ASN findings during its inspections, highlighted a lack of expertise in the welding operations carried out on the VVP pipes and shortcomings in EDF monitoring of its contractors. The identification of shortcomings in EDF's monitoring of its contractors led ASN to ask EDF to conduct a review of the quality of the Flamanville 3 EPR reactor equipment, extended to include a broader scope of equipment and subcontractors, while adapting the depth of the review to the specific implications concerned.

In July 2018, EDF undertook to restore the required mechanical properties of the welds concerned by the identified deviations, except for the eight welds located in the annulus between the two containment walls of the reactor building, where access is harder. In December 2018, EDF sent ASN a file aiming to demonstrate that the quality of these eight welds is sufficient, enabling their breakage to be ruled out with a high level of confidence. This demonstration is more particularly based on an in-depth characterisation of the welds material. The conclusions of ASN's review of the EDF file, with the support of IRSN, were presented to the Advisory Committee for NPE on 9th and 10th April 2019. The Advisory Committee considered that the numerous deviations affecting these eight welds were major obstacles to the application of a break preclusion approach and that EDF must therefore repair them, failing which break preclusion for these welds would have to be abandoned.

In June 2019, EDF requested ASN's opinion on the possibility of repairing these welds around 2024, after the reactor was commissioned. In its letter of 19 June 2019, ASN noted that it is technically feasible to bring the feed-through welds back into conformity before the reactor is commissioned. The postponement of repair operations after the commissioning of the reactor would raise several difficulties, in particular with regard to the justification for the safety of the reactor during the transitional period. ASN therefore considers that the repair of the welds concerned before the reactor is commissioned is the reference solution.

##### 18.2.4.2.2 Qualification of other equipment items

As part of the detailed review of the Flamanville reactor 3 design (see § 18.3) and the examination of the commissioning authorisation application for this reactor, several subjects linked to the qualification of equipment items are studied:

- qualification under accident conditions which aims to verify that the equipment used in the management of incidents and accidents remains usable under degraded environmental conditions;
- equipment reliability, which aims to verify that the equipment is capable of performing the functions necessary for the safety case with a sufficient degree of reliability.

At the same time, ASN is conducting spot checks on the qualification process applied by the licensee.

## *18.3 Design choices*

### 18.3.1 ASN requests

The general technical regulations include texts of a general nature setting the technical rules in terms of nuclear safety, whether they are of a binding regulatory nature (see § 7.1.3.2) or not (see § 7.1.3.3).

At the preliminary design study stage for a reactor, the manufacturer can submit a safety options file containing the main characteristics and general design choices in terms of safety (see § 7.2.1). This file can more specifically include technical baseline requirements (design or construction code, basic safety rules (RFS), ASN guide, etc.) that the licensee envisages using.

Once the nuclear facility has been commissioned after receiving ASN's authorisation, all the modifications made by the licensee that could affect public health and safety or the protection of nature and the environment, are either notified to ASN or require ASN authorisation or even, for substantial modifications, Government authorisation after consulting ASN. The licensee must also perform periodic safety reviews taking account of any changes in techniques and regulations, as well as experience feedback.

In July 2017, ASN published guide N° 22 on the design of pressurised water reactors. This guide formally sets out recommendations for the design and construction of new nuclear power reactors and updates the “technical directives for the design and construction of the next generation of pressurised water reactors" adopted by ASN in 2004.

This guide also includes recommendations for taking account of organisational and human aspects in the design of the socio-technical system. Over and above the technical criteria, ASN is also attentive to the conditions that are favourable or prejudicial to the positive contribution by operators and worker groups to the safety of nuclear facilities. In general, ASN requires that organisational and human factors be integrated in a way that is appropriate for the safety issues concerning the facilities and worker safety in the design of a new facility or the modification of an existing one (see chapter 12).

### 18.3.2 Measures taken for nuclear power reactors

#### 18.3.2.1 Design measures

The safety case in the safety analysis report presents the consequences of the postulated events, in envelope conditions (incidents, accidents, hazards).

The control of the consequences of these events demonstrates the ability of the material and organisational measures to control these situations and thus prevent the occurrence of consequences that are unacceptable for the environment.

An analysis of the situations involving multiple failures that could lead to core melt is thus also carried out. As part of the defence in depth system, lines of defence are put in place to prevent core melt situations and mitigate their consequences.

The design of the EPR takes account of multiple failures and severe accidents:

**Risk reduction and prevention of situations that can lead to core melt**

A risk-reduction process by preventing situations that can lead to core melt is implemented by analysing the combinations of predominant events that can lead to core melt situations through multiple failures.

From the technical standpoint, additional safeguard systems have been designed and installed to prevent core melt during these sequences.

**Consideration of hypothetical accidents with core melt ("severe accidents”)**

Apart from the reduction in overall core melt frequency, the EPR aims to achieve a significant reduction in radioactive releases that could result from all accident situations, including accidents with core melt which are taken into account as of the design stage in the EPR safety case. In this respect:

- accident situations with core melt that would lead to significant early releases are "practically eliminated": when they cannot be considered as being physically impossible, measures are taken at the design stage to preclude their occurrence;
- for the other accident situations with core melt studied by means of a deterministic approach, the radiological consequences are such that only protection measures that are extremely limited in scope and duration would be needed, given the design measures taken:
    - passive autocatalytic recombiners (PAR) and devices for monitoring the hydrogen concentration in the various compartments within the containment.
    - the system for ultimate removal of heat from the reactor building (EVU) enables the pressure in the containment to be controlled in all accident situations, including accidents with core melt;
    - the containment and the peripheral buildings are designed such that there is no direct leakage path from the reactor containment to the environment;
    - the primary system is depressurised by two redundant primary system discharge lines in the event of a severe accident;
    - the corium catcher is designed to collect the corium, cool it and stabilise it. The design also ensures that the reactor pit and the corium spreading zone are kept dry when the corium arrives. These measures prevent basemat melt-through. In the longer term, the reactor building ultimate heat removal system (EVU) enables the residual heat to be removed from the corium;
    - control room ventilation is backed up by the station blackout (SBO) diesel generators. The control room remains habitable.

These deterministic approaches are supplemented by a probabilistic verification. This is based on a level 2 PSA to verify the reliability to the measures adopted, through the residual nature of the accident sequences leading to significant releases.

#### 18.3.2.2 Lessons learned from the Fukushima Daiichi NPP accident (EPR reactor)

After the accident on the Fukushima Daiichi NPP, EDF identified the following measures to deal with Station Black Out (SBO)[12] and loss of heat sink situations for a period in excess of 24h:

- the possibility of providing ultimate water make-up for the steam generator feedwater tanks (ASG tanks) and the fuel storage pool by mobile means and the installation of additional connection points at the disposal of the FARN (see §16.3.1.2);
- provision for extending the autonomy of the ultimate backup diesel-generator sets by a mobile means of supply by gravity topping up of fuel from the main generator set tanks.

Other measures to reinforce the robustness of the Flamanville 3 EPR installation were selected:

- extension of the duration of electrical supply for essential functions by deploying additional fixed or mobile electrical power sources;
- means of restarting the instrumentation and control dedicated to severe accidents in the event of failure to recover an electrical power source within 12 hours following the initiating event;
- addition of a mobile and independent water make-up device (motor-driven pump) in the reactor building.

A new local emergency management centre (CCL) that is robust to extreme hazard levels is being completed on the Flamanville site. The CCL will enable the emergency response teams to carry out long-term management of a serious emergency such as that encountered during the Fukushima Daiichi NPP accident, more particularly where several reactors are affected simultaneously.

### 18.3.3 Measures taken for research reactors

Although the RJH is of a recent design that integrates operating experience feedback from the other experimental reactors, the stress tests process has resulted in the CEA identifying possibilities for improvements that will be implemented, in spite of the advanced state of construction. ASN thus considered that some of the proposals made by CEA, including the adoption of a “hardened safety core”, which are likely to make the facility more robust, should be implemented. Moreover, making these improvements at the design/construction stage favours prevention, rather than mitigation of the consequences of possible accident situations.

### 18.3.4 ASN analysis and oversight

#### 18.3.4.1 Oversight of construction of the Flamanville 3 reactor

The oversight of construction of the Flamanville 3 reactor comprises an examination of the detailed design, including the studies defining the data needed for the production and production inspection activities, which encompass site preparation after delivery of the creation authorisation, manufacture, construction, qualification, assembly and testing of the structures, systems and components, whether on the construction site or on the manufacturers' premises.

[12] The SBO situation corresponds to the combined loss of off-site electrical sources (electricity grid) and “conventional” on-site back-up electrical sources (four main electricity generator sets). In this situation, two ultimate back-up diesel generator sets are available to supply the required equipment.

This oversight also applies to the manufacture of the NPE that will form part of the nuclear steam supply system (see § 18.2.4).

##### 18.3.4.1.1 Detailed design review

The approach for verifying reactor design consistency with respect to the different lines of defence in depth is presented in the preliminary safety analysis report (RPS). These elements have been updated in the safety analysis report submitted with the commissioning authorisation application.

The NPE represent an important topic for the pressurised water reactors. The detailed design review of the nuclear pressure equipment is examined as part of their conformity assessment.

**Technical review of design studies**

The detailed design review is carried out by ASN, with the technical support of IRSN, on the basis of an examination of the documents transmitted by EDF either prior to submission of the commissioning authorisation application file, or subsequently, on the basis of the elements in this file.

From 2013 to 2015, ASN and IRSN thus examined the detailed design of reactor backup systems and of systems supporting these backup systems. Furthermore, examination of the analysis methods and the rules defined for analysing the incident and accident transients continued over this period.

Between 2014 and 2018, seven meetings of the GPR were devoted to Flamanville 3. They specifically covered the level 1 probabilistic safety assessments, the safety classification principles, the correspondence between the reactor control means and the organisation of the control crew, severe accidents and their radiological consequences, the design of safety systems and protection against the effects of internal and external hazards, examination of the safety analysis report and the safety of fuel assembly storage and handling operations.

**Oversight of the quality of the design studies**

In addition to the technical review of the detailed design studies, ASN from 2013 to 2018 conducted inspections in the engineering departments responsible for the detailed design studies and for their monitoring.

During its inspections, ASN observed that the organisation put in place in the various EDF departments, whether engineering or the teams in charge of monitoring the activities performed by its contractors, was on the whole satisfactory.

##### 18.3.4.1.2 Oversight of the Flamanville 3 reactor construction and start-up test activities

Each year, with the support of IRSN, ASN performs inspections on the Flamanville 3 reactor construction site (see table 7).

ASN faces numerous challenges in overseeing the construction, start-up tests and preparation for operation of the Flamanville 3 reactor. These are:

- checking the quality of the equipment manufacturing activities in the factory and on the site, as well as construction of the installation in a manner commensurate with the safety, radiation protection and environmental protection issues, in order to be able to rule on the ability of the installation to meet the defined requirements;

- ensuring that the various players learn the lessons from the construction and start-up testing phase;
- ensuring that the start-up tests programme is complete, that the tests are correctly performed and that the deviations brought to light are dealt with;
- ensuring that the licensee take the necessary steps so that the teams in charge of operating the installation after commissioning are well-prepared.

Table 7: Inspections performed on the Flamanville 3 reactor construction site

| Year | Inspections performed | Main themes |
|---|---|---|
| 2016 | 20 | Preparation for and performance of the start-up tests, mechanical assemblies, preparation for operation, nuclear pressure equipment and performance of hydrotests, safety management and organisational and human factors, emergency response organisation and resources. |
| 2017 | 20 | Start-up tests, electrical and mechanical assemblies, preparation for operation, notably in the field of radiation protection, preparation for reactor partial commissioning, in-service monitoring of PE and NPE, protection of the environment. |
| 2018 | 20 | Start-up tests, in-service monitoring of PE and NPE, mechanical assemblies, monitoring of radiographic inspections, preparation for operation, control of fire risk, NDT at completion of manufacturing, repair work on ARE. |

Generally speaking, ASN considers that the organisation implemented for preparation for operation and the performance of start-up tests is on the whole satisfactory in 2018. EDF needs to further develop its practices concerning the performance of the start-up tests so that they are carried out in the planned conditions and to document the demonstration of their representativeness.

ASN will continue its oversight of these topics, more specifically on preparation for operations, start-up tests and the compliance work on the main secondary systems.

##### 18.3.4.1.3 Monitoring of NPE manufacturing

This point is developed in § 18.2.

#### 18.3.4.2 Monitoring the construction of the RJH and ITER reactors

To facilitate oversight of the construction of the RJH and ITER, and pursuant to the resolutions of 27th May 2011 and 12th November 2013 mentioned in § 18.3.3, CEA and ITER Organization (IO) transmit monthly lists of deviations detected on the work site and quarterly project progress reports. These documents identify the activities or particular points which ASN considers need to be included in its spot checks during its inspections. The majority of the inspections conducted by ASN focus on construction and design and the monitoring of outside contractors by the licensee.

The oversight and inspections of ITER are carried out by ASN in accordance with the same provisions as for the other BNIs on French territory. A framework programme concerning inspections and oversight has been established between ASN and IO in accordance with the provisions of Article 3 of the agreement between the Government of the French Republic and the ITER international Organisation, published by Decree 2008-334 of 11th April 2008. Given the international nature of the ITER project, this agreement also makes provision for inspections within the foreign domestic agencies representing each of the member states. As stipulated by French regulations, these agencies are outside contractors of the IO nuclear licensee, which finance many equipment items and place contracts with suppliers. This particular project organisation makes supervision of the outside contractor chain by the licensee extremely complex. This point was the subject of repeated requests from ASN, after several failures were observed in the adoption and dissemination of the safety requirements defined by IO. The latest ASN inspections show that, on the whole, there has been a significant improvement in the assimilation of a safety culture shared by the entire subcontracting chain.

On the whole, ASN considers that the organisation of the RJH construction site is rigorous, since its Decree in 2009. ASN also observes that the system for dealing with nonconformities between CEA and the project manager is considered to be operational and effective. However, the licensee encountered a number of technical difficulties and significant nonconformities during construction of the reactor, thus leading to a slippage in the schedule. The handling of these nonconformities by CEA and its project manager, as well as CEA supervision of its contractors, are considered to be satisfactory by ASN.

# 19. Article 19: Operation

*Each Contracting Party shall take the appropriate steps to ensure that:*

*i) the initial authorisation to operate a nuclear installation is based on an appropriate safety analysis and a commissioning programme demonstrating that the installation, as built, is consistent with design and safety requirements;*

*ii) the operating limits and conditions derived from the safety analysis, tests and operating experience are defined and revised as necessary to delimit the safe operating range;*

*iii) operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;*

*iv) procedures are established to respond to anticipated operating incidents and to accidents;*

*v) the necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;*

*vi) incidents significant to safety are notified the regulatory body in a timely manner by the holder of the corresponding licence;*

*vii) programmes to collect and analyse operating experience data are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organisations and regulatory bodies;*

*viii) the production of radioactive waste resulting from the operation of a nuclear installation is as low as possible for the process concerned, both in activity and in volume, and that conditioning and disposal are taken into consideration in any necessary treatment and storage operations for spent fuel and waste resulting directly from operation and situated on the same site as the nuclear installation.*

## *19.1 Commissioning of a BNI*

### 19.1.1 ASN requirements

Commissioning corresponds to the first use of radioactive materials in the installation.

In application of Article R593-35 of the Environment Code, the introduction of nuclear fuel within the perimeter of the installation and the start-up of the installation are subject to ASN authorisation. One year before the planned date of commissioning and 6 months before nuclear fuel is introduced into the BNI perimeter, the licensee must send ASN a file comprising:

- the safety analysis report (RDS);
- the general operating rules (RGE);
- a study of the installation's waste management,
- the on-site emergency plan (PUI);
- the decommissioning plan;
- the updated installation impact study.

After checking that the installation complies with the objectives and rules specified in the regulations, ASN authorises the commissioning of the installation and communicates this decision to the Minister responsible for nuclear safety and to the Prefect.

Before the actual authorisation procedure is started or completed, partial commissioning may be authorised by an ASN resolution for a limited period of time in the following cases:

- the performance of specific operating tests requiring the introduction of radioactive materials into the installation;
- the introduction of nuclear fuel into the perimeter of the reactor before the first loading of fuel into this reactor (see § 19.1.4.1).

The resolution authorising commissioning sets the deadline for the licensee to submit to ASN a start-up completion file for the installation, comprising:

- a summary report of the installation start-up tests;
- an assessment of the acquired operating experience;
- an update of the documents constituting the commissioning application.

### 19.1.2 Measures taken for nuclear power reactors

#### 19.1.2.1 Commissioning

In addition to the appropriate inspections and tests carried out in the factory or on specific test facilities, the "start-up" tests are carried out on equipment items installed on site to verify compliance with their functional requirements. They represent a transition step towards normal operation of the various systems constituting the reactor.

The start-up tests comprise:

- pre-operational tests, which comprise:
    - the preliminary and initial start-up tests of the equipment items and functions, which do not involve interaction between the primary system or the auxiliary systems and the secondary systems;
    - the cold and hot functional tests of the primary and secondary systems before loading the fuel;
- "first start-up" tests (operational tests): fuel loading, pre-critical tests, tests at various power levels, with performance verifications.

The start-up tests follow the test procedure programmes which specify, for each elementary system or category of tests, the aim and the list of tests to be carried out and the criteria to be satisfied.

During the overall start-up test periods, things are organised to enable the stakeholders to fully exercise their roles and responsibilities:

- The Operational Start-up Group (GOD) is tasked with planning, scheduling and coordinating the work and tests in the short and medium terms. It meets periodically, and in principle on a daily basis when the scheduled test density justifies this;
- the on-site tests commission (CES) is primarily responsible, at various stages of performance of the overall start-up tests, for ensuring that the start-up test programme objectives have been achieved and allow continuation to the next phase, using complete and up-to-date test files, and if necessary subject to obtaining the necessary approvals.

**Preparation for operation of the Flamanville 3 EPR**

A unit of licensees based at Flamanville 3 is carrying out the work in preparation for operation of the future reactor.

The site is preparing for operation in order to attain the top international standards, using the IAEA and WANO baselines as levers in collaboration with the other EPR licensees.

The site is putting in place the safety fundamentals and developing the safety culture of the personnel.

An independent safety organisation is in place. It oversees the quality of the activities carried out on the unit and implements an annual programme of audits and verifications. The site is continuing to contribute to the development of the operating baseline requirements, especially the RGEs, in collaboration with the designer, by checking their applicability with the help of Human Factors experts.

Preparation of the operating and maintenance documentation, which began in 2010, is nearing completion, with the writing of optimised maintenance programmes and initialisation of the databases used for the multiyear programming and performance of the operating activities.

The transfer of the elementary systems from the manufacturer to the future licensee has been underway for several years and is based on detailed verifications.

A first practice fresh fuel reception exercise was carried out in late 2015.

The first industrial building (pumping station) has been transferred to the licensee.

The partially set-up operational control teams have been on shift in the control room 24h/24h since early 2017. They operate the transferred systems, monitor the facility and assist with the start-up tests. The "operations service" also ensures all the work site lockout/tagout operations.

All the on-call technical teams were set up when the operating teams started shift operation. The maintenance department carries out the maintenance work on the transferred equipment.

The first exercises deploying part of the final emergency response organisation integrating the lessons learned from the Fukushima Daiichi NPP accident were carried out in 2018 at the local emergency management centre (CCL).

Preparation for operation is continuing in 2019 focusing on:

- setting up the licensee's Safety Leadership on the site;
- finalisation of the operating documentation;
- participation in the start-up tests, particularly the hot tests, in close collaboration with the designer;
- continuation of takeover of operation of the installation as the transfers proceed;
- enhancing the reliability of operations on the facility;
- preparation of the start-up dimensioning milestones, particularly the arrival and loading of the fuel,
- sharing experience with the other EPR licensees and integration of international operating experience feedback from the sites in the start-up phase (WANO and IAEA).

### 19.1.3 Measures taken for research reactors

Start-up tests are carried out to verify that all the elements important for protection of the facility are functioning correctly and to declare that the elements concerned are available in compliance with their specified requirements.

The operating teams are set up well in advance and are trained to develop the personnel skills required for the installation and to disseminate the safety culture.

### 19.1.4 ASN analysis and oversight

#### 19.1.4.1 The nuclear power reactors

On 19th March 2015, ASN received the commissioning authorisation application for Flamanville 3. Assisted by IRSN, its technical support organisation, ASN carried out a preliminary review of this application to check that it contains all the documents required by the regulations and the necessary information to allow a full technical examination. Following this preliminary examination, ASN considered that additional information was needed to enable it to rule on a possible commissioning authorisation for Flamanville 3. The additional information requested concerns in particular the conformity of the as-built installation with the file submitted, the dimensioning of the systems and the accident studies.

ASN has nevertheless started the detailed technical examination of the file on the subjects for which few elements were missing, as indicated in § 18.3.4.1.

Furthermore, on 19th March 2015, ASN received the partial commissioning authorisation application for Flamanville 3 needed to admit fuel within the perimeter of the facility and carry out certain tests (introduction of steam containing tritium into some of the reactor systems to prepare and perform the hot tests of the secondary system). ASN carried out a preliminary examination of this file, which concluded that a certain amount of additional information was required, more specifically to assess the risks and detrimental effects which could result from tests using radioactive tracer gases to verify the correct operation of certain effluent treatment systems.

In June 2017, ASN received updated versions of the commissioning and partial commissioning authorisation application files. Some elements still need to be provided before ASN is able to issue a position statement on the commissioning authorisation application file. In 2018, ASN issued requests for additional information regarding the general operating rules.

ASN will continue to monitor the installation of equipment, the preparation for and performance of the start-up tests and the preparation of the various operating support documents. The nuclear safety inspectors will continue with inspections at a sustained rate.

ASN will continue to examine the commissioning authorisation application and will issue a position statement on the partial commissioning application, corresponding to the arrival of nuclear fuel on the site.

Finally, ASN will continue to examine the processing of deviations affecting the main secondary system welds, along with the conformity assessments of the nuclear pressure equipment most important for safety.

#### 19.1.4.2 Research reactors

As the regulations apply to all nuclear facilities in the same manner, research reactors are subject to the same commissioning rules as nuclear power reactors.

With regard to the RJH reactor, on 20th March 2017 the CEA submitted an application to modify the reactor creation authorisation decree aiming to extend its commissioning time frame. ASN, in cooperation with the Ministry of Ecological and Solidarity-Based Transition, is currently examining this request to push back commissioning.

Commissioning of ITER is planned for 2035.

## *19.2 The operating range of BNIs*

When a licensee plans commissioning a BNI, it sends ASN a file containing the general operating rules (RGE) describing the operating conditions, transposing the initial hypotheses and the conclusions of the analyses of the safety analysis report into operating rules. Implementation of this collection of rules is authorised by ASN before the installation is commissioned. Any modification in the abovementioned rules is notified to ASN and, if the said modification has an impact on the level of safety of the installation, its implementation is subject to ASN authorisation.

### 19.2.1 ASN requirements

#### 19.2.1.1 ASN requirements for nuclear power reactors

The general operating rules (RGE) cover the operation of nuclear power reactors. These are drafted by the licensee and are the operational implementation of the hypotheses and conclusions of the safety assessments constituting the nuclear safety case. They set the limits and conditions for operation of the installation.

The technical operating specifications (STE), which constitute chapter III of the general operating rules, define the normal operating conditions based on the design and sizing hypotheses and necessitate the systems required for maintaining the safety functions, in particular the integrity of the radioactive substance containment barriers and the monitoring of these functions in the event of an incident or accident. They also stipulate the action to take in the event of temporary failure of a required system or if a limit is exceeded, situations which constitute degraded operation.

The STEs evolve to integrate the lessons learned from their application and the modifications made to the reactors. The licensee can also modify them temporarily if need be, for example to carry out an operation in conditions that differ from those initially considered in the nuclear safety case. In such cases the licensee must demonstrate the relevance of this temporary modification and define adequate compensatory measures to control the associated risks.

STE modifications that could affect protected interests require, depending on their significance, either submittal of an authorisation application to ASN or notification to ASN before they are implemented.

#### 19.2.1.2 ASN requirements for research reactors

The perimeter covered by the RGEs for the research reactors is the same as for the nuclear power reactors. The provisions defined therein remain commensurate with the safety issues and take into account the particularity of operation of some of these reactors which operate in divergent condition for very few hours per year during the experiments (Cabri reactor).

The regulatory process for granting licensees the right to implement RGE modifications is the same as for the nuclear power reactors, as was described earlier. Furthermore, research reactor licensees also use the regulatory provision which gives the possibility of dispensing a licensee from the procedure for notifying modifications of its installations for operations of minor importance only.

### 19.2.2 Measures taken for nuclear power reactors

For each operating range, the STEs define the applicable physical parameter limits and the safety functions which must be available in order to remain within the bounds of the safety case.

The unavailability of any item involved in a required safety function or any crossing of a normal operating limit constitutes an event. For each operating range, the STEs define the action to take following an event: fallback state, time taken to enter fallback state or repair time.

Fallback state is a reactor state in which the safety functions are ensured over the long term. Transition from the initial operating state to fallback state is made by applying normal operating procedures.

STE modifications involving major safety implications are subject to ASN authorisation.

STE modifications involving minor safety implications, based on a list of eligibility criteria set by an ASN resolution, undergo an internal checking process by EDF and are then notified to ASN before being applied.

### 19.2.3 Measures taken for research reactors

#### 19.2.3.1 CEA reactors

The operation of research reactors is based on the RGEs which supplement the safety analysis report for the operational aspects. The waste management study and the on-site emergency plan for the centre supplement the general operating rules (RGE).

These basic documents are supplemented by a set of procedures and instructions managed by the relevant services which ensure that all operations are carried out in compliance with the applicable rules, with which outside contractors must also comply. The licensee must ensure that the contractors comply with these rules.

Requests for temporary modifications to the RGEs may be submitted to ASN on the basis of an in-depth safety analysis and a justification file.

A notification system has been put in place for the operations that comply with the criteria defined by ASN resolution 2017-DC-0616 of 30th November 2017 relative to significant modifications to BNIs.

Experimental systems designed and operated in the facilities likewise comply with specified safety requirements. A complete safety analysis taking into account the reactor safety baseline requirements must demonstrate that the risks have been taken into consideration and that overall safety is ensured.

A technical design guide drawn up by the DSSN defines the design and construction rules and the safety analysis of experimental systems. It serves among other things to determine the safety requirement levels and the technical provisions to adopt with respect to the safety issues.

#### 19.2.3.2 The ILL high flux reactor (HFR)

Operation of the HFR is also based on compliance with its general operating rules (RGEs). The reactor has its own waste management study and its own on-site emergency plan (PUI), even though it shares common resources with the CEA Grenoble centre. The operating rules are supplemented with procedures and instructions. Operation of the reactor must comply with the rules mentioned earlier and the ILL must ensure that the service providers also comply with them.

### 19.2.4 ASN oversight and analysis

#### 19.2.4.1 ASN's oversight and analysis of the nuclear power reactors

During NPP inspections, ASN verifies that the licensee complies with the STEs and, if applicable, the compensatory measures associated with any temporary modifications. It also checks the consistency between the modifications made to the facilities and the normal operating documents, such as operational control instructions, alarm sheets, the STEs and the training of the persons responsible for applying them;

Control of the operating activities is satisfactory on the whole.

Although a few one-off cases of deviations from the STEs result in problems with equipment, the most frequent deviations result from human failings or the operating organisation. A large proportion of these events lead to the unavailability of systems important for safety. ASN has noted the steps taken by EDF in the last few years to correct these deviations.

#### 19.2.4.2 ASN's oversight and analysis of the research reactors

Inspections on the theme of operating rigour are also carried out on the research reactors. They focus essentially on reviewing the organisational setup and conducting random checks of compliance with the operating conditions and performance of the periodic tests. Although for the research reactors the management of maintenance operations, the periodic tests and the monitoring of the operational baseline requirements are satisfactory, areas for improvement remain in the human and organisational factors (HOF) and the monitoring of activities performed by outside contractors.

## *19.3 Operating, maintenance, inspection and test procedures*

### 19.3.1 ASN requirements

The BNI order defines the responsibilities of nuclear installation licensees as well as the specifying of items important to protection (EIP). These EIPs must undergo a qualification process that is representative of the requirements they must satisfy. Maintaining their qualification over time requires the implementing of appropriate design, construction, tests, inspection and maintenance provisions.

The nuclear power reactors and research reactors must be operated in accordance with the RGEs (see § 19.2).

### 19.3.2 Measures taken for nuclear power reactors

#### 19.3.2.1 Inspections and tests

The purpose of the periodic tests is to verify, throughout the operation of the reactor, with a sufficient level of confidence:

- the availability of the safety-classified equipment and systems;
- compliance with the assumptions chosen for the operating conditions taken into account in the accident studies in the safety analysis report.

The periodic tests described in chapter IX of the RGEs concern the nuclear installation's items important to protection associated with radiological accidents (EIPS). The systems containing EIPS's are covered by an exhaustivity analysis note. This note aims to determine all the inspections necessary to guarantee the availability of the equipment items and their ability to fulfil their function. The periodic test rules and the associated summary tables are submitted to ASN.

Satisfactory performance of the periodic test programmes of the RGEs is one of the prerequisites for declaring that the equipment items and systems are available in accordance with the definition of availability given in the STEs. If this is not the case, the item concerned must be declared unavailable.

The safety test criteria take explicitly into account the measurement uncertainties.

The test programmes are updated when the facility undergoes changes, particularly during the periodic safety reviews.

#### 19.3.2.2 Maintenance

EDF's maintenance policy for the nuclear fleet in operation is structured to enhance the reliability of the equipment and systems, to guarantee throughout the installation's life cycle that the EIPs are capable of fulfilling their assigned functions with respect to stresses and ambient conditions that can prevail in the situations for which they are required, in accordance with the installation's creation authorisation file.

**Organisation of maintenance**

The equipment and elementary EIP systems for which it is decided to create "national basic maintenance programmes" are identified on the basis of the implications for the Fleet (safety, radiation protection, environment, regulations, patrimony, availability, costs, security).

The national basic maintenance programmes specify the nature and substance of the tasks and the frequency of the preventive maintenance activities. The programmes follow a continuous improvement process based on operating experience feedback from the systems, structures and components.

If an EIP item or elementary system is not identified as "high risk", it is not necessarily subject to national requirements. Local issues can nevertheless lead individual NPPs, if they consider it necessary, to define the local preventive maintenance programmes as a complement to any prescriptions decided by the DPN, based on their quality organisation and analysis of operating experience feedback.

Preventive maintenance helps ensure compliance with regulatory requirements and protected interests, and maintain the reliability and service life of the systems, structures and components.

**Scheduling the maintenance activities**

The preventive maintenance activities are planned on a schedule that takes into account their conditions of performance (reactor in operation or during periodic outage, for example) and their frequency.

They are scheduled in compliance with the conditions provided for in the general operating rules.

**Control of the performance of maintenance activities**

The maintenance activities identified as being important for the protection of the protected interests, as defined in the BNI order, are subject to the following requirements:

- preparation of the maintenance work, including the preparation of a file drafted, checked and approved by qualified personnel,
- performance of the maintenance work using appropriate means,

- requalification after the maintenance work, which consists in checking operation of the equipment or system to ensure that the required design-basis performance is maintained or restored further to the work, to a modification or to an operating event,
- putting back into operation after the maintenance work when equipment availability is demonstrated further to requalification,
- detection and correction of deviations: any deviation with respect to a defined requirement is identified, undergoes a formal analysis, curative actions and, if applicable, corrective and preventive actions.
- production of a work report to turn the experience feedback to good account.

**Risk of Counterfeit, Fraudulent and Suspect Items (CFSI)**

Following the affair of the irregularities at the Creusot Forge plant, EDF has reconsidered its inspection of product manufacture in suppliers' plants and of on-site repairs and modifications as follows:

- during the invitation for bids phase, introducing the possibility of assessing the industrial scheme proposed by the bidders and recommending that certain suppliers be banned or used with reservations,
- organising unannounced inspections,
- organising adversarial monitoring (for example, adversarial ultrasound inspections, measurement of chemical composition, inter-laboratory tests, re-viewing radiographic films),
- comparison with the original reports issued by the organisations,
- preventive visits to certain suppliers, with adversarial inspections without there having been any confirmed cases of CFSI.

**Experience feedback**

An experience feedback process is organised at local and national level through organisational measures and bodies for processing the collected data (findings, events, operating data, etc.) It is highlighted as part of the monitoring of equipment performance to improve the maintenance baseline requirements and practices.

**Ageing management**

As part of the defence in depth approach, a programme for analysing the ageing modes of certain EIPs is put in place as from the preparation for the 3rd periodic safety reviews, integrating in particular operating experience feedback and the current state of knowledge. The aim of this programme is to verify the adequacy of the operating and maintenance measures to control the ageing of EIPs.

**Spare parts procurement**

The process for procuring equipment and spare parts contributes to the long-term durability of EIP qualification. It aims at obtaining items identical to those to be replaced, except when obsolescence or operating experience feedback dictates otherwise. This process is based on a quality management system and contractual requirements which guarantee a logistic and technical response that is appropriate for the sites' equipment and spare parts requirements.

In this context, and to avoid calling into question the initial design by ensuring interchangeability from the functional, dimensional, reliability and resistance aspects, the procurement of spare parts forms the subject of:

- specifications and contractual technical conditions which meet the equipment design requirements, the regulatory requirements, the quality requirements and requirements concerning the EDF codification and in-house technical specifications,
- monitoring, traceability and documenting of product manufacture in compliance with the prescriptions setting the requirements relative to quality assurance, monitoring implementation, identification rules for the delivered equipment and spare parts, the documents to provide according to the contract and the rules for their transmission,
- storage conditions guaranteeing preservation of the quality of the spare parts until they are used.

### 19.3.3 Measures taken for research reactors

#### 19.3.3.1 CEA reactors

A set of procedures and instructions managed by the relevant services ensure that all the operations are carried out in compliance with the applicable rules, rules with which outside contractors must also comply.

The licensee must ensure that the contractors comply with these rules.

Experimental systems designed and operated in the facilities likewise comply with very strict safety requirements.

In order to check the operation of items important for safety in each facility and ensure their availability, they undergo inspections and periodic tests. The inspection and test frequency is precisely defined and can be calendar-based or event-based.

Satisfactory performance of these tests at the planned frequency enables the items concerned to be declared available. The aim of systematic maintenance is to prevent failures of these items of equipment and to preserve their ability to fulfil their function with the required performance. This preventive maintenance is carried out periodically in the same way as the periodic inspections and tests, in accordance with validated procedures and accompanied by a risk assessment if the intervention could affect safety.

#### 19.3.3.2 The ILL high flux reactor (HFR)

The measures taken for the Laue Langevin Institute (ILL) reactor are similar to those taken for the CEA reactors.

### 19.3.4 ASN oversight and analysis

#### 19.3.4.1 Nuclear power reactors

##### 19.3.4.1.1 Operation of the reactors

Several activities have been the source of significant events over the last few years, the root causes of which are multiple and cumulative. Among these causes, ASN notes deficiencies in activity preparation, meaning that the persons concerned are not sufficiently aware of the risks involved or of the applicable documentation.

With regard to the periodic tests, the efforts in the management of their planning, preparation and performance must be maintained. Thus, both the prior analysis of the operation and the interpretation of the results need to be taken to greater depth. ASN also considers that the process used by EDF for retrospective ruling on the validity of the tests needs to be reinforced in order to promote a questioning attitude.

Furthermore, the periodic safety reviews of the nuclear power reactors can result in modifications to the qualification requirements of several items of equipment due to an extension of the scope of the safety case or a re-evaluation of the stress levels to which these items of equipment may be exposed.

The inspections performed and the deviations detected show that the compliance of the facilities with their baseline safety requirements needs to be reinforced: control of this compliance will thus be a key aspect of ASN oversight in 2019, more particularly during the reactor conformity checks.

Examination of the significant modification authorisations for installations presented by EDF enables ASN to exercise an *a priori* check of the measures taken by EDF to guarantee the long-term durability of the qualification of modified equipment. This check is based on the substantiating documents required by ASN resolution 2017-DC-0616 of 30th November 2017 relative to significant modifications to BNIs. Changes in equipment qualification methods are examined within this framework.

The inspections conducted by ASN on EDF suppliers' premises, in the EDF engineering centres and the NPPs also aim at checking that the services and goods provided and built meet the specified requirements, particularly those relative to equipment qualification. Any deviations and their combinations are systematically assessed for their effects on the safety of the installation as part of the process that ASN applies to deliver the reactor start-up authorisation after refuelling.

#### 19.3.4.1.2 Maintenance activities

ASN noted over the 2017-2018 period that the quality of maintenance work needed to be further improved, on account more specifically of a persistently high number of maintenance quality deficiencies. An insufficiently questioning and proactive attitude in the implementation of appropriate corrective actions is all too often observed in identifying and processing maintenance-related deviations.

ASN still observes activity management problems owing to difficulty with the procurement of spares, in particular because spares are unavailable or non-conforming, but the slight improvement trend observed in 2017 was confirmed in 2018.

ASN also regularly observes a lack of rigour in technical oversight of maintenance work and in contractor monitoring, along with deficiencies in work traceability and reliability-enhancement. These difficulties are more particularly encountered in unscheduled activities, such as when dealing with unexpected events.

The management of maintaining equipment qualification for accident conditions must be further improved, in particular so that the sites can adopt binding documents, as the operational documents are inappropriate or poorly applied. Post-maintenance requalification of equipment is not always able to detect work that has been incorrectly performed. Consequently, maintenance quality deficiencies are all too often detected during the reactor restart phases, which can significantly prolong these phases.

The maintenance method, AP-913 (see § 19.3.2.2) deployed by EDF is designed to enable the licensee to have better knowledge of the state of its facilities and to ensure their maintenance more regularly. ASN observes that most sites have managed to successfully carry out large-scale maintenance operations, such as the preparation for and performance of the periodic safety reviews, which place considerable demand on their human resources, especially the most experienced, owing to the particularly intense maintenance phases.

With a view to the continued operation of its reactors, the "grand carénage" major overhaul programme, and in the light of the lessons learned from the Fukushima accident, ASN considers that it is important for

EDF to continue its ongoing efforts to remedy the difficulties encountered and to improve the effectiveness of its maintenance activities.

#### 19.3.4.1.3 Condition of equipment

The various maintenance programmes implemented by the licensee help to maintain the NPP equipment in generally satisfactory condition.

**The first barrier (fuel cladding)**

The condition of the first containment barrier is on the whole satisfactory in the majority of the nuclear power plants.

ASN notes that the progress observed in 2017 continued in 2018 with regard to the risk of entry of foreign material into the primary cooling system. For example, several sites set up training programmes for outside contractor personnel, without which they are not authorised to work. However, despite this progress, ASN once again repeatedly found foreign material in the primary cooling systems and will therefore remain attentive to this in 2019.

The recurring blockages encountered during control rod operation or dropping in 2017 and 2018 on certain 1300 MWe reactors, owing to wear of the reactor vessel closure head thermal sleeves, led EDF to initiate an inspection programme on all the reactors and replace the most heavily worn thermal sleeves. Until these inspections - which must be performed during the reactor outages – have actually been carried out, operating restrictions are implemented at the request of ASN.

Finally, with regard to fabrication of the fuel assemblies, ASN is continuing its inspections, notably as a result of the anomalies encountered in 2017 on MOX (presence of large sized plutonium-enriched islands) and the fuel cladding (cladding compliance inspection anomalies). EDF's notification of a significant nuclear safety event concerning the phenomenon of rising neutron flux at the bottom of the fissile column of MOX fuel assemblies, led ASN in 2018 to ask EDF to characterise the loss of the first barrier integrity margin and to take compensatory measures pending the deployment of a change to the design of these assemblies. ASN will remain attentive to the deployment and effectiveness of these measures.

**Pressure equipment and the second barrier**

The situation of the nuclear pressure equipment (NPE) in the EDF power reactors in operation is satisfactory on the whole, although some difficulties detailed below have received particular attention from ASN since 2016.

The requirements of the regulations, more particularly with regard to maintenance work, processing defects, visits and periodic requalification of the main primary and secondary systems, are satisfied on the whole.

In 2011, the discovery of stress corrosion cracking on a bottom-mounted instrumentation (BMI) penetration on Gravelines reactor No.1 led ASN to ask EDF to begin BMI penetration inspections on all the reactors. The BMI penetration of Gravelines reactor No.1 was repaired by definitively plugging the penetration. Another indication was detected in 2016 on a BMI penetration of Cattenom reactor No.3. EDF is currently looking into a process to repair or eliminate the defect.

Furthermore, the discovery of areas displaying major positive carbon segregations on the domes of the Flamanville EPR reactor pressure vessel has led ASN to ask EDF whether such segregations might exist in the components installed on the reactor fleet in service.

EDF has identified certain steam generator channel heads manufactured by Framatome in its Creusot plant and by the Japanese manufacturer Japan Casting and Forging Corporation (JCFC) as potentially displaying such segregations. Carbon measurements were carried out *in-situ* and revealed the presence of carbon segregations on 46 steam generator channel heads. Non-destructive examinations were then carried out to make sure there were no defects in the areas affected by the carbon segregations and compensatory operating measures were implemented. A test programme is currently being prepared in order to better characterise the overall mechanical properties of the segregated zones.

Lastly, ASN has been particularly attentive to the level of soiling of certain steam generators, which in some cases has led to preventive chemical cleaning operations on these steam generators.

**The third barrier and the containment**

Overall management of the containment function

The organisation put into place by EDF for monitoring the activities and systems liable to have an impact on the static and dynamic containment of the facilities remains satisfactory on the whole, even if a complete formal definition is sometimes not yet available. Even if EDF has taken steps to maintain the dedicated systems in good condition, improvements are still needed regarding the containment condition of the third barrier and its constituents, in particular maintenance of the floor drains and the components of the doors contributing to static containment.

Single wall containments with an internal metal sealing liner

The ten-yearly tests of the 900 MWe reactor containments performed since 2009 during their third periodic safety review have not brought to light any particular problems liable to compromise their operation for a further ten years, with the exception of the Bugey NPP reactor No.5. This reactor is now regularly monitored since an unfavourable change in the leak-tightness of its containment was revealed in 2011. This containment was repaired in 2017.

The ageing of the 900 MWe reactor containments was examined by ASN with the support of IRSN in 2018 and was presented to the GPR during a session dedicated to ageing. This examination concluded that the cleanness of the outer part of the containments needed to be improved in order to guarantee that there is no stagnant water, debris, moss and other vegetation.

Double-wall containments

The results of the double-wall containment tests performed during the first periodic safety reviews of the 1300 MWe reactors revealed a rise in the leak rate from the inner wall of some of them, under the combined effect of deformations of the concrete and loss of prestressing in certain cables that were greater than anticipated at the design phase.

EDF then initiated major work consisting in locally applying a resin sealing coating to the interior surface of the inner wall of the containments of the most severely affected 1300 MWe reactors, as well as to the 1450 MWe reactors.

All the tests carried out after this work, during the second and third periodic safety reviews of the 1300 MWe reactors and the first periodic safety reviews of the 1450 MWe reactors, satisfied the leakage rate criteria. In order to ensure that these criteria will continue to be met over the long-term, EDF decided to improve the leak-tightness of the inner wall of these reactor buildings by applying the sealing coatings to their outer surface.

ASN remains vigilant with regard to changes in the leak-tightness of these containments and to maintaining the long-term effectiveness of the coatings. The effectiveness of the containment function of the reactors with the double-wall system was examined in 2013. ASN concluded that:

- in addition to EDF's satisfactory monitoring of the condition of the concrete, additional measures to prevent or limit the ingress of water from outside also had to be envisaged because, given the current state of knowledge, this is the primary means of protecting the containments, particularly against concrete swelling pathologies;
- EDF had to reinforce in-service monitoring and visual inspection of certain containment singularities (sleeves, equipment hatch);
- the instrumentation system that ensures continuous monitoring of the containment leak rate (Sexten) must be given a safety classification by EDF, and must be subject to in-service monitoring of its operation.

EDF has started taking steps in response to these conclusions. ASN checks that they are correctly implemented, notably by means of inspections.

##### 19.3.4.2 Research reactors

The research reactor maintenance activities are based on similar principles to those developed for the nuclear power reactors. The requirements defined for the "inspections and periodic tests (CEP) and maintenance" of the research reactors are integrated in the corresponding chapter of the general operating rules (RGEs) and the associated maintenance programmes.

The listed equipment items undergo inspections and operating tests on account of the CEPs with corresponding specified requirements. Furthermore, certain listed items of equipment undergo preventive maintenance operations which take into account both the manufacturer's servicing specifications and the experience feedback for the equipment.

ASN conducts regular inspections on the subject of "CEP and maintenance". For the 2016-2019 period, ASN observes that maintenance of the research reactors at both the CEA and ILL is generally well managed. Maintenance work performance, schedule management and traceability are considered satisfactory.

## *19.4 Management of incidents and accidents*

### 19.4.1 ASN requirements

The operating range of the nuclear facilities is set by the general operating rules (RGE) which include the operational management procedures for incident and accident situations.

**The stress tests**

The stress tests examined procedures required to manage situations of severity exceeding the design-basis situations. The warning and management procedures implemented on the sites to protect against flooding were also analysed.

### 19.4.2 Measures taken for nuclear power reactors

The operating parameters are measured continuously and in the event of pre-defined limits being exceeded, automatic systems trigger an alarm in the control room so that the operators can analyse the situation and take appropriate control measures, in particular as required by the technical operating specifications (STE). The analysis of alarms and physical variables may lead the operator to make a diagnosis that results in entry into an incident procedure.

To this end, all the EDF nuclear power plants in operation today use the state-based approach, an operational control method that enables all "thermo-hydraulic" incidents or accidents, whether simple or multiple, and whether combined or not with losses of systems or electrical power sources or with human failings. Its primary goal is to prevent the risk of core melt.

In the hypothetical event of core melt occurring, the priority is to safeguard the containment. The operational control strategy in this case is supported by the Severe Accident Management Guidelines (SAMG) which are designed for the management of new and complex phenomena in severely degraded situations.

The decision to apply the SAMG, which marks the abandonment of the state-based approach procedures, is taken on criteria concerning the core outlet temperature and the dose rate in the reactor containment. The Ultimate Backup Diesel Generator provides electrical back-up for the instrumentation and equipment allowing operational management in severe accident situations.

The existing measures and those currently being deployed further to the stress tests to face up to the risks identified in a severe accident situation are set out below.

- **Risk due to the production of hydrogen:**

  Since the end of 2007, all the EDF reactors are equipped with hydrogen passive autocatalytic recombiners (PAR). These recombiners reduce the risks of hydrogen combustion to a very low level, whether in the reactor building or the peripheral buildings.

- **Risk of slow pressurisation of the containment:**

  If the residual power is not removed, the time frame for loss of containment caused by exceeding the mechanical characteristics of the reactor containment varies from one to several days depending on the accident scenario. This risk is countered by a containment venting-filtration system and the associated operating procedure that preserves its long-term integrity. The venting-filtration system is opened after 24 hours at the earliest. Thanks to the filtration of long-lived products, the opening of this system mitigates the long-term radiological consequences. In response to an ASN requirement, EDF studied the possibilities of improving this containment venting-filtration system (U5), including a review of the hydrogen risk and its potential consequences, and the resistance to earthquakes. The results were transmitted at the end of 2013.

  The setting up of a mobile diesel generator set for preheating the U5 system, brought by the Nuclear Rapid Intervention Force (FARN) enables the $H_2$ to be excluded in the U5 filter. This filter will be reinforced to withstand the maximum historically probable earthquake (MHPE).

  In response to an ASN requirement, EDF adopted the implementation, by the 4th periodic safety review of the 900 MWe reactors (PSR4 900), of a Hardened Safety Core provision called EASu, designed to preserve reactor containment integrity without opening the venting system. This system consists in cooling the water injected into the tank by a hardened safety core pump during the phases of recirculation on the containment sumps by means of an ultimate heat sink that is independent of the RRI (component cooling system) / SEC (essential service water system which cools the RRI) and the normal heat sink.

Baskets of sodium tetraborate which also trap the organic iodines in the containment have been installed since late 2017 on the reactors of the 1300 MWe and 1450 MWe plant series which are not provided with Silver Indium Cadmium (SIC) alloy control rod clusters.

These provisions as a whole will mitigate the short and long-term consequences.

- **Risk of reactor containment leak-tightness fault:**

  Isolation of the containment is requested systematically (by the automatic systems and by the accident operational management documents) before entering into severe accident status and is then confirmed on entry into severe accident status. The backing up via an electrical channel (channel A) of the containment isolation by the Ultimate Backup Diesel Generator Set (DUS) is in the final phase of deployment.

- **Risk of direct heating of the containment:**

  To avoid direct containment heating (DCH), the operating procedure requires depressurisation of the primary system of the reactors in service by opening the pressuriser relief lines immediately on entry into the severe accident situation. A hardware modification (integration of a bistable control accessible from the relaying room using a new independent mobile safety means) to enhance the reliability of opening and keeping open the relief valves, decided before the Fukushima Daiichi NPP accident, is currently being applied to all the reactors during their periodic safety reviews. In the interim, the reactors in which the modification had not yet been implemented have been equipped with a provisional mobile safety means enabling the pressuriser safety relief valves to be opened from the relay circuitry.

- **Risk of return to criticality**:

  EDF has carried out reactivity studies to analyse the risk of return to criticality for different corium configurations - compact or fragmented - in the reactor vessel or the reactor pit following the injection of water. These studies conclude that the criticality risk is zero when the corium is not fragmented in the water and excluded when borated water is injected at the minimum boron concentration of the tank.

  As the Severe Accident Management Guidelines (SAMG) prohibit the injection of non-borated water as long as the corium is in the reactor vessel, the risk of return to criticality is ruled out for such configurations. After reactor vessel melt-through, the injection of clarified water could be envisaged after analysis and if recommended by the emergency response team. The return of criticality risk is ruled out in the short term but borated water make-ups must be available in the long term

- **Risk of basemat melt-through**:

  Reflooding the corium in the vessel or injecting water into the reactor pit via the perforated vessel to keep the corium flooded, limits the risk of basemat melt-through, or failing this, delays its occurrence. The SAMG defines the water injection conditions, particularly with respect to the risks of early loss of containment.

During the 4th periodic safety reviews of the 900 MWe plant series, under the requirements concerning the Hardened Safety Core, EDF will put in place a system to prevent basemat melt-through in the event of core melt and perforation of the reactor vessel. This system is based on dry spreading of the corium followed by passive flooding of the corium with the water from the sumps. This strategy also rules out any risk of corium-water interaction and therefore of loss of containment.

In addition to these measures to prevent basemat melt-through, measures to counter the dissemination of radioactive products by the "water route", i.e. potential contamination of the groundwater in the event of a severe accident with basemat melt-through, have been examined. In late 2012 EDF submitted a study on the setting up of such "water route" countermeasures which concludes that the measures that could be envisaged display substantial uncertainties regarding their feasibility and effectiveness and would bring only minimal gains in safety. EDF considers that the modifications envisaged to further reduce the risk of core meltdown and those envisaged to prevent the risk of basemat melt-through taken as a whole will consolidate the residual nature of this risk. This led EDF to favour prevention of the risk of basemat melt-through, which enables the corium to be maintained in the containment.

In response to an ASN requirement, EDF has implemented a modification concerning the installation of redundant means for detecting reactor vessel melt-through and the presence of hydrogen.

**Feasibility of the immediate actions in the Severe Accident Management Guide (SAMG)**

Taking the hypothesis of an event leading to a severe accident on one plant unit which could affect operation of the other units on the site, the feasibility of the actions necessary to manage the situation of each reactor over the long term must be guaranteed.

In this respect, EDF has studied the appropriateness of the internal and external resources, both human and material, and the capacity of the socio-technical system to manage the situation of the site and in particular the activities associated with deployment of the Hardened Safety Core (including the immediate actions of the SAMG) and the additional equipment proposed following the stress tests.

**Habitability of the control room**

EDF has planned to reinforce the electrical back-up of control room ventilation and filtration through the ultimate backup diesel generator. In the interim, a modification has been made to enable one train of the control room ventilation system (DVC/DCC) to be resupplied from the control room by an ultimate backup diesel generator set ("GE LLS").

**Spent fuel pools**

The improvement in the safety of storage in the spent fuel pool has been examined on several occasions by the Advisory Committee of Experts, with the review of this subject on the 900 MWe and 1300 MWe plant series at their third periodic safety reviews and on the N4 plant series at their first periodic safety review.
Several modifications stemming from the review of this subject have already been integrated on the reactors in service.
For example, the following modifications reinforce prevention of the risks of accidental emptying:

- automatic shutdown of the PTR pumps and automatic isolation of the PTR suction line if the very low level of the spent fuel pool is reached,

- redimensioning of the siphon vacuum breaker of the PTR discharge line to interrupt emptying by siphoning initiated by a guillotine break of this line.

Further to the Fukushima accident, additional physical and organisational means deployed as part of the EDF Post-Fukushima programme reinforce the prevention of fuel assembly uncovering. The main modifications are as follows:

- restoring electricity supply for the Off/On measurements of the spent fuel pool by the ultimate backup diesel generator set,
- resupplying the spent fuel pool with water with the setting up of an ultimate water source (SE-u).

Beyond the safety objective of non-uncovering of the fuel assemblies, EDF has studied the addition of a supplementary and diversified means called "PTR bis" to improve management of situations of loss of the spent fuel pool heat sink.

The addition of this "PTR bis" system at the 4th PSR of the 900 MWe plant series, provides, in addition to the two PTR cooling channels, a resilience factor for the return to fuel pool cooling based on a diversified heat sink. This additional cooling system will be based primarily on mobile equipment which will be brought to the site, aligned and put into service by the FARN, operational in 24h.

### 19.4.3 The measures taken for research reactors

#### 19.4.3.1 CEA reactors

Outside normal operating situations, the analysis of the alarms and operating parameters measured on the installation and transmitted to the control room, can lead the operators to enter into incident or accident operating procedures.

These procedures describe the operational control applicable in such situations, the objectives being to maintain the reactor in a safe condition and to mitigate the consequences of the incident or accident.

The operational management rules applicable in incident and accident situations are described in the general operating rules (RGE).

The Cabri, Orphée and RJH reactors have a secondary control bay, in a location elsewhere than the control room which is used in normal operation, from which accident situations can be managed. These secondary control bays are used in particular during the emergency exercises held frequently in coordination with ASN, its technical support agency and the public authorities.

The management of accident situations will be reinforced to take into account the extreme situations resulting from the experience feedback from the Fukushima accident (see § 16.3.2). These provisions are more specifically planned to reinforce the emergency management means of the CEA Cadarache centre.

#### 19.4.3.2 The ILL high flux reactor (HFR)

General operating rule No.11 and the reactor note "Infra PUI" (On-site emergency plan infrastructure) describe the operational control applicable outside normal operating situations and the conditions of transition to accident mode organisation.

This organisation is described in the on-site emergency plan (PUI). The criteria for triggering the PUI are indicated in it, as are the particular operating rules that must be applied according to the situation.

The stress tests enabled the safeguard, prevention and mitigation systems to be supplemented. These systems are controlled automatically, but it is possible to revert to manual control at any time. All these safeguard system are duplicated. After rod drop, cooling by natural convection is sufficient, therefore it is not necessary to guarantee a heat sink. The safeguard systems essentially allow a minimum water inventory to be maintained around the fuel element and the depressurisation of the reactor containment to avoid any overpressure that could lead to a discharge. Lastly, the emergency management room can withstand simultaneous extreme external hazards (see § 16.3.3).

### 19.4.4 ASN analysis and oversight

#### 19.4.4.1 Nuclear power reactors

The strategies and reactor operating rules for an incident or accident situation are defined in the RGE. These evolve notably to take account of experience feedback from incidents and accidents, to correct the anomalies detected during their application or to take account of modifications made to the facilities, in particular those resulting from the periodic safety reviews. Most of these modifications require ASN authorisation.

ASN regularly checks the processes to draft and validate the incident or accident operating rules, their pertinence and how they are implemented.

To do this, ASN can place the facility's control teams in a simulated situation to check how they apply the above-mentioned rules and manage the specific equipment used in accident operating situations. It in particular ensures correct application of the emergency teams organisation principles described in the EDF baseline requirements validated by ASN. This organisation more particularly requires that each emergency team member take part in an exercise at least once a year.

The various works carried out in the framework of the stress tests took into account scenarios that had not been considered in the past. Consequently, integration of the conclusions of the stress tests and the associated requirements will lead to significant modifications in the various documents relating to severe accident management.

These measures are specified on the ASN website and detailed in the national action plan resulting from the stress tests. They include provisions relative to severe accident management, particularly concerning:

- implementation of a hardened safety core of robust material and organisational measures (see § 6.2.1.2);
- The integration into the accident operational management procedures and the severe accident management documents, including the SAMG, of the new provisions for handling the extreme situations studied in the stress tests and affecting several reactors on the same site, for all operating states, as well as the fuel storage buildings;
- development of the accident situation operational control of the reactors to adapt it to the different reactor states;
- the defining of new emergency procedures that will integrate the new provisions identified through the stress tests. The implementation of this organisation is accompanied by specific personnel training.

ASN has issued other requirements relative to severe accident management:

- Installation before December 2017 of redundant means in the reactor pit to detect vessel melt-through and redundant means in the containment to detect the presence of hydrogen. (requirement ECS-19). The corresponding modifications have been carried out by EDF;

- Installation of reinforced instrumentation in the pool for measuring the state of the spent fuel pool (pool temperature and water level) and the radiological atmosphere in the fuel building hall (requirement ECS-20). The modifications have been carried out by EDF;
- Implementation of additional measures to prevent or mitigate the consequences of a fuel transport package falling in the fuel building on the Bugey and Fessenheim sites (requirement ECS-21). The corresponding modifications have been carried out by EDF;
- Reinforcement of the measures to prevent accidental rapid draining of the fuel storage pools (requirement ECS-22). The corresponding modifications have been carried out by EDF.
- Study of the possible measures, in the event of total loss of electrical power supplies and accidental emptying, to ensure the safe positioning of a fuel assembly during handling in the fuel building, before the ambient conditions no longer allow access to the premises (requirement ECS-23). The corresponding studies have been carried out by EDF.
- Study of the evolution over time of the fuel and the water present in the spent fuel pool, in situations of emptying and loss of cooling, and presentation of the planned modifications (requirement ECS-24). The studies submitted describe the kinetics and the consequences of a boiling crisis in the fuel pool. The proposed mitigation measures consist in restoring the water inventory in the pools through water make-up which forms part of the hardened safety core, with the pool then being cooled by a mobile means.
- Study of conceivable changes to equipment or operating conditions to prevent uncovering of the fuel assemblies during handling, as the result of a break in the transfer tube between the pools of the reactor building and the fuel building or in the compartment drainage pipes (requirement ECS-25). The study has been submitted and is currently being analysed;
- Study of the feasibility of installing a geotechnical containment;
- EPR reactor: reinforcement of the provisions for controlling the pressure in the containment (requirement ECS-28);
- Detailed study of the possibilities for improving the U5 venting-filtration device, taking account of the robustness to hazards, the limitation of the risks of hydrogen combustion, the efficiency of filtration in the case of simultaneous use on two reactors, the improved filtration of fission products, particularly iodines and the radiological consequences of opening of the device, notably on site accessibility, and the radiological atmosphere of the emergency rooms and the control room (requirement ECS-29);
- Modifications planned on a site to ensure that, in the event of release of dangerous substances or opening of the venting-filtration system, operation and monitoring of all the facilities on the site are guaranteed until a long-term safe state is reached, and the corresponding deployment schedule (requirement ECS-31). The licensee has submitted the dose assessments for various scenarios and various emergency management players. The instrumentation specific to the hardened safety core shall be put in place along with the hardened safety core;
- Reinforcing of the material and organisational measures to take account of accident situations affecting all or part of the site's facilities simultaneously (requirement ECS-32). A new on-site emergency plan (PUI) baseline has been deployed on all EDF sites since 15 November 2012. It takes into account accident situations affecting several facilities on a given site simultaneously.

#### 19.4.4.2 Research reactors

The licensees carried out stress tests on each of their research reactor installations.

The management of extreme accident situations resulting from the lessons learned from the Fukushima Daiichi NPP accident has formed the subject of ASN requirements on the various sites accommodating research reactors. While the necessary work has effectively been carried out for the ILL, ASN observes delays in the implementation of the emergency management provisions for extreme situations on the CEA sites. ASN will be attentive to the reinforcing of the provisions guaranteeing control of the risks in emergency situations on the Saclay and Cadarache sites. Pending the setting up of these reinforcements, compensatory measures are implemented.

## *19.5 The technical support*

### 19.5.1 ASN requests

The regulations, and the BNI order in particular, require that the licensees establish and implement a policy for public health and safety and protection of nature and the environment. This policy defines objectives, indicates the licensee's strategy to achieve them and the resources it undertakes to assign to it.

The licensee must indicate how it organises its technical capabilities, that is to say whether they are held internally, in subsidiaries or through third parties with whom formal agreements must be made; the most fundamental capabilities must be held by the licensee or one of its subsidiaries;

The licensee must also implement an integrated management system.

Consequently, ASN expects the licensees to have appropriate expertise and technical skills to ensure operation of the facilities, maintenance of the equipment and systems and management of incidents and accidents.

### 19.5.2 Measures taken for nuclear power reactors

The NPPs have an integrated management system.

EDF has its own national engineering centres with appropriate NPP design, construction and operating skills to support the NPPs.

An operational engineering guide (GIOP) defines the organisation and responsibilities for the NPP material and documentation changes. This guide, which is now exists in electronic format (e-GIOP), has been revised in order to synchronise the design engineering processes and the operating processes. The milestones for the various steps have been more strictly defined, from the studies through to deployment of the modifications on the NPPs.

The subcontracted operations, maintenance in particular, are subject to contracts and monitoring.

Design integrity is guaranteed through the setting up of the "Design Authority" and its "Responsible Designers".

### 19.5.3 Measures taken for research reactors

At each CEA centre, technical support units bring together the various skills required for the activities involved in operating the facilities. These technical support units establish contracts with the outside contractors called upon by the facilities for maintenance of the equipment items. These technical support units are different from the nuclear safety support units, but their expertise is called upon wherever necessary.

### 19.5.4 ASN analysis and oversight

ASN carries out inspections in the head office departments of the main nuclear licensees, the workshops or design offices of the subcontractors, the construction sites, and the plants or workshops manufacturing components that are important for safety.

Maintenance and modification activities on French reactors are to a large extent subcontracted by EDF to outside contractors. EDF justifies the use of subcontracting by the need to call on specific or rare expertise, as well as the highly seasonal nature of reactor outages and thus the need to absorb workload peaks.

EDF takes the necessary steps to control the risks associated with the subcontracted activities and regularly updates them. It has thus reinforced the preparation of outages, more particularly to guarantee the availability of human and material resources.

ASN checks the conditions surrounding the preparation for (schedule, required human resources, etc.) and performance of the subcontracted activities (relations with the licensee, monitoring by the licensee, etc.). It also checks that the workers involved have the means needed (tools, operating documentation, etc.) to perform their tasks, in particular when these means are made available by EDF.

The technical support for the CEA's facilities is provided in particular by the DSSN and services which intervene in their areas of competence. These services provide the facilities with the assistance of specialists in diverse technical areas such as seismic risks, paraseismic engineering, fire, criticality, chemical risks, pressure equipment, dynamic mechanics, thermomechanics, instrumentation and control, containment-ventilation, measurements, impact studies (environment and drawbacks) and human and organisational factors (HOF). With regard to subcontracting, which represents a significant share of the safety-related activities, the CEA must step up its monitoring and control of these activities.

## *19.6 Significant events*

Operating experience feedback is one source of improvement in the areas of safety, radiation protection and the environment. The regulations, and the BNI order in particular, stipulate this principle and require the licensee to implement an integrated management system that includes the provisions enabling it to identify and process the deviations and significant events (see § 7.3.3.3).

### 19.6.1 ASN requests

ASN requires the licensees to notify it of any significant events that occur in the nuclear power plants. Criteria have been set for notifying the public authorities in a document named "Guide to the conditions of notification and codification of the criteria relative to significant events involving safety, radiation protection and the environment applicable to BNIs and the transport of radioactive materials". Each significant event is classified by ASN on the INES scale.

Licensees must notify ASN of all events that are significant for nuclear safety within 48 hours, with a proposed classification on the INES scale (ASN has sole responsibility for the final classification decision). ASN analyses this initial notification to verify the implementation of immediate corrective measures, to decide whether to perform an on-site inspection to analyse the event in depth and, if necessary, to prepare the communication of information to the public.

The use of the INES scale enables ASN to select, among all the events and incidents that occur, those that have sufficient significance to be subject to communication on its part:

- events rated level 1 always form the subject of an incident report published on www.asn.fr13;
- events rated level 2 and higher also form the subject of a press release and are notified to the IAEA;

The notification is supplemented within two months by a report indicating the conclusions the licensee has drawn from the analysis of the event and the measures it is taking to improve safety or radiation protection and to prevent recurrence of the event. ASN checks that the licensee has suitably analysed the event, taken the appropriate measures to correct the situation and prevent it occurring again, and has circulated the lessons learned from it.

ASN performs specific inspections to investigate the circumstances, causes and consequences of certain incidents.

### 19.6.2 Measures taken for nuclear power reactors

Between 2016 and 2018, the number of significant safety events classified on the INES scale (excluding level 0) remained relatively stable, within the historical average: 57 in 2016 (1 / reactor.year), 65 in 2017 (1.1 / reactor.year) and 74 in 2018 (1.3 / reactor.year).

In 2017, EDF counted 4 significant safety events relating to insufficient earthquake resistance of the structures, rated level 2 on the INES scale and comprising two events relative to design or construction faults and two to maintenance faults. EDF has carried out work to restore conformity after their detection and has drawn up action plans to address the root causes.

### 19.6.3 Measures taken for research reactors

#### 19.6.3.1 CEA reactors

Over the 2016-2018 period, one significant event of level 1 on the INES scale was notified at the Cadarache site in BNIs 42 and 95 (EOLE-MINERVE), concerning the shipping of a radioactive material transport package displaying two deviations with respect to its approved model.

In September 2018, a type TNBGC-1 package containing uranium-bearing materials was shipped from the Éole/Minerve installations (critical mock-ups, today in final shutdown status) to another installation in the CEA Cadarache centre. This was therefore an "on-site" transport operation which did not take the public highway. During handling of the package prior to this transfer, an aluminium protective plate of the outer shell of the packaging, intended to prevent any physical contact between the operators and the package, got damaged and was then removed. Furthermore, the temperature measurements of the external surface of the package required before transport were not carried out. These deviations from the safety rules were not detected until after the transport operation. This event was rated level 1 on the INES scale.

[13] http://www.asn.fr/Controler/Actualites-du-controle

It can be noted on the basis of the events rated level 0 that:

- 28% result from failure to comply with the safety baseline requirements (periodic inspections and tests);
- 25% result from containment control problems
- 17% result from reactor trips
- 18% are due to miscellaneous problems (support system, water ingress, etc.)
- 8% concern radiation protection
- 3% concern the environment

#### 19.6.3.2 The ILL high-flux reactor (HFR)

The ILL reported one significant event rated level 1 on the INES scale over the 2016-2018 period, concerning the incomplete removal of a fuel element : in May 2017 the ILL reported a significant safety-related event, rated level 1 on the INES scale, involving the jamming of a spent fuel element in its handling cask during operations to transfer it to the non-exposable part of the storage pool. This event had no immediate consequences on either the facility, the workers or the environment. The recovery of the spent fuel element took several weeks, as the winch used to handle the transfer cask had to be modified. During this period the fuel element was in a secure condition and cooled normally. The analysis of the event identified the causes and enabled corrective measures to be put into place to prevent it from recurring.

Events rated level 0 can be grouped in families:

- 35% of the events concern periodic test schedules, a proportion that is decreasing constantly;
- 15% result from the untimely activation of a safeguard system;
- 15% of the events result from manual or automatic actuation of the reactor trip function, whether untimely or not;
- 15% result from failure to comply with the safety baseline requirements;

### 19.6.4 ASN analysis and oversight

ASN examines all notified significant events both locally and nationally. For certain significant events considered more noteworthy due to their nature or their frequency of occurrence, ASN has IRSN conduct a more detailed analysis. If this analysis reveals information that warrants international dissemination, it may subsequently be published in the IAEA and NEA's International Reporting System (IRS) database.

The number and rating on the INES scale (International Nuclear and Radiological Event Scale) of the significant events which have occurred in a nuclear facility are not on their own indicators of the facility's level of safety. On the one hand, a given rating level is an over-simplification and is unable to reflect the complexity of an event and, on the other, the number of events listed depends on the level of notification compliance. The trend in the number of events does not therefore reflect any real trend in the safety level of the facility concerned.

In order to guarantee rapid dissemination of information, ASN endeavours to inform its counterparts as quickly as possible when a notable event occurs in France by using the existing multinational structures and networks.

During its nuclear installation inspections, ASN examines the organisation and measures taken by the sites to deal with significant events. ASN analyses the way the licensees (EDF, CEA, ILL) deal with significant events on an annual basis, and takes this into consideration in its assessment of the overall performance of the nuclear installations.

#### 19.6.4.1 The nuclear power reactors

Table 8 shows how the number of significant events notified by EDF and classified on the INES scale has evolved since 2013. Only INES rated events are recorded (no level 0).

Table 8: Evolution of the number of significant events classified on the INES scale in the EDF nuclear power plants between 2013 and 2018

| INES level | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| 1 | 103 | 99 | 89 | 101 | 87 | 103 |
| 2 | 2 | 0 | 1 | 0 | 4 | 0 |
| Total | 817 | 765 | 697 | 717 | 835 | 875 |

Table 9 shows the evolution of the number of significant events notified since 2013 by domain: events significant for safety (ESS), events significant for radiation protection (ESR) and events significant for the environment (ESE). Events not rated on the INES scale are also taken into account.

Table 9: Evolution of the number of significant events by domain in the EDF nuclear power plants between 2013 and 2018

| Type of SE | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| ESS | 689 | 640 | 586 | 583 | 688 | 686 |
| ESR | 120 | 116 | 109 | 122 | 130 | 169 |
| ESE | 93 | 112 | 79 | 77 | 98 | 75 |
| Total | 902 | 868 | 774 | 782 | 916 | 930 |

Several events which are similar or result from common causes affect several nuclear power plants. They are grouped under the term generic significant events (ESG). Twenty-six were notified in 2018, of which twenty-five were in the field of nuclear safety and one in the field of radiation protection.

The breakdown of the number of ESS’s by reporting criteria shows that about half of them are due to non-compliance STEs.

Some of these activities are regulated by prescriptive documents. However, the reported significant events reveal deficiencies in safety management and in the organisation put in place on the licensee's site.

Furthermore, the number of ESRs increased by 30% over the same period. This rise is mainly due to industrial radiology operations and the non-performance of technical inspections (zoning and mobile radiation protection devices).

#### 19.6.4.2 Research reactors

No events of level 2 or higher on the INES scale have occurred on research reactors since the 5th review meeting of the CNS.

In application of the rules relative to notification of significant events in the areas of safety, radiation protection and the environment, the research reactor licensees (CEA and ILL) notified between 24 and 32 significant events classified on the INES scale (relating to nuclear and radiological safety) per year between 2016 and 2018. As indicated in § 19.6.3, there were only two significant events rated level 1 between 2016 and 2018.

## *19.7 Integration of experience feedback*

### 19.7.1 ASN requests

The BNI order stipulates this principle and requires the licensee to implement an integrated management system that includes provisions enabling it to identify and process the deviations (difference between an observed situation and a required situation) and significant events, and to gather the experience feedback from the operation of its facility or other facilities, whether similar or not and in France or abroad, or resulting from research and development.

ASN also endeavours to disseminate experience feedback from French nuclear facilities during bilateral or multilateral discussions with its counterparts and other safety organisations. ASN and IRSN also participate in various discussion forums within the IAEA, the NEA and the European Union. For example, ASN is a member of the NEA's *Working Group on Operating Experience* (WGOE) addressing reactors in operation, and the *Working Group on the Regulation of New Reactors* which focuses more specifically on experience feedback from the construction of new reactors. ASN is also a member of the Nuclear Energy Agency's *Multinational Design Evaluation Programme (MDEP)* which evaluates the design of new reactors.

The significant event reports and the periodic assessments submitted by the licensees form the basis of the experience feedback organisation. ASN asks the reactor licensees to turn the experience feedback from significant events and reactor operation to good account. They must also draw the lessons from significant events that occur abroad, particularly from the reports in the IRS database of the IAEA and the NEA.

### 19.7.2 Measures taken for nuclear power reactors

The continuous improvement in performance in the areas of safety, security, radiation protection, environmental protection and production is based on a systematic process of turning acquired experience to good account. The use of OEF consists in drawing the lessons from the past to improve the future. EDF's operating experience today represents 1,900 reactor-years.

The EDF events-related OEF process is organised around the following phases:

- the events collection, selection, weighing-up and codification phase,
- the analysis phase, including the defining of corrective, preventive and conservative actions when necessary (for the most significant events, EDF uses the in-depth events analysis method based on international standards),
- the phase of implementation of the defined corrective or preventive actions, integrating the oversight of implementation and verification of their effectiveness,
- the phase of sharing experience feedback with the work teams.

This system is implemented in all the EDF nuclear power plants and at national level, with greater managerial involvement compared with the preceding systems. This system is subject to annual efficiency assessment reviews.

The perimeter of the EDF OEF loop includes, in addition to the events resulting from the operation of its own reactors, the analysis of events recorded in the IAEA and WANO databases, a selection of the events having occurred on reactors of foreign licensees with which EDF has cooperation agreements (EPRI, ESKOM, CGNPC, EDF Energy in particular) and an annual review of the events occurring in other industries (ARIA database of the Ministry of Ecological and Solidarity-based Transition). This system for handling events-based OEF is moreover supplemented by a process for dealing with deviations in the sense of the regulations.

Lastly, through its participation in various committees and international organisations, EDF shares OEF on good practices and the internationals standards, and in the area of nuclear R&D. These aspects are detailed in chapter 20.

### 19.7.3 Measures taken for research reactors

At the CEA, deviations and their processing are recorded in sheets for each facility. The support services can also open deviation sheets.

A CEA circular specifies that the duties of the head of a facility include analysing the anomalies and events affecting their facility.

Taking OEF into account in the centres consists notably in organising and promoting exchanges between the facilities and the centres. On this account an experience feedback leader is designated in the unit that performs the checks on behalf of the director of each centre.

At the CEA's general management level, it is the role of the DSSN to make sure that the various units consult one another, and to ensure the integration of experience feedback and the exchange of best practices. The DSSN also draws up an assessment of the significant events and defines the lines of progress. This role also leads it to identify situations that require the expertise of the competence centres.

Experience feedback is also integrated in the documents (circulars and recommendations, directives, technical data sheets) that the DSSN is responsible for producing.

The aids used are:

- the OEF sheets initiated by DSSN;
- the Central Experience File (FCE) which contains all the notified events that have occurred since 1990;
- the significant event analysis and processing guide;
- the significant events situation assessment, established from the significant event reports (CRES);
- the IAEA international database.

### 19.7.4 ASN analysis and oversight

The significant events notified to ASN are systematically assessed with the aim of deciding, among other things, on the appropriateness of the corrective and preventive actions implemented by EDF. The events that have the greatest implications for safety are analysed in depth and if necessary lead to requests for additional measures. With regard to events occurring on installations in other countries, whether similar to the French nuclear power reactors or not, ASN has asked EDF to systematically analyse their causes and examine any weaknesses in its installations in the light of this analysis.

The statistical examination of the events significant for safety (ESS) reported by EDF during the last 3 years reveals the following trends:

- a large proportion of events relating to the compliance of the installations call into question the ability of the items important to protection (EIP) to fulfil their function(s) in all the situations in which they are required to function. The majority of these events result from insufficient command of the qualification and maintenance requirements;
- an increase in the installation monitoring faults; these faults mainly concern the EIPs necessary for the cooling function and the electrical power sources;
- the level of deficiencies in the command of maintenance activities remains high, particularly as concerns equipment requalification, revealing a lack of effectiveness of the action plans implemented by EDF;
- relative stability in the number of "precursory" events. Nevertheless, EDF's assessment of the excess risk of core melt does not take into account all the conformity deviations that affect the reactor concerned by each precursory event;
- difficulties in disseminating and sharing information with the aim of learning lessons from experience feedback.

As a general rule, the trends described above highlight the fact that the actions to improve the process for gathering and utilising EDF's operating experience feedback, which stem from the periodic review of the integrated management system, are not yet contributing sufficiently to the control of conformity of the facilities and their operating documentation with their requirements.

ASN periodically calls on the GPR with regard to the OEF from the reactors and the OEF concerning behaviour of fuel.

The periodic safety reviews aim to improve the safety of the nuclear installations, particularly in the light of the OEF from operation of the facility or from other nuclear facilities in France and abroad, and the lessons learned from other facilities or items of equipment at risk. Integration of the licensee's experience feedback can result in modifications to equipment (and the management procedures) which are subject to review by ASN.

During inspections in the nuclear reactors and the EDF head office departments, ASN checks the licensee’s organisation and the steps taken to learn the technical and organisational lessons from operating experience feedback.

For the research reactors, as a complement to the inspections ASN examines, on the scale of the installations, the organisation and the actions taken to integrate experience feedback and the analysis of the main events in the context of the periodic safety reviews. For the CEA research reactors, ASN considers that measures should be taken to better learn the lessons from experience feedback from other research reactors.

## *19.8 Management of radioactive waste and spent fuel*

### 19.8.1 ASN requests

Directive 2011/70/Euratom of 19th July 2011 establishes a European framework for the safe and responsible management of spent fuel and radioactive waste. It applies to the management of spent fuel and the management of radioactive waste, from production to disposal. Like the directive of 25th June 2009, it calls for each Member State to set up a coherent and appropriate national framework and sets various requirements for the States, the safety regulators and the licensees. The content of this directive has been transposed in France, more specifically through the Environment Code and its provisions relative to waste and the waste act.

**National radioactive materials and waste management plan (PNGMDR)**

A National Radioactive Materials and Waste Management Plan (PNGMDR) is established every three years and sets a programme of research and work concerning radioactive waste for which there is no definitive means of management, along with a schedule for implementing it.

**Radioactive waste management**

The treatment of the waste is checked on a case-by-case basis when the activities producing the waste are subject to a licensing system (as is the case with the BNIs). In addition to what is written in § 15.1.2.2.4, the management of radioactive waste coming from BNIs is based on a regulatory framework, notably the BNI order of 7th February 2012 and ASN resolution 2015-DC-0508 of 21st April 2015 relative to the study of the management of waste and the assessment of the waste produced in the BNIs and ASN resolution 2017-DC-0587 of 23rd March 2017 relative to the conditioning of radioactive waste and the conditions of acceptance of radioactive waste packages in the disposal BNIs. Furthermore, ASN Guide No. 23 details some of the conditions of application of resolution 2015-DC-0508.

The regulations provide for:

- a waste management study: it presents a description of the operations behind the production of waste, the characteristics of the waste produced or to be produced and an estimation of the waste production streams. It thus establishes an assessment of the waste management situation on each site;
- a waste zoning plan: integrated in the waste management study, it presents and substantiates the methodological principles relative to:
    - the delimiting of potential nuclear waste production zones and conventional waste zones, enabling a reference waste zoning map to be drawn up,
    - the procedures implemented for temporary or definitive waste zoning delicensing or reclassification measures;
    - the traceability and conservation of the historical record of the zones in which the structures and soils could have been contaminated or activated.
- an annual quantitative and qualitative waste management assessment.

The waste studies system should help improve the overall management of waste, particularly in terms of transparency, and help develop optimised management routes.

**Spent fuel management**

France has opted for a strategy of reprocessing the spent fuel resulting from the nuclear power process, a choice that is confirmed by the Act of 28th June 2006. The licensee is responsible for the processing and what becomes of the spent fuel and associated waste it produces.

The waste produced on the nuclear power plant site is operational waste which includes activated waste. To this can be added the legacy waste and waste resulting from ongoing decommissioning operations. Licensees are the owners of high-level and intermediate-level long-lived waste resulting from its spent fuel reprocessing in the Orano Cycle La Hague plant.

The management strategy for the spent fuel produced in research reactors is developed according to the characteristics of the fuel and depending on the case may involve reprocessing or direct disposal. The quantities of spent fuel planned for direct disposal are nevertheless very much smaller than the quantities of reprocessed fuel.

### 19.8.2 Measures taken for nuclear power reactors

**Spent fuel management**

EDF uses two types of nuclear fuel in the pressurised water reactors;

- uranium oxide (UO2) based fuels enriched with uranium-235 to a maximum of 4.5%;
- fuels consisting of a mixture of depleted uranium oxide and plutonium oxide (MOX).

Fuel management is specific to each reactor series.

After a period of about three to five years, the spent fuel is removed from the reactor to cool down in a spent fuel storage pool, first on the NPP site, then in the Orano reprocessing plant at La Hague. The spent fuel assemblies follow a reprocessing-recycling process, with reprocessing at the Orano La Hague plant.

EDF, in collaboration with its French industrial partners Orano and Andra, keeps up to date a file on the coherence of the fuel cycle in France in the medium term. The compatibility between the developments in fresh or spent fuels (design, characteristics, management) of the nuclear fleet and the fuel cycle facilities (front-end and back-end plants, storage facilities, logistics) is analysed. ASN completed its review of the most recent version of this file in 2018 (see 19.8.4.2).

Lastly, the design and the resistance of the spent fuel pools situated in the NPPs and the fuel cycle facilities were examined in the framework of the stress tests performed further to the Fukushima Daiichi NPP accident.

**Radioactive waste management**

As for the waste resulting directly from operation of the reactors, its modes of management comprise the following main phases: "waste zoning", collection, sorting, characterisation, reprocessing/conditioning, storage and shipment.

Collection is a sensitive waste management phase in the nuclear facilities. The waste is collected selectively, either directly by the process or by personnel on the sites (sorting at source). Right from the collection phase, the physical management of radioactive waste must at all levels be separate from that of conventional waste and prevent any mixing of incompatible materials.

The radioactive waste resulting from the operation of PWRs is essentially very low, low or intermediate level short-lived waste It can be classified in two categories:

- the process waste that comes from the purification and treatment of the liquid or gaseous effluents to reduce their activity before being discharged;
- the technological waste that comes from maintenance operations. This waste can be solid or liquid.

The intermediate level waste is conditioned in concrete containers. A portion of the process waste and the technological waste is coated or immobilised in a hydraulic binder on fixed facilities: NPP nuclear auxiliaries building or effluent treatment building. For the final conditioning of the ion exchange resins, EDF uses the MERCURE process (coating in an epoxide matrix), implemented using two identical mobile machines. This waste is sent to the Aube repository for disposal.

For the treatment of sludge, EDF uses fixed conditioning facilities on the 900 MWe series (apart from Fessenheim) and is developing a mobile facility (for the other plant series and Fessenheim) which is planned to enter service late 2019 at the earliest for conditioning them in concrete packages. Pending availability of the mobile treatment machine, the sludge produced is stored on the sites.

For the borated concentrates, EDF has several treatment possibilities: encapsulation in concrete shell on the fixed facilities of the 900 MWe plant series (apart from Fessenheim), incineration on CENTRACO and a mobile machine for producing concrete shells.

The solid low-level waste is:

- either compacted on site in 200-litre metal drums and sent directly to ANDRA's CSA repository to be further compacted and disposed of definitively after concreting in 450-litre drums;
- or compacted in 200-litre plastic drums and sent to the CENTRACO plant of SOCODEI for incineration. The residual ash and clinkers from incineration are conditioned in 400-litre thick metal drums and definitively disposed of at the CSA repository;

The very low level waste, which essentially comprises metal waste and rubble, is shipped to CIRES (Industrial centre for grouping, storage and disposal), a dedicated repository situated in Morvilliers, also managed by ANDRA and which entered service in 2003.

### 19.8.3 Measures taken for research reactors

#### 19.8.3.1 CEA reactors

**Waste management**

The majority of the waste produced by the operation of CEA's experimental reactors is routed to the disposal facilities managed by ANDRA.

**Spent fuel management**

All the spent fuel from the CEA experimental reactors undergoes or will undergo reprocessing. On this account the spent fuel from the Osiris and Orphée reactors is regularly transferred to the Orano Cycle La Hague plant.

#### 19.8.3.2 The ILL high-flux reactor (HFR)

The majority of the waste produced by the operation of the experimental reactor at the Laue Langevin Institute (ILL) is routed to the disposal facilities managed by ANDRA. The spent fuel is transferred to the Orano Cycle La Hague plant.

### 19.8.4 ASN analysis and oversight

#### 19.8.4.1 Radioactive waste management

For all radioactive waste, ASN examines the baseline requirements of the licensee's waste study, in accordance with the regulations.

This baseline requirement comprises the following themes:

- an assessment of the existing situation, summarising the different wastes produced and their quantities;
- the waste management procedures and the organisation of waste transport;
- the "waste zoning";
- the state of the existing disposal solutions.

Each site sends ASN annually a detailed report of its waste production with the chosen disposal routes, an analysis of the trends compared with previous years, an assessment focusing on the observed deviations and the functioning of the site's waste management organisation and the notable events that have occurred. The future prospects are also considered.

During its NPP inspections, ASN examines the organisation and measures taken by the sites in terms of waste management, from sorting through to conditioning, and spent fuel management. The inspectors review various points, such as the processing of deviations. They also check the operation of the waste storage and treatment areas.

EDF has developed and implemented standard baseline operating requirements for the buildings in which radioactive waste is managed. It enables the management rules to be specified for each phase of the nuclear waste management process. These baseline requirements are then adapted by each NPP.

As part of the periodic safety review of the reactors, ASN asks EDF to update the safety report for the NPPs concerned so that it contains the safety analysis approach adopted for the buildings concerned, along with the main elements of the safety case. Alongside this, ASN has asked EDF to integrate in the general operating rules (RGE), the provisions for guaranteeing compliance during normal operation with the hypotheses considered in the safety case.

EDF's intention to extend the operating life time of the nuclear power reactors will lead to an increase in maintenance work. ASN considers that these maintenance operations must be sufficiently anticipated in order to take into account the volumes of waste produced and the available treatment routes.

ASN has asked EDF to present its strategy for the next ten years for the management of radioactive waste resulting from the operation of its nuclear power reactors (from operation to dismantling).

Furthermore, the management strategy for the radioactive waste resulting from the operation and decommissioning of the nuclear power plants underwent an examination which was presented to the GPD and GPU Advisory Committees on 1st July 2015. The Advisory Committees were particularly attentive to the soundness in terms of safety of EDF's organisation for waste management, from production through to disposal or storage, and the optimisation of the management routes associated with the control of the radiological characterisation of the waste.

To conclude, ASN considers that EDF has made significant progress in its waste management strategy. Improvements are nevertheless still required, particularly with regard to the characterisation of certain long-lived radionuclides present in the waste, the setting up of appropriate waste management means, and the optimisation of these means in order to cope with the availability problems of certain outlets.

Since the end of 2015, the CEA has undertaken substantial work to prioritise all its decommissioning operations. The prioritisation is based on criteria of safety and removal of the radioactive materials present in the facilities and which could potentially be released in the event of an accident. Other safety-related criteria supplement this step, namely economic (distribution of the annual funds allocated to decommissioning,), symbolic (delicensing of certain centres: Grenoble and Fontenay-aux-Roses), human (maintaining skills and knowledge) and regulatory (operations regulated by decree).

In 2019, ASN confirmed to the CEA the overall appropriateness of its prioritisation process, with the existing means, subject to compliance with its commitments and integration of the ASN requests.

The priority in the decommissioning or preparation for decommissioning of the research reactors is to rapidly remove the potential source term in order to reduce the nuclear risk that the facility presents. ASN is attentive to the prioritisation of the CEA's decommissioning objectives and their compatibility with protection of the public, the workers and the environment.

#### 19.8.4.2 Spent fuel management

The safety of fuel storage in the nuclear power reactor spent fuel pools has been the subject of in-depth examinations during past or ongoing periodic safety reviews, as well as during the stress tests.

These successive examinations have led to the defining and implementation of modifications to prevent the risk of emptying of the spent fuel pool, to improve the robustness of the water make-up means and to improve the management of accident situations (see § 19.4.2).

Moreover, the stress tests included an in-depth examination of the consequences of a major natural hazard on the systems that can evacuate the residual heat from the fuel stored in pools, on the integrity of the pools in the fuel building or the reactor building and the systems connected to them, and the risks of storage rack deformation and falling loads. The conclusions of the analyses have led ASN to issue requirements, in particular to reinforce the electrical power resources, the water supply resources, the instrumentation and the measures to prevent accidental emptying of the pools.

The management of spent fuels from the research reactors (which also undergo reprocessing on the Orano La Hague site) was also studied during the stress tests, particularly with regard to the risk of fuel uncovering in the transfer canals or the research reactor pools.

**Impact of energy policy decisions on the nuclear fuel cycle**

In June 2016, at the request of ASN, EDF submitted the "2016 Cycle Impact" file for the 2016-2030 period. Drawn up in collaboration with Framatome, Orano Cycle and Andra, this file notably identifies the predictable breakdown thresholds (capacity saturation, reaching the fuel isotopic content limit, etc.) until

2040, considering several scenarios for the development of the energy mix. On 18 October 2018, ASN delivered its opinion after completing its review of this file.

ASN considers that the "2016 Cycle Impact" file provides a satisfactory overview of the consequences of the various nuclear fuel cycle development scenarios on the nuclear facilities, transport operations and waste. However, the consequences of the unforeseen events which could affect the operation of the cycle need to be studied in greater depth.

ASN underlines the need to anticipate any strategic change in the functioning of the fuel cycle by at least ten years so that it can be designed and carried out under controlled conditions of safety and radiation protection. It is a question, for example, of ensuring that - given the incompressible development times for industrial projects - the needs for new spent fuel storage facilities or for new transport packaging designs are addressed sufficiently early.

It emerges in particular that to avoid reaching the capacity limit of existing storage facilities too quickly (spent fuel pools of nuclear reactors and at La Hague facilities), the proportion of electricity produced from reactors using MOX fuel and that produced from reactors using enriched natural uranium (ENU) must be maintained at or above the current levels for the next decade to ensure that all the spent ENU fuel is reprocessed and that the resulting plutonium is consumed.

In the longer term, it will be necessary either to have new storage capacities that are significantly greater than the current and projected capacities, or to be able to use MOX fuel in reactors other than the 900 MWe reactors, which are the oldest. The time-frame required for the design and production of these options is about ten years. ASN therefore asks the industrial players to start examining these two options without delay.

**Centralised storage pool project**

In response to ASN's request to increase the storage capacities in anticipation of the existing storage capacities reaching saturation by 2030 (La Hague plant pools and the NPP pools), EDF submitted the safety options dossier (DOS) for a new centralised spent fuel storage pool in 2017.

The DOS adopts in particular the objective of not implementing population protection measures (no sheltering, no taking of stable iodine tablets, no evacuation), in the same way as the general objectives set for the generation-III reactors.

The dossier has been examined by ASN, which considers that the safety options adopted by EDF for its project are satisfactory, provided that EDF:

- justifies the chosen design solution for the basins (reinforced concrete with a waterproof metal liner), notably in terms of validation of the dimensioning, of the ability to produce it, the management of ageing and the monitoring and leak detection possibilities;
- adopts a storage building design that provides for ultimate retention in the event of leakage of water from a storage basin or transfer canal, which keeps the fuel assemblies covered with water and facilitates return of the installation to a safe state.

EDF plans to submit the creation authorisation application file in 2020.

# G – International cooperation

## 20. International cooperation measures

### *20.1 ASN's international activities*

The nuclear installations regulated by ASN represent one of the largest and most diverse fleets in the world. ASN therefore aims to ensure that its nuclear regulation and radiation protection activities constitute an international reference.

ASN's international action aims to "promote the French and European approach with regard to nuclear safety and radiation protection". This action must foster the development of a culture of continuous safety improvement and result in top-down international harmonisation of nuclear safety and radiation protection requirements.

ASN's international action also brings external enlightenment to the issues of policy, technical questions or societal acceptability, thereby enriching the national debates and consolidating ASN decisions.

In the context of its international action, ASN endeavours in particular:

- to develop exchanges of information with its foreign counterparts on regulatory systems and practices, communicate and explain the French approach and practices and provide information on the steps taken to solve the problems encountered;
- to inform our foreign counterparts of events that have occurred in France and provide the countries concerned with all necessary information about the French nuclear facilities located close to their borders;
- to actively participate in the work to harmonise nuclear safety and radiation protection principles and standards and the work for the development, transposition and implementation of European Community law;
- to implement the undertakings of the French State concerning nuclear safety and radiation protection, in particular within the framework of international conventions to which IAEA is warden;
- to participate in the international committees that produce the scientific syntheses and the recommendations stemming from them.

On the whole ASN bases its international action on the provisions of Article L. 592-28 of the Environment Code which now formalises ASN's participation in representing France in the bodies of the competent international and European Community organisations in its areas of competence, with the exception of purely associative frameworks between nuclear regulators (WENRA, HERCA, INRA, NSSG).

Moreover, Article L. 592-28-1 stipulates that: "ASN cooperates with the competent authorities of the other countries in its areas of competence. At the request of these countries, it can provide consultancy services and carry out technical support missions under agreements which can provide for the reimbursement of expenses incurred. »

ASN can examine the conformity of the safety options of nuclear installation models intended for export with the requirements applicable to the same type of installation in France. Such cases are referred to

ASN under the conditions stipulated in the first paragraph of Article L. 592-29 and it renders public the conclusions of the examination."

## *20.2 IRSN's international activities concerning nuclear safety and radiation protection*

Within the scope of the duties assigned to it by the public authorities, IRSN (Institute for Radiation Protection and Nuclear Safety) develops international relations with regard to research and expertise in the safety of nuclear reactors and fuel cycle facilities, the safety of transport of nuclear and radioactive materials, human and environmental protection, security and regulation of sensitive nuclear materials and the organisation and preparation for the management of radiological emergency situations.

The international action of IRSN is driven by the need to guarantee a high level of nuclear safety and radiation protection across the world. It is built to underpin the credibility of the expertise and to develop research, scientific excellence and knowledge management.

The international activities of IRSN are developed along three lines:

- enhance scientific and technical knowledge;
- contribute to the establishing of international consensus both on technical questions and on the production of guides, recommendations and standards;
- take part in the implementation of projects intended to reinforce radiation protection, nuclear safety and security abroad.

The activities aim to:

- share and enrich expert assessment methods and practices and scientific and technical knowledge to respond to the nuclear safety and radiation protection challenges;
- jointly construct a common forum for the Technical and Scientific Support Organizations (TSOs) that enables them to mutually coordinate and harmonise their activities and exercise fully and collectively their responsibilities with respect to the nuclear regulators;
- mutualise and optimise the resources and research work in nuclear safety and radiation protection.

IRSN's international action is carried out and applied in the area of multilateral cooperation, as in the European and international organisations, and in the framework of bilateral partnerships.

In Europe, IRSN is very active within the ETSON (European Technical Safety Organisations Network), of European associations (SNETP, MELODI, ALLIANCE, EURADOS, NERIS, SITEX, NUGENIA) of the ENEN (European Nuclear Education Network). The various actions are based on European programmes (EURATOM, ICSN/EINS, Health, Safety), the European Commission, the Common Research Centre (CCR) as well as ENSREG/WENRA. Outside Europe, IRSN participates in the work carried out under the auspices of international organisations such as the IAEA, the OECD/NEA, the WHO, UNSCEAR, and the ICRP. IRSN is particularly attentive to the training of the TSOs of new entrants and less advanced countries. Lastly, bilateral partnerships are established to develop joint actions that will continue over the long term.

## *20.3 The international peer reviews*

**Topical peer review (TPR)**

Council Directive 2014/87/EURATOM of 8th July 2014 amending Directive 2009/71/Euratom establishing a Community framework for the nuclear safety of nuclear installations, institutes a six-yearly peer review of a technical aspect relating to the safety of nuclear facilities. The first review focused on the management of ageing. This subject is addressed in § 14.2.1.4.

**Reviews coordinated by the IAEA**

IRRS: ASN has always supported the development of the peer review missions, either by participating in IRRS (Integrated Regulatory Review Service) missions in foreign countries or by hosting them in France (see § 10.4.1).

Thus, after an initial plenary mission and a follow-up mission which took place in 2006 and 2009 respectively, ASN hosted another "full scope" IRRS mission in 2014, further to which the auditors issued 46 recommendations and suggestions.

ASN developed an action plan to take appropriate measures in response to these recommendations and suggestions. The follow-up mission was held from 1st to 9th October 2017. The auditors concluded that France has significantly strengthened the framework of its oversight of nuclear safety and radiation protection, but also indicated the need for ASN to remain vigilant with regard to the question of human resources in view of the safety issues at the French nuclear facilities. A total of 40 recommendations were closed or are considered to be closed "subject to implementation of the ongoing measures". The concluding report of this mission - like the previous reports - was put on line on the ASN website in March 2017.

OSART: For many years now, France has also asked the IAEA to conduct OSART (Operational Safety Review Team) missions to assess operating safety. On average, one OSART mission is organised in France each year. In 2016, all French NPPs underwent at least one OSART mission.

Half a dozen missions are planned over the 2019-2021 period, including two follow-up (FU) missions and one mission on the EPR in 2019.

**WANO review**

The safety performance of the NPPs in the French fleet is assessed by the World Association of Nuclear Operators (WANO) by means of peer reviews. Since 2013, each unit undergoes a review every four years, in conjunction with an EDF nuclear inspectorate audit.

## *20.4 EDF's international activities concerning reactor safety*

EDF's international activities are developed along three main lines:

- Experience sharing between licensees:
    - ➢ bilateral exchanges of experience, mainly via twinning agreements; the development of nuclear projects internationally enables EDF to turn increased mutual experience feedback to good account and to develop synergies within the Group, particularly with regard to safety;

- The international institutions (WANO, FROG, PWROG, EPROOG, EPRI, WNA, ENISS, IAEA, etc.) promote dialogue and exchanges between nuclear licensees. EDF makes extensive use of these institutions with the aim of improving the safety and operating reliability of nuclear power plants on a global scale;
- Consultancy and service activities in the form of contracts.

- International safety standards:
  - In the field of safety, whether considering the regulatory aspects (international agreements, European directives), normative aspects (IAEA, ISO, IEC, CEN standards) or for establishing recommendations (WENRA Safety Reference Levels), EDF participates in the standardisation organisations and is involved in the discussions with the text issuing bodies, particularly via ENISS, in consultation with the other European licensees;
  - The preparation of the reactors of the future and technological watch. EDF's activity is exercised essentially through its participation in the European Utility Requirements (EUR) organisation, the Cooperation on Reactor Design Evaluation and Licensing (CORDEL) group and the World Nuclear Association (WNA), the latter including, among other things, a task-force on Small Modular Reactors (SMRs).
- In the area of nuclear R&D:
  - EDF contributes to the sharing of information and experience and the promotion of international cooperation for research programmes at R&D installations in various organisations such as the OECD (NEA/CSNI), EPRI, NUGENIA and in cooperative actions co-funded by the European Commission.
  - Bilateral programmes with foreign partners governed by MoU (Memorandum Of Understanding) and/or collaboration contracts, depending on the subjects, provide for collaborative or partner-funded activities on the topics of safety (severe accidents, earthquake, and probabilistic safety studies).
  - Several R&D centres situated notably in China, the United Kingdom and the United States, enable EDF to step up its R&D cooperation with its industrial or academic nuclear partners.

## *20.5 CEA's international activities concerning reactor safety*

The CEA participates in international collaborations in the nuclear sector, particularly the area concerning the safety of nuclear power reactors.

Research into safety focuses chiefly on the following main objectives:

- organisational and human factors in operation (see § 12.3.1);
- the use of passive systems for returning to a safe state from an accident situation;
- reducing the probability of core melt;
- mitigation of the off-site consequences of a severe accident situation, notably by reinforcing containment.

The CEA contributes to the IAEA's work on research reactors and has established regular exchanges with foreign counterparts, based on operational experience and lessons learned from incidents. In the area of fast-neutron reactors, it maintains close contact with Japan, Russia and, to a lesser extent, India and China.

With regard to the 4th generation reactors, within the collaborative framework of the GIF Forum, the CEA contributes to the work conducted on the concepts with which France has clearly adopted a favourable position (sodium-cooled fast-neutron reactors first and foremost). The CEA is moreover involved in some of the studies on the fuel and the safety of the experimental gas-cooled fast-neutron reactor carried out within the VG4 consortium (ALLEGRO project).

With regard to radiation protection, the CEA participates in various research activities as well as the activities of UNSCEAR.

## 20.6 French participation in the Nuclear Safety and Security Group (NSSG) of the G7

ASN provides its technical support to the French authorities within the Nuclear Safety and Security Group of the G7 countries (G7/NSSG). Since the accident at the Fukushima Daiichi NPP, this group has essentially worked on coordinating the actions of the seven member States and of the European Commission to support the preparation then implementation of the IAEA's Action Plan on Nuclear Safety, and in the work on improving the international safety framework (increasing the effective application of the relevant international conventions). France is chairing this group in 2019 and has promoted the addressing of several subjects related to safety, notably those relative to ageing management, the use of the technical expert assessment, the instruments for supporting new entrants to nuclear power, and the independence of the regulators. This group highlights the work undertaken in these various areas of cooperation, supporting the more conventional frameworks between regulators.

# APPENDIX 1 – List and location of nuclear reactors in France

## *1.1. Location of the nuclear reactors*

The nuclear power reactors and research reactors in operation as at 15-08-2019 are distributed over French territory as shown in the following map. A nuclear power reactor (*1) and two research reactors (*2) are also under construction.

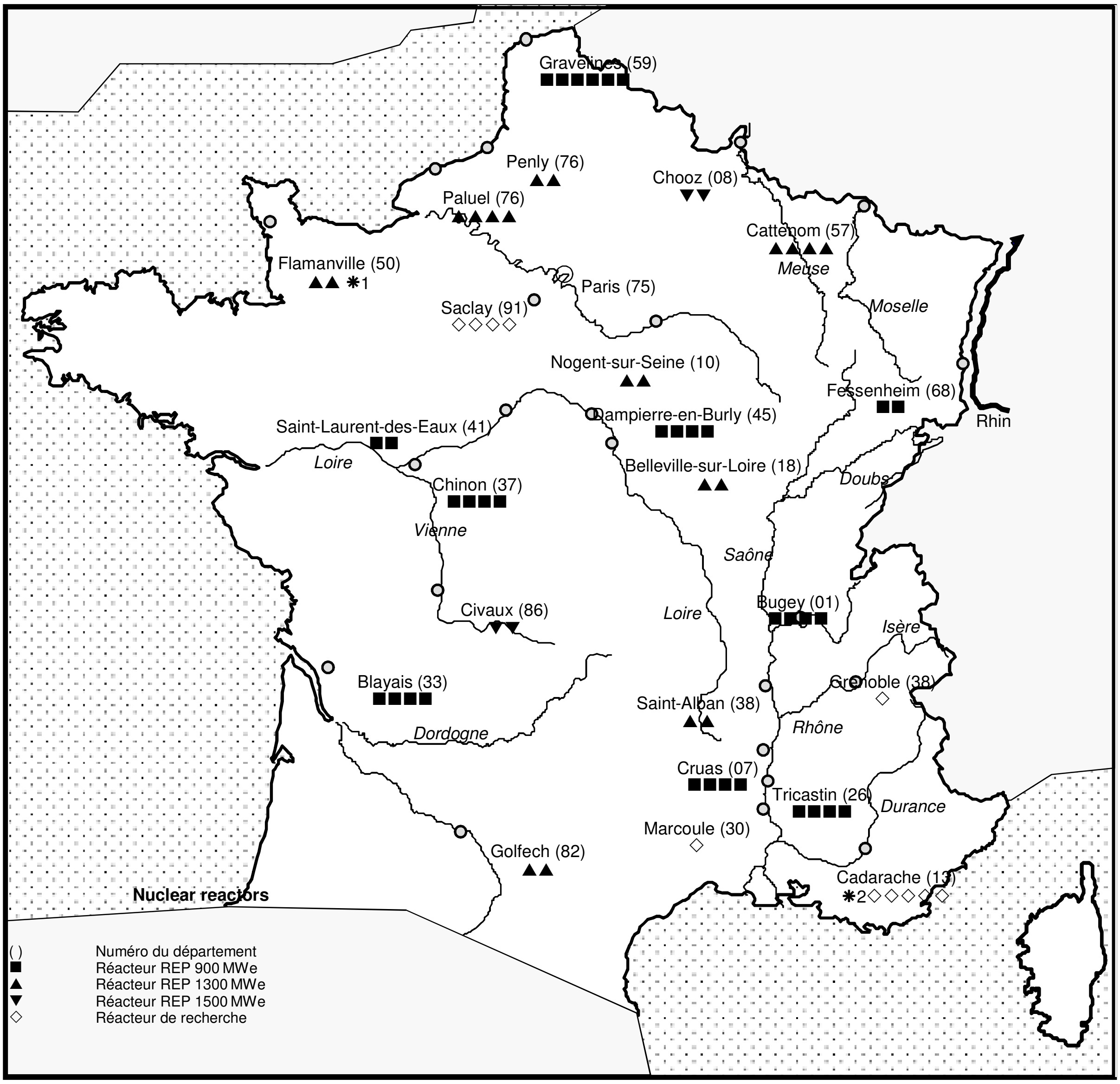


Figure 9: Map of France showing the nuclear reactors in operation and under construction

## *1.2. List of nuclear power reactors*

Table 10: Nuclear power reactors in operation and under construction

| BNI N° | NAME AND LOCATION OF THE FACILITY | Licensee | Type of facility | Authorised on: | OBSERVATIONS |
|---|---|---|---|---|---|
| 75 | FESSENHEIM NPP<br>(reactors 1 and 2)<br>68740 Fessenheim | EDF | 2 PWR reactors<br>CP0<br>900 MWe | 03.02.72 (JO of 10.02.72) | Modification of perimeter:<br>Decree of 10.12.85<br>J.O. of 18.12.85 |
| 78 | BUGEY NPP<br>(reactors 2 and 3)<br>01980 Loyettes | EDF | 2 PWR reactors<br>CP0<br>900 MWe | 20.11.72 (JO of 26.11.72) | Modification of perimeter:<br>Decree of 10.12.85<br>J.O. of 18.12.85 |
| 84 | DAMPIERRE-EN-BURLY NPP<br>(reactors 1 and 2)<br>45570 Ouzouer-sur-Loire | EDF | 2 PWR reactors<br>CP1<br>900 MWe | 14.06.76 (JO of 19.06.76) | |
| 85 | DAMPIERRE-EN-BURLY NPP<br>(reactors 3 and 4)<br>45570 Ouzouer-sur-Loire | EDF | 2 PWR reactors<br>CP1<br>900 MWe | 14.06.76 (JO of 19.06.76) | |
| 86 | LE BLAYAIS NPP (reactors 1 and 2)<br>33820 Saint-Ciers-sur-Gironde | EDF | 2 PWR reactors<br>CP1<br>900 MWe | 14.06.76 (JO of 19.06.76) | Modification of perimeter:<br>Decree of 10.02.14 (JO of 12.02.14) |
| 87 | TRICASTIN NPP (reactors 1 and 2)<br>26130 Saint-Paul-Trois-Châteaux | EDF | 2 PWR reactors<br>CP1<br>900 MWe | 02.07.76 (JO of 04.07.76) | Modification of perimeter:<br>Decree of 10.12.85<br>(JO of 18.12.85); Decree of 15.12.15 (JO of 17.12.15) |
| 88 | TRICASTIN NPP (reactors 3 and 4)<br>26130 Saint-Paul-Trois-Châteaux | EDF | 2 PWR reactors<br>CP1<br>900 MWe | 02.07.76 (JO of 04.07.76) | Modification of perimeter:<br>Decree of 10.12.85<br>(JO of 18.12.85); Decree of 29.11.04<br>(JO of 02.12.04); Decree of 15.12.15 (JO of 17.12.15) |
| 89 | LE BUGEY NPP (reactors 4 and 5)<br>01980 Loyettes | EDF | 2 PWR reactors<br>CP1<br>900 MWe | 27.07.76 (JO of 17.08.76) | Modification of perimeter:<br>Decree of 10.12.85<br>(JO of 18.12.85) |
| 96 | GRAVELINES NPP (reactors 1 and 2)<br>59820 Gravelines | EDF | 2 PWR reactors<br>CP1<br>900 MWe | 24.10.77 (JO of 26.10.77) | Modification of perimeter:<br>Decree of 29.11.04<br>(JO of 02.12.04); Decree of 20.11.15 (JO of 22.11.15) |
| 97 | GRAVELINES NPP (reactors 3 and 4)<br>59820 Gravelines | EDF | 2 PWR reactors<br>CP1<br>900 MWe | 24.10.77 (JO of 26.10.77) | Modification of perimeter:<br>Decree of 29.11.04<br>(JO du 02.12.04);<br>Decree of 20.11.15 (JO of 22.11.15) |
| 100 | ST-LAURENT-DES-EAUX NPP<br>(reactors B1 and B2)<br>41220 La Ferté-St-Cyr | EDF | 2 PWR reactors<br>CP2<br>900 MWe | 08.03.78 (JO of 21.03.78) | |
| 103 | PALUEL NPP (reactor 1)<br>76450 Cany-Barville | EDF | 1 PWR reactor<br>P4<br>1300 MWe | 10.11.78 (JO of 14.11.78) | |
| 104 | PALUEL NPP (reactor 2)<br>76450 Cany-Barville | EDF | 1 PWR reactor<br>P4<br>1300 MWe | 10.11.78 (JO of 14.11.78) | |

| BNI N° | NAME AND LOCATION OF THE FACILITY | Licensee | Type of facility | Authorised on: | OBSERVATIONS |
|---|---|---|---|---|---|
| 107 | CHINON NPP (reactors B1 and B2)<br>37420 Avoine | EDF | 2 PWR reactors<br>CP2<br>900 MWe | 04.12.79 (JO of 08.12079) | Modification: Decree of 21.07.98<br>(JO du 26.07.98);<br>Modification of perimeter: Decree of 05.01.15 (JO of 07.01.15) |
| 108 | FLAMANVILLE NPP (reactor 1)<br>50830 Flamanville | EDF | 1 PWR reactor<br>P4<br>1300 MWe | 21.12.79 (JO of 26.12.79) | |
| 109 | FLAMANVILLE NPP (reactor 2)<br>50830 Flamanville | EDF | 1 PWR reactor<br>P4<br>1300 MWe | 21.12.79 (JO of 26.12.79) | |
| 110 | LE BLAYAIS NPP (reactors 3 and 4)<br>33820 Saint-Ciers-sur-Gironde | EDF | 2 PWR reactors<br>CP1<br>900 MWe | 05.02.80 (JO of 14.02.80) | Modification: Decree 2013-440 of 28.05.13<br>(JO of 31.05.13) |
| 111 | CRUAS NPP (reactors 1 and 2)<br>07350 Cruas | EDF | 2 PWR reactors<br>CP2<br>900 MWe | 08.12.80 (JO of 31.12.80) | Modification of perimeter: Decree of 10.12.85<br>(JO of 18.12.85) and Decree of 29.11.04<br>(JO of 02.12.04) |
| 112 | CRUAS NPP (reactors 3 and 4)<br>07350 Cruas | EDF | 2 PWR reactors<br>CP2<br>900 MWe | 08.12.80 (JO of 31.12.80) | Modification of perimeter: Decree of 29.11.04<br>(JO of 02.12.04) |
| 114 | PALUEL NPP (reactor 3)<br>76450 Cany - Barville | EDF | 1 PWR reactor<br>P4<br>1300 MWe | 03.04.81 (JO of 05.04.81) | |
| 115 | PALUEL NPP (reactor 4)<br>76450 Cany - Barville | EDF | 1 PWR reactor<br>P4<br>1300 MWe | 03.04.81 (JO of 05.04.81) | |
| 119 | SAINT-ALBAN NPP (reactor 1)<br>38550 Le Péage-de-Roussillon | EDF | 1 PWR reactor<br>P4<br>1300 MWe | 12.11.81 (JO of 15.11.81) | |
| 120 | SAINT-ALBAN NPP (reactor 2)<br>38550 Le Péage-de-Roussillon | EDF | 1 PWR reactor<br>P4<br>1300 MWe | 12.11.81 (JO of 15.11.81) | |
| 122 | GRAVELINES NPP (reactors 5 and 6)<br>59820 Gravelines | EDF | 2 PWR reactors<br>CP1<br>900 MWe | 18.12.81 (JO of 20.12.81) | Modification of perimeter: Decree of 10.12.85<br>(JO of 18.12.85);<br>Modification of Decree of 02.11.07 (JO of 03.11.07) |
| 124 | CATTENOM NPP (reactor 1)<br>57570 Cattenom | EDF | 1 PWR reactor<br>P'4<br>1300 MWe | 24.06.82 (JO of 26.06.82) | |
| 125 | CATTENOM NPP (reactor 2)<br>57570 Cattenom | EDF | 1 PWR reactor<br>P'4<br>1300 MWe | 24.06.82 (JO of 26.06.82) | |
| 126 | CATTENOM NPP (reactor 3)<br>57570 Cattenom | EDF | 1 PWR reactor<br>P'4<br>1300 MWe | 24.06.82 (JO of 26.06.82) | |
| 127 | BELLEVILLE-SUR-LOIRE NPP (reactor 1)<br>18240 Léré | EDF | 1 PWR reactor<br>P'4<br>1300 MWe | 15.09.82 (JO of 16.09.82) | |
| 128 | BELLEVILLE-SUR-LOIRE NPP (reactor 2)<br>18240 Léré | EDF | 1 PWR reactor<br>P'4<br>1300 MWe | 15.09.82 (JO of 16.09.82) | Modification of perimeter: Decree of 29.11.04<br>(JO of 02.12.04) |

| BNI N° | NAME AND LOCATION OF THE FACILITY | Licensee | Type of facility | Authorised on: | OBSERVATIONS |
|---|---|---|---|---|---|
| 129 | NOGENT-SUR-SEINE NPP (reactor 1) 10400 Nogent-sur-Seine | EDF | 1 PWR reactor P'4 1300 MWe | 28.09.82 (JO of 30.09.82) | Modification of perimeter: Decree of 10.12.85 (JO of 18.12.85) |
| 130 | NOGENT-SUR-SEINE NPP (reactor 2) 10400 Nogent-sur-Seine | EDF | 1 PWR reactor P'4 1300 MWe | 28.09.82 (JO of 30.09.82) | Modification of perimeter: Decree of 10.12.85 (JO of 18.12.85) |
| 132 | CHINON NPP (reactors B3 and B4) 37420 Avoine | EDF | 2 PWR reactors CP2 900 MWe | 07.10.82 (JO of 10.10.82) | Modification: Decree of 21.07.98 (JO du 26.07.98) |
| 135 | GOLFECH NPP (reactor 1) 82400 Golfech | EDF | 1 PWR reactor P'4 1300 MWe | 03.03.83 (JO of 06.03.83) | Modification of perimeter: Decree of 29.11.04 (JO of 02.12.04) |
| 136 | PENLY NPP (reactor 1) 76370 Neuville-lès-Dieppe | EDF | 1 PWR reactor P'4 1300 MWe | 23.02.83 (JO of 26.02.83) | |
| 137 | CATTENOM NPP (reactor 4) 57570 Cattenom | EDF | 1 PWR reactor P'4 1300 MWe | 29.02.84 (JO of 03.03.84) | |
| 139 | CHOOZ B NPP (reactor 1) 08600 Givet | EDF | 1 PWR reactor N4 1450 MWe | 09.10.84 (JO of 13.10.84) | Postponement of commissioning Decrees of 18.10.1993 (JO of 23.10.93) and 11.06.99 (JO of 18.06.99) |
| 140 | PENLY NPP (reactor 2) 76370 Neuville-lès-Dieppe | EDF | 1 PWR reactor P'4 1300 MWe | 09.10.84 (JO of 13.10.84) | |
| 142 | GOLFECH NPP (reactor 2) 82400 Golfech | EDF | 1 PWR reactor P'4 1300 MWe | 31.07.85 (JO of 07.08.85) | |
| 144 | CHOOZ B NPP (reactor 2) 08600 Givet | EDF | 1 PWR reactor N4 1450 MWe | 18.02.86 (JO of 25.02.86) | Postponement of commissioning Decrees of 18.10.93 (JO of 23.10.93) and 11.06.99 (JO of 18.06.99) |
| 158 | CIVAUX NPP (reactor 1) BP 1 86320 Civaux | EDF | 1 PWR reactor N4 1450 MWe | 06.12.93 (JO of 12.12.93) | Postponement of commissioning Decree of 11.06.99 (JO of 18.06.99) |
| 159 | CIVAUX NPP (reactor 2) BP 1 86320 Civaux | EDF | 1 PWR reactor N4 1450 MWe | 06.12.93 (JO of 12.12.93) | Postponement of commissioning Decree of 11.06.99 (JO of 18.06.99) |
| 167 | FLAMANVILLE NPP (reactor 3) 50830 Flamanville | EDF | 1 PWR reactor EPR 1600 MWe | 10.04.07 (JO of 11.04.07) | Decree 2007-534 of 10.04.07 (JO of 11.04.07) |

## *1.3. List of research nuclear reactors*

Table 11: Research reactors in operation, in the administrative sense, and under construction

| BNI N° | NAME AND LOCATION OF THE FACILITY | Licensee | Type of facility and thermal power | Authorised on: | OBSERVATIONS |
|---|---|---|---|---|---|
| 24 | CABRI (Cadarache)<br>13115 Saint-Paul-lez-Durance | CEA | Reactor<br>25 MW-th | | Modification: Decree of 20.03.06 (JO of 21.03.06)<br>Modified reactor divergence authorised by decision of 20/10/15 |
| 39 | MASURCA (Cadarache)<br>13115 Saint-Paul-lez-Durance | CEA | Reactor<br>0.005 MW-th | 14.12.66 (JO of 15.12.66) | Finally shut down on 31 December 2018 |
| 40 | ISIS (Saclay)<br>91191 Gif-sur-Yvette Cedex | CEA | Reactor<br>0.70 MW-th | 08.06.65 (JO of 12.06.65) | Finally shut down on 30 March 2019 |
| 42 | EOLE (Cadarache)<br>13115 Saint-Paul-lez-Durance | CEA | Reactor<br>0.0001 MW-th | 23.06.65 (JO of 28 and 29.06.65) | Finally shut down on 31 December 2017 |
| 67 | HIGH-FLUX REACTOR (RHF)<br>38041 Grenoble Cedex | Max von Laue Paul Langevin Institute | Reactor<br>57 MW-th | 19.06.69 (JO of 22.06.69); 05.12.94 (JO of 06.12.94) | Modification of perimeter: Decree of 12.12.88<br>(JO of 16.12.88) |
| 95 | MINERVE (Cadarache)<br>13115 Saint-Paul-lez-Durance | CEA | Reactor<br>0.0001 MW-th | 21.09.77 (JO of 27.09.77) | Finally shut down on 31 December 2017 |
| 101 | ORPHÉE (Saclay)<br>91191 Gif-sur-Yvette Cedex | CEA | Reactor<br>14 MW-th | 08.03.78 (JO of 21.03.78) | Final shut down no later than 31 December 2019 |
| 172 | JULES HOROWITZ (RJH) (Cadarache)<br>13115 Saint-Paul-lez Durance Cedex | CEA | Reactor<br>100 MW-th | 12.10.09 (JO of 14.10.09) | Decree 2009-1219 of 12.10.09 (JO of 14.10.09) |
| 174 | ITER<br>13067 St.Paul-lez-Durance | ITER Organization | 700 MW fusion reactor | 9.12.2012 | Decree 2012-1248 of 9 November 2012 |

# APPENDIX 2 – Main legislative and regulatory texts

## *2.1. Codes, acts and regulations*

- Environment Code:
  - Book I – Part II – Chapter V (Articles L. 125-10 to L.125-40);
  - Book V – Part IV – Chapter II (Articles L. 542-1 to L.542-14);
  - Book V – Part IX (Articles L. 591-1 to L.59-7-46).
- Public Health Code: Articles L 1333-1 et seq. and R.1333-1 et seq., relative to the general protection of individuals against the hazards of ionising radiation.
- Labour Code: Articles 4451-1 et seq. and R.4451-1 et seq., relative to the protection of workers against the hazards of ionising radiation.
- Defence Code: Articles D. 1333-68 and 69 relative to the Interministerial Committee for Nuclear or Radiological Emergencies.
- Act 2006-686 of 13th June 2006 relative to Transparency and Security in the Nuclear Field (Articles 19 and 21).
- Planning Act 2006-739 of 28th June 2006 relative to the Sustainable Management of Radioactive Materials and Waste (Articles 3 and 4).
- **Decree 2018-434 of 4th June 2018 introducing various measures concerning nuclear activities**
- **Decree 2018-437 of 4th June 2018 relative to the protection of workers against the hazards of ionising radiation**
- **Decree 2018-438 of 4th June 2018 relative to the protection against the hazards of ionising radiation to which certain workers are exposed**
- **Decree 2019-190 of 14th March 2019 codifying the provisions applicable to basic nuclear installations, the transport of radioactive substances and transparency in the nuclear field**
- Order of 7th February 2012 setting the general rules concerning basic nuclear installations
- Interministerial Order of 10th November 1999 relative to the monitoring of operation of the main primary system and the main secondary systems of nuclear pressurized water reactors
- **Order of 30th December 2015 relative to nuclear pressure equipment**
- **Order of 20th November 2017 relative to the in-service monitoring of pressure equipment and simple pressure vessels**

## 2.2. ASN regulations

Table 12: List of ASN resolutions as at end of 2018

| Topic | Text adopted | Consultations |
|---|---|---|
| **Texts relative to the procedures** | | |
| Obligations on BNI licensees in terms of preparedness for and management of emergency situations and the content of the on-site emergency plan | Resolution 2017-DC-0592 of 13th June 2017 Approved by Order of 28/08/2017 (JORF of 03/09/2017) | From 01/03/2017 to 21/03/2017 on the Internet |
| Conditioning of radioactive waste and the conditions of acceptance of the radioactive waste packages in the disposal basic nuclear installations. | Resolution 2017-DC-0587 of 23 March 2017 Approved by Order of 13/06/2017 (JORF of 23/06/2017) | From 17/08/2015 to 17/10/2015 on the Internet |
| Conditions for water intake and consumption, discharge of effluents and monitoring of the environment around PWR reactors | Resolution 2017-DC-0588 of 6th April 2017 Approved by Order of 14/06/2017 (JORF of 29/06/2017) | From 22/02/2016 to 22/04/2016 on the Internet |
| Noteworthy modifications to basic nuclear installations | Resolution 2017-DC-0616 of 30th November 2017 Approved by Order of 18/12/2017 (JORF of 21/12/2017) | From 05/08/2017 to 07/10/2017 on the Internet |
| Decommissioning and post-operational clean-out | | |
| Hearings of licensees and CLIs | ASN resolution 2010-DC-0179 of 13th April 2013 | |
| Periodic safety review | | From 25/04 to 26/05/2013 (1st consultation on 18/03/10 by post and via the Internet from 18/04/10 to 15/7/2010; WENRA on 26/03/10 (by e-mail)) |

| | | |
|---|---|---|
| Safety analysis report (content), | ASN resolution 2015-DC-0532 of 17th November 2015<br>Approval:<br>Order of 11/01/2016 (JORF of 15/01/2016) | On 21/04/11 by post and via the Internet from 30/04/11 to 31/07/2011) |
| **Technical texts** | | |
| **Control of accident risks and detrimental effects (excluding waste)** | | |
| RGE and BNI operation resolution | | 22/06/10 by post and on the Internet from 06/07/10 up to 30/09/2010<br>WENRA on 06/07/10<br>by e-mail |
| PWR shutdowns and restarts | ASN resolution 2014-DC-0444 of 15th July 2014.<br>Approved by Order of 21/11/2014 (JORF of 02/12/2014) | On 30/03/10 by post and via the Internet from 18/04/10 to 15/7/2010;<br>WENRA on 09/04/10<br>(by e-mail) |
| Waste disposal facility | | |
| Waste storage facilities | | |
| Control of fire risks | ASN resolution 2014-DC-0417 of 28th January 2014.<br>Approved by Order of 20/03/2014 (JORF of 02/04/2014) | From 26/12/12 to 28/02/13 on the Internet |
| Control of the criticality risk in BNIs | Resolution 2014-DC-0462 of 7th October 2014.<br>Approved by Order of 20/11/2014 (JORF of 02/12/2014) | From 06/01/2014 to 04/02/2014 on the Internet |

| | | |
|---|---|---|
| Control of detrimental effects and impact on the environment | Resolution 2013-DC-0360 of 16th July 2013.<br>Approved by Order of 09/08/2013 (JORF of 21/08/2013)<br>Modified by resolution 2016-DC-0569 of 29th December 2016.<br>Approved by Order of 05/12/2016 (JORF of 22/12/2013) | From 15/03/13 to 16/04/13<br>CSPRT: 03/07/2013<br>(1st consultation on 12/07/10 by post and via the Internet from 19/07/10 to 15/10/10) |
| Conditions for water intake and consumption, discharge of effluents and monitoring of the environment around PWR reactors | Resolution 2017-DC-0588 of 6th April 2017<br>Approved by Order of 14/06/2017 (JORF of 29/06/2017) | From 22/02/2016 to 22/04/2016 on the Internet |
| Prevention of risks resulting from the dispersal of pathogenic micro-organisms (legionella and amoeba) by PWR secondary system cooling installations | Resolution 2016-DC-0578 of 6th December 2016<br>Approved by Order of 13/01/2017 (JORF of 19/01/2017) | From 02/03/2015 to 04/05/2015 on the Internet |
| **Waste management and disposal** | | |
| Study of waste management and the inventory of waste produced in the BNIs. | Resolution 2015-DC-0508 of 21st April 2015.<br>Approved by Order of 01/07/2015 (JORF of 04/07/2015) | On 28/05/10 by post and on the Internet from 26/05/10 to 31/08/10;<br>WENRA on 16/10/10<br>by e-mail |
| Conditioning of radioactive waste and the conditions of acceptance of the radioactive waste packages in the disposal basic nuclear installations. | Resolution 2017-DC-0587 of 23rd March 2017<br>Approved by Order of 13/06/2017 (JORF of 23/06/2017) | From 17/08/2015 to 17/10/2015 on the Internet |
| Conditions for approval of waste conditioning | | On 26/07/10 by post and via the Internet from 20/09/10 to 05/12/10) |
| Design and operation of on-site waste storage facilities | | |
| **Management of emergency situations** | | |
| Management of emergency situations | | On 21/05/10 by post and via the Internet from 26/05/10 to 31/08/2010)<br>WENRA on 10/06/10<br>by e-mail |
| **Information of the authorities and the public** | | |

| | | |
|---|---|---|
| Notification of incidents | | |
| Spare parts for the main primary system (MPS) and main secondary system (MSS) | Resolution 2012-DC-0236 of 3rd May 2012<br>Approval: Order of 22/06/2012 (JORF of 4/07/2012) | On 01/10/10 by post and on the Internet from 11/10/10 to 31/12/2010<br>CCAP 04/10/2011 |
| Conformity of nuclear pressure equipment (NPE) | Resolution 2016-DC-0571 of 11th October 2016<br>Approval: Order of 10/11/2016 (JORF of 26/11/2016) | From 01/06/2016 to 15/07/2016 on the Internet |
| Regulations applicable to NPE | | |

After a first series of consultations in 2010 and 2011, the draft resolutions were revised in the light of any observations made and of the order of 7th February 2012 *setting the general rules relative to basic nuclear installations*. The new versions of the draft resolutions were submitted for consultation before they were adopted.

## *2.3. Basic safety rules and guides*

As indicated in § 7.1.3.3, as part of the on-going restructuring of the general technical regulations, the basic safety rules (RFS) are being modified and transformed into guides.

There are at present about forty RFS and other technical rules published by ASN which can be consulted on its website.

### 2.3.1 Rules relative to PWRs

| | |
|---|---|
| RFS 2002-1 | Basic safety rule 2002-1 concerning the development and utilisation of probabilistic safety assessments for pressurised water nuclear reactors (26th December 2002). |
| RFS-I.2.a. | Integration of risks related to airplane crashes (5th August 1980). |
| RFS-I.2.b. | Integration of risks of projectile release following fragmentation of the turbine generator sets (5th August 1980). |
| RFS-I.2.d. | Integration of risks related to the industrial environment and communication routes (7th May 1982). |
| RFS-I.3.a. | Use of the single failure criterion in safety analyses (5th August 1980). |
| RFS-I.3.b. | Seismic instrumentation (8th June 1984) |
| RFS-I.3.c. | Geological and geotechnical site studies; determination of soil characteristics and study of soil behaviour (1st August 1985). |
| RFS-II.2.2.a. | Design of containment spray system (5th August 1980); revision 1 (31st December 1985). |
| RFS-II.3.8. | Construction and operation of the main secondary system (8th June 1990). |

RFS-II.4.1.a Software for safety-classified electrical systems (15th May 2000).

RFS-IV.I.a. Classification of mechanical equipment, electrical systems, structures and civil engineering works (21st December 1984).

RFS-IV.2.a. Requirements to be considered in the design of safety-classified mechanical equipment carrying or containing a fluid under pressure and classified level 2 and 3 (21st December 1984).

RFS-IV.2.b. Requirements to be considered in the design, qualification, implementation and operation of electrical equipment included in safety-classified electrical systems (31st July 1985).

RFS-IV.I.a. Determination of the activity released outside the fuel to be considered in accident safety studies (18th January 1982).

RFS-IV.I.b. Meteorological measurement means (10th June 1982).

RFS-V.2.b. General rules applicable to civil engineering works (ref.: RCC-G code), (30th July 1981).

RFS-V.2.c. General rules applicable to the production of mechanical equipment (ref.: RCC-M code), (8th April 1981); revision 1 (12th June 1986).

RFS-V.2.d. General rules applicable to the production of electrical equipment (ref.: RCC-E code), (28th December 1982); revision 1 (23rd September 1986).

RFS-V.2.e. General rules applicable to the production of fuel assemblies (ref.: RCC-C code), (28th December 1982); revision 1 (25th October 1985); revision 2 (14th December 1990).

RFS-V.2.g. Seismic calculations for civil engineering works (31st December 1985).

RFS-V.2.h. General rules applicable to the construction of civil engineering works (ref.: RCC-G code), (4th June 1986).

RFS-V.2.j. General rules relative to fire protection (20th November 1988).

Notice SIN 3130/84 of 13th June 1984 concerning the conclusions of the review of the document entitled: “Design and construction rules for PWR nuclear power plants. Handbook of rules on processes - 900 MWe reactors" (ref.: RCC-P code).

### 2.3.2 Rules relative to the other BNIs

RFS-I.1.a. Integration of risks related to airplane crashes (7th October 1992).

RFS-I.1.b. Integration of risks related to the industrial environment and communication routes (7th October 1992).

RFS-I.2.a. Safety objectives and design bases for surface facilities intended for long-term disposal of solid radioactive waste with short or intermediate half-life and low or intermediate specific activity (8th November 1982); revision 1 (19th June 1984).

RFS-I.2.b. Design basis of ionisers (18th May 1992).

RFS-I.3.c. Criticality risk (18th October 1984).

RFS-I.4.a. Fire protection (28th February 1985).

RFS-II.2. Design and operation of ventilation systems in BNIs other than nuclear reactors (20th December 1991).

RFS-III.2.a. General provisions applicable to the production, monitoring, processing, conditioning and interim storage of various types of waste resulting from reprocessing of fuel irradiated in PWRs (24th September 1982).

RFS-III.2.b. Special provisions applicable to the production, monitoring, processing, conditioning and storage of high-level waste conditioned in the form of glass and resulting from reprocessing of fuel irradiated in PWRs (12th December 1982).

RFS-III.2.c. Special provisions applicable to the production, monitoring, processing, conditioning and interim storage of low or intermediate level waste encapsulated in bitumen and resulting from reprocessing of fuel irradiated in PWRs (5th April 1984).

RFS-III.2.d. Special provisions applicable to the production, monitoring, processing, conditioning and interim storage of waste encapsulated in cement and resulting from reprocessing of fuel irradiated in PWRs (1st February 1985).

RFS-III.2.e. Prerequisites for the approval of packages of encapsulated solid waste intended for surface disposal (31st October 1986); (revision of 29th May 1995)

### 2.3.3 Other basic safety rules

RFS 2001-01 Determination of seismic movements to be considered for the safety of the facilities (Revision of RFS-I.2.c and RFS-I.1.c – 16th May 2001).

RULE SIN C-12308/86 (RR1)

Cleaning systems equipping nuclear research reactor ventilation systems (4th August 1986).

RULE SIN A-4212/83

Relative to meteorological measurement means (12th August 1983).

RULE SIN C-12670/9-1 (RR2)

Protection against the fire risk in nuclear research reactors (1st July 1991).

### 2.3.4 Guides

**The ASN guides (in force as at April 2019) concerning the subject of the report**

ASN guide 2/01 of 26th May 2006 on the inclusion of the seismic risk when designing civil works for basic nuclear installations other than radioactive waste long-term disposal facilities.

General orientation safety guide for the siting of a low-level, long-lived waste disposal facility (May 2008).

No. 1 Disposal of radioactive waste in deep geological formations (08/02/2008).

No. 2 Transport of radioactive materials in airports (15/02/2006)

No. 3 Recommendations for writing annual public information reports concerning basic nuclear installations (20/10/2010).

No. 6 Final Shutdown, Decommissioning and Delicensing of Basic Nuclear Installations in France (30/08/2016).

No. 7 Civil transport of radioactive packages or substances on the public highway (Shipment approval applications) (Volume 1: 15/02/216; Volume 2: December 2014; Volume 3: 11/11/2015).

No. 8 Conformity assessment of nuclear pressure equipment (04/09/2012).

No. 9 Determining the perimeter of a BNI (31/10/2013).

No. 10 Local involvement of CLIs in the 3rd ten-yearly outage inspections of the 900 MWe reactors (01/06/2010).

No. 12 Notification and codification of criteria related to significant safety, radiation protection or environmental events applicable to BNIs and to radioactive material transport operations (21/10/2005).

No. 13 Protection of BNIs against external flooding (08/01/2013).

No. 14 Acceptable complete clean-out methodologies in BNIs in France (30/08/2016).

No. 15 Control of Activities in the Vicinity of Basic Nuclear Installations (24/03/2016).

No. 17 Content of radioactive substance transport incident and accident management plans (22/12/2014).

No. 19 Application of the Order of 12/12/2005 relating to nuclear pressure equipment (21/02/2013)

No. 21 Processing of non-compliance with a requirement defined for an element important for protection (EIP) (06/01/2015).

No. 22 Design of pressurised water reactors (18/07/2017)

No. 23 Drafting and modification of the waste zoning plan for basic nuclear installations (30/08/2016)

No. 24 Management of soils polluted by the activities of a basic nuclear installation (30/08/2016)

No. 25 Drafting of an ASN regulation or an ASN guide (22/11/2016)

No. 28 Qualification of scientific computing tools used in the nuclear safety case (27/07/2017)

No. 34: Implementation of the regulatory requirements applicable to on-site transport operations (27/06/2017)

**Planned ASN guides (as at April 2019)**

Table 13: List of planned ASN guides

| Title |
|---|
| Management of emergency situations |
| Control of fire risks |
| All external natural hazards |

# APPENDIX 3 – Organisation of nuclear reactor licensees

## *3.1. EDF organisation for nuclear reactors*

The EDF Group, one of the world's top ten energy companies, is a limited company (EDF S.A.) with a board of directors, which is active along the entire electricity value chain. It is present in all the electricity disciplines: nuclear, renewables and fossil energy productions, transport, distribution, marketing, energy efficiency and management services, as well as energy trading. In France, Électricité de France S.A. is the main electricity production company and is today the only one to operate nuclear power reactors.

The EDF group's nuclear organisation is mainly built around two departments (see Figure 10):

- the **Nuclear and Thermal Fleet Department (DPNT),**
- the **Engineering and New Nuclear Projects Department (DIPNN)**.

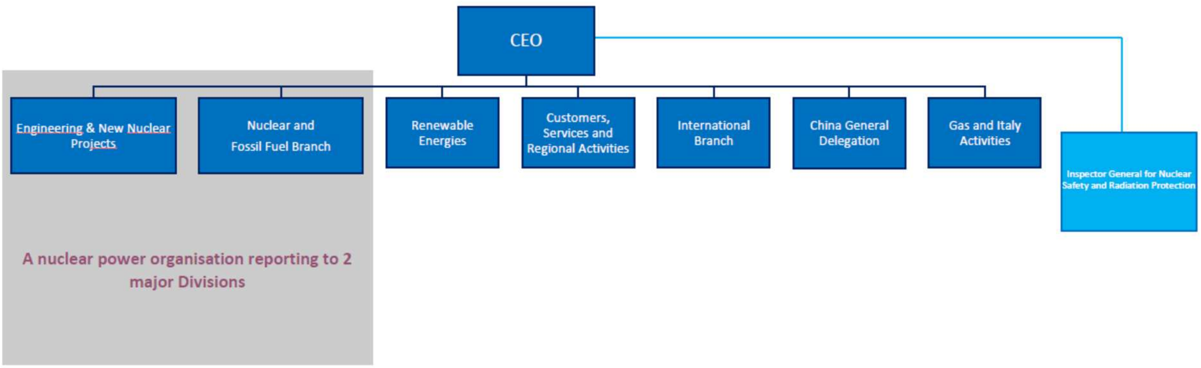


Figure 10: Organisation of the EDF SA Group

These two Departments handle the design and construction of new reactors (in France, the Flamanville 3 EPR), maintaining the highest level of safety for the nuclear fleet in operation and successfully completing the work to renovate and prolong the lifetime of the existing fleet in complete safety, developing an industrial sector for nuclear dismantling and management of radioactive waste, reinforcing the performance and innovation of nuclear engineering, on behalf of new construction projects, the major overhaul programme, or dismantling projects.

With regard to operation of the nuclear reactors, the **DPNT** includes in particular:

- the Nuclear Power Operations Division (DPN), with all the sites in operation (NPPs: Nuclear Power Plants), the National Operational Engineering Unit (UNIE) and the Operational Technical Unit (UTO);
- The Nuclear Fleet, Dismantling and Environment Division (DIPDE);
- The Nuclear Fuel Division (DCN);
- the "Major Overhaul" Programme Department (DPGC).
- the Dismantling and Waste Projects Department (DP2D)

With regard to engineering and new nuclear projects in France, the **DIPNN** more specifically includes:

- two Project Departments: Flamanville 3 project department and EPR 2 project department;
- four Operational Departments: Projects Support and Digital Transformation Department (DSPTN), Industrial Department (DI), Technical Department (DT) and Development Department (DD);
- two Engineering Departments: the national electricity generating equipment centre (CNEPE) and EDVANCE (subsidiary reporting to the DIPNN).

With these units of expertise, which also support the fleet in service, the DIPNN is at the centre of the challenges facing the nuclear sector.

### 3.1.2 Principles of nuclear safety and radiation protection responsibilities within EDF S.A.

EDF S.A. is the named holder of the creation authorisation decrees for its BNIs and has responsibility as nuclear licensee.

Nuclear safety and radiation protection are applicable to all BNIs operated by EDF SA, as well as to radioactive substance transports from and to them. This concerns all persons working in or finding themselves in a BNI in whatsoever capacity. In this respect, the EDF Group has defined and implemented a policy reaffirming:

- the priority given to the protection of the interests mentioned in Article L. 593-1 of the Environment Code (public health and safety, protection of nature and the environment), primarily by preventing accidents and mitigating their consequences in accordance with the demands of nuclear safety
- and the **constant search for improvements in the measures taken** to protect these interests.

As nuclear licensee, EDF S.A.'s **responsibilities in terms of nuclear safety and radiation protection are delegated to three levels**:

- **the Chairman of EDF S.A**,
- **the national entities:** in charge of BNI construction and operation projects and the design of BNI modifications,
- **the nuclear production sites.**

Each of these levels of delegation and competence is **responsible for developing a management system** which contributes to the **rules of nuclear safety and radiation protection** in the organisation and operation of its entity and, more generally, to the **protection of the interests** identified by the Environment Code. It thus guarantees the **priority granted to the protection of the above-mentioned interests**.

§ 3.1.2.1 to § 3.1.2.4 of this appendix summarise the responsibilities of these 3 levels.

In addition to this **management line** given responsibility for nuclear safety and radiation protection, each level of the company calls on the services of an **Independent Safety Team** (FIS) providing an **independent view** of how the nuclear licensee performs its duties. The FIS ensures that priority is given to nuclear safety by exercising a **role of verification and advice** for the management.

Each level in the company organises the integration of the FIS into the *ad hoc* bodies, so that this independent view can be provided at the appropriate level. At each level of the company, the FIS reports to the manager of the level concerned.

In the event of any serious breach of the nuclear safety rules, the FIS is duty bound to sound the alert which may, if necessary, be sent to the next higher management level.

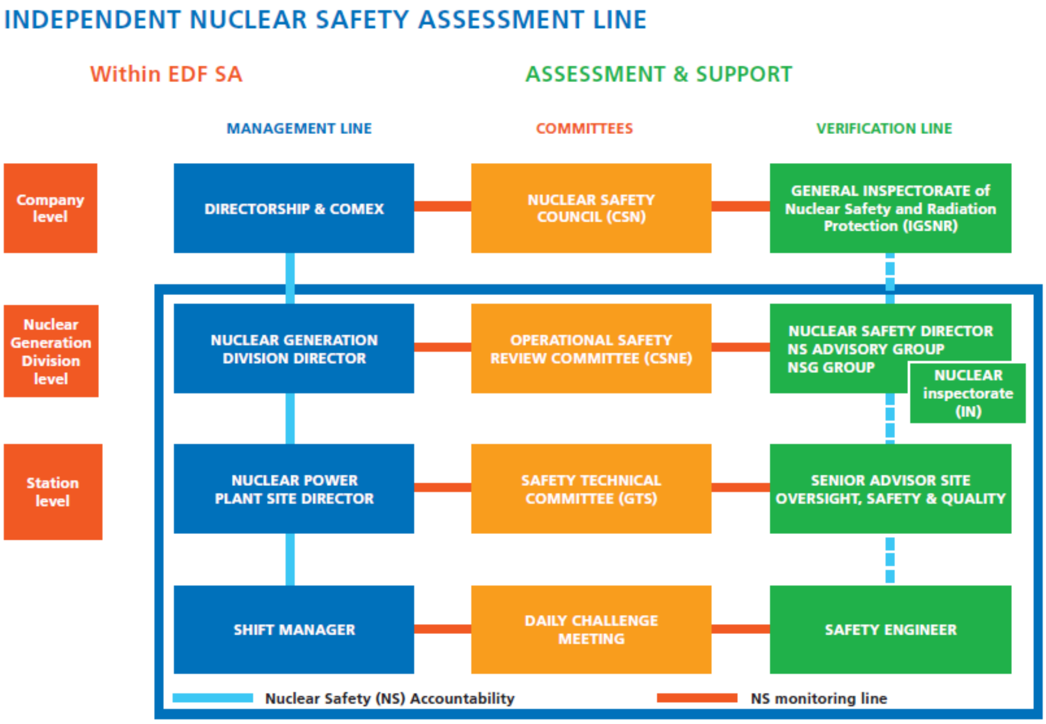

Figure 11: The Independent Safety Team (FIS)

### 3.1.2 Assignment of responsibilities for nuclear safety and radiation protection within EDF S.A.

In its capacity as nuclear licensee, **the EDF S.A. legal person is represented by the following natural persons**:

#### 3.1.2.1 At EDF SA Chairman level:

Under the delegation of powers granted to his or her by the Board of Directors, the **CEO** has all the powers needed for EDF S.A. to exercise its duties as nuclear licensee. He or she in particular determine the strategic orientations regarding nuclear safety and set the general principles of organisation and resources allowing the correct performance of EDF S.A.'s responsibility as nuclear licensee, with the assistance of the Group Executive Director in charge of nuclear and thermal production and the Group Executive Director in charge of engineering and new nuclear projects

He or she chairs the **Nuclear Safety Council** and ensures the consistency of the main orientations and actions of the different sectors of the company that may affect nuclear safety and radiation protection, including in areas such as purchasing of goods and services, implementation of training programmes, research and development.

In order to define and implement these strategic orientations as organisational principles, the EDF SA CEO relies on the following within the EDF Group executive committee:

- for BNIs under construction (Flamanville 3), on the Group Executive Director in charge of Engineering and New Nuclear Projects, to whom he or she delegates the responsibility of nuclear licensee, as of the submission of the creation authorisation application and up to transfer of responsibility for them to the entity in charge of operations,
- for the BNIs in operation14 on the Group Executive Director in charge of the Nuclear and Thermal NPP flee, to whom he or she delegates the responsibility of nuclear licensee, as of their transfer.

**The two Group Executive Directors** are the guarantors that nuclear safety and radiation protection are taken into account within their respective perimeters (BNIs under construction / BNIs in operation respectively), within the EDF Group executive committee.

They are responsible for drawing up the general organisational principles such as to ensure correct performance of the function of nuclear licensee by EDF S.A. on the BNIs within their perimeter (design-construction projects / reactors in operation respectively) and implement these principles within these BNIs. They ensure the consistency of the main orientations and actions of the different sectors of EDF SA that may affect nuclear safety and radiation protection. They more specifically aim to guarantee that priority is given to nuclear safety in the investments and asset selections decided on by the Chairman. They ensure that the design and construction of BNIs throughout their lifecycle comply with the applicable nuclear safety requirements. They are the points of contact for the nuclear safety regulator (ASN)

**The Inspector General for Nuclear Safety and Radiation Protection** ensures that nuclear safety and radiation protection concerns are properly taken into account for the company's nuclear facilities and reports to the **CEO** in this respect

#### 3.1.2.2 Within the entities in charge of "new nuclear "projects

At present and for France, this concerns the **Flamanville 3 BNI Project Department**. Under the powers delegated to him or her by the Group Executive Director in charge of Engineering and New Nuclear Projects, the **Flamanville 3 Project Director** is the representative of the EDF SA nuclear licensee for this BNI in its entirety. He or she takes all the steps needed for EDF S.A. to perform its duties as nuclear licensee.

He or she ensures that priority is given to protection of the abovementioned interests, first of all through **design, construction and commissioning** (up to transfer of responsibility to the entity in charge of operations), aiming to **prevent accidents and mitigate their consequences** in terms of nuclear safety.

**The Group Executive Director in charge of Engineering and New Nuclear Projects** acts as Backer for nuclear safety and radiation protection in the Flamanville 3 BNI. **The project owner is the Flamanville 3 Project entity.** In this respect, the **Flamanville 3 Project Director** guarantees that the design of the facilities and their construction within the BNI perimeter and their subsequent modifications throughout the project are compliant with the baseline safety requirements in force. In so doing, he or she calls on the expertise of the engineering centres reporting to the New Nuclear Projects Engineering Department (DIPNN).

On behalf of the Group Executive Director in charge of the Nuclear and Thermal Fleet and the Executive Director in charge of Engineering and New Nuclear Projects, the **Technical Department (DT)** of the DIPNN has the role of ensuring the **control and implementation of the technical baseline requirements for the new nuclear projects and for the existing NPP fleet.** It is assisted by the

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[14] The licensee's responsibility is transferred in two stages: within a perimeter limited to the equipment needed for storage of the new fuel assemblies in the pool at arrival of the first fuel element in the BNI (partial commissioning), and then on the entire BNI when the first assembly is loaded into the vessel (commissioning).

Industrial Department (DI) to ensure involvement by the industrial sector in drawing up these baseline requirements.

#### 3.1.2.3 Within the entities in charge of BNI operation and BNI design and modification at EDF SA:

The following are concerned**:** the Nuclear Operations Division, the **Nuclear Fleet, Dismantling and Environment Division (DIPDE)**;

Under the powers delegated to him or her by the Group Executive Director in charge of the Nuclear and Thermal Fleet and under their authority, the **DPN Director** is the representative of the EDF S.A nuclear licensee for all the facilities in operation.

He or she take all the steps needed for EDF S.A. to perform its duties as nuclear licensee. He or she develops a management system which contributes to compliance with the rules of nuclear safety and radiation protection in the organisation and operation of their entity and, more generally, to the protection of the interests identified by the Environment Code. In this respect, he or she ensures that **priority is given to protection of the abovementioned interests and its constant improvement**, principally by **preventing accidents and mitigating their consequences in terms of nuclear safety**. He or she aims to ensure the development of continuous improvement and the adoption of best practices, including those identified internationally.

The principles of this management system are applied on the sites in operation, under the responsibility of the **Unit Directors (NPP)**.

For the BNIs he or she operates, the DPN Director carries out the duties of nuclear licensee throughout the lifetime of these BNIs. He or she may be required to make a final ruling on the decisions taken within the nuclear sector of EDF S.A. with regard to the BNIs for which they are responsible. This responsibility is exercised more particularly within the bodies comprising cross-participation by the entities of the sector.

The **Group Executive Director in charge of the Nuclear and Thermal Fleet** acts as Backer for nuclear safety and radiation protection for the BNIs in operation within his or her perimeter.

**The Project Manager is the Nuclear Operation Division for the BNIs in operation**.

The Group Executive Director in charge of the Nuclear and Thermal fleet appoints the **Fleet Engineering, Dismantling and Environment Division (DIPDE)** as the **Design Authority** for BNIs in operation, on behalf of the Backer and Project Owner. In this respect, the **Director of the DIPDE** guarantees that the design status of the facilities within this perimeter and their modifications throughout their lifecycle are in conformity with the baseline safety requirements in force.

For this purpose, the **Design Authority** draws on the expertise of the engineering centres appointed as **Responsible Designers,** whether reporting to the Nuclear and Thermal Fleet Department (DPNT) or the New Nuclear Project Engineering Department (DIPNN).

The **Nuclear Fuels Division is Project Manager for activities related to the nuclear fuel cycle,** as well as **Project Manager for the removal of radioactive waste**.

On behalf of the Group Executive Director in charge of the Nuclear and Thermal Fleet and the Executive Director in charge of Engineering and New Nuclear Projects, the **Technical Department (DT)** of the DIPNN has the role of ensuring the **control and implementation of the technical baseline requirements for the new nuclear projects and for the existing NPP fleet**. It is assisted by the Industrial Department (DI) to ensure involvement by the industrial sector in drawing up these baseline requirements.

#### 3.1.2.4 On the nuclear sites:

The **Flamanville 3 Development Director is the representative of the nuclear licensee, EDF S.A.,** under delegation from the Flamanville 3 Project Director.

The **Directors of the nuclear power plants are the representatives of the nuclear licensee, EDF S.A.,** for those facilities for which they have been delegated responsibility by the Director of the DPN.

More specifically, these unit directors take all steps needed for the exercise of this responsibility, in all the phases of the process for which the company is responsible, they:

- draw up and implement a protection of interests policy;
- propose and implement the principles of organisation and operation that ensure compliance with nuclear safety and radiation protection rules, as well as the effective exercise of the responsibilities of EDF S.A. as nuclear licensee,
- rely on a management system and ensure verification of compliance with the requirements through appropriate internal monitoring. In this respect, each NPP Development Director (or site director) ensures that priority is given to Safety when categorising the issues being addressed. They aim to ensure the development of continuous improvement and the adoption of best practices, including those identified internationally.
- report the information relating to nuclear safety and radiation protection to the Director of the Flamanville 3 Project / Director of the DPN, for the BNIs in operation. They are the points of contact for the national and local competent authorities in the area of nuclear safety and radiation protection for the aspects specific to the installations under their responsibility.

### *3.2. Organisation of CEA*

A new general organisation was set up at CEA in January 2016; in January 2018, the nuclear protection and safety division and the central security division were merged into the Nuclear Security and Safety Division (DSSN). This organisation is presented in Figure 12.

With regard to safety, which includes nuclear security, there are three levels of delegation of responsibilities:

- the Chairman, head of the CEA and, as such, the nuclear licensee of the reactors;
- the Directors of the centres, local representatives of the Chairman, more specifically with regard to his or her duty as nuclear licensee;
- the Facility Managers, responsible for ensuring compliance with the regulations and internal rules applicable to their facility at all times.

To guarantee that the safety objectives are duly taken into consideration for the through-life support of the reactors, the Director of Nuclear Energy signs an annual safety objectives contract (COS) with the Chairman, formally setting out the objectives. Execution of this COS is monitored by the Nuclear Safety and Security Department on behalf of the Chairman.

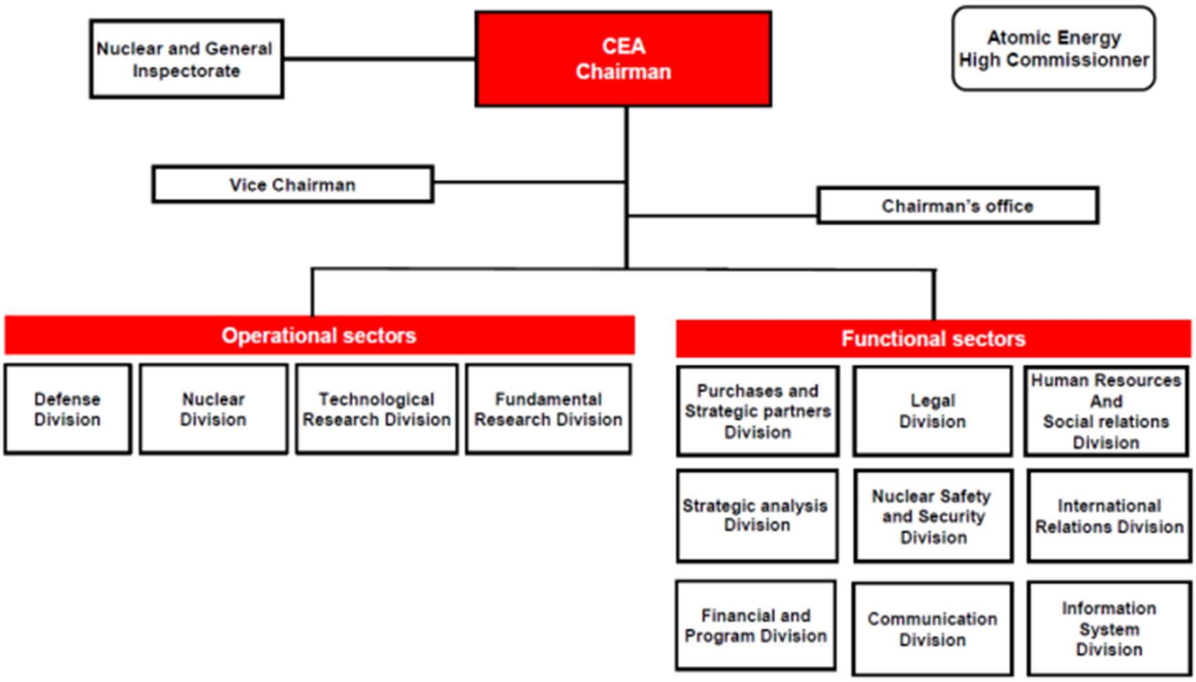



Figure 12: General organisation at CEA since January 2018

### 3.3. ILL organisation

The Laue-Langevin Institute (ILL) was founded in January 1967 by Germany, France and the United Kingdom, in order to obtain a very intense neutron source entirely dedicated to civil fundamental research. It is managed by these three founding countries, in association with its 11 scientific member states (Spain, Italy, Switzerland, Austria, Czech Republic, Hungary, Slovakia, Poland, Belgium, Sweden and Denmark).

It is currently organised into four divisions managed by the Director:

- the science division groups together all the scientific activities;
- the projects and techniques division manages the infrastructures needed for carrying out experiments. It also includes activities for the development of experimental techniques and the construction or modification of experimental devices;
- the administration division is responsible for normal administrative activities and some general services;
- the reactor division is responsible for the reactor, its facilities and auxiliary equipment.

The Radiation Protection and Environmental Monitoring Service, which also includes conventional security, reports directly to the Director of the ILL. Quality assurance and risk assessment also report directly to the ILL Director.

With regard to the management of the BNI and the other facilities specified in the safety analysis report, the Director delegates his responsibilities as licensee to the head of the Reactor Division. The head of the Reactor Division is Deputy Director with regard to the safety and management of the BNI and the other facilities specified in the safety analysis report. In this capacity he or she is responsible for the final decision concerning the safety of the operating conditions of the reactor, the instruments and the experimental devices.

# APPENDIX 4 - Environmental monitoring

## *4.1. Nature of monitoring of NPP discharges (based on the most recent licenses issued by ASN)*

### 4.1.1 Regulation monitoring of NPP liquid discharges

Table 14: Regulation monitoring of NPP liquid discharges

| ORIGIN AND NATURE | REGULATION SAMPLING AND INSPECTION TO BE PERFORMED BY THE LICENSEE |
|---|---|
| **T TANKS**<br>Residual effluents,<br>Auxiliary effluents,<br>SG blowdown | Sampling from each tank, after homogenisation:<br>▪ analyses prior to discharge:<br>➢ pH, $\alpha_G$, $\beta_G$, $\gamma_G$, $^3H$, $\gamma$ spectrometry<br>➢ chemical substances depending on site configuration<br>▪ subsequent analyses: $^{14}C$<br>Continuous measurement of $\gamma$ activity on the discharge line upstream of its outlet into the cooling waters<br>At the end of the month, production of a monthly average aliquot sample<br>▪ analyses: $^{63}Ni$, COD and metals |
| **EX tanks**<br>(Turbine hall effluents) | Sampling from each tank, after homogenisation:<br>▪ analyses prior to discharge:<br>➢ $\beta_G$, $^3H$<br>➢ chemical substances depending on site configuration<br>At the end of the month, production of a monthly average aliquot sample<br>▪ analyses:pH, $\alpha G$, $\beta G$, $\gamma G$, $^3H$, $\gamma$ spectrometry |
| Wastewater, rainwater | Spot sampling of water - analyses: $\beta_G$, potassium, $^3H$<br>Sampling of deposits in the sewage system, at least once a year<br>▪ analyses:$\gamma$ spectrometry |

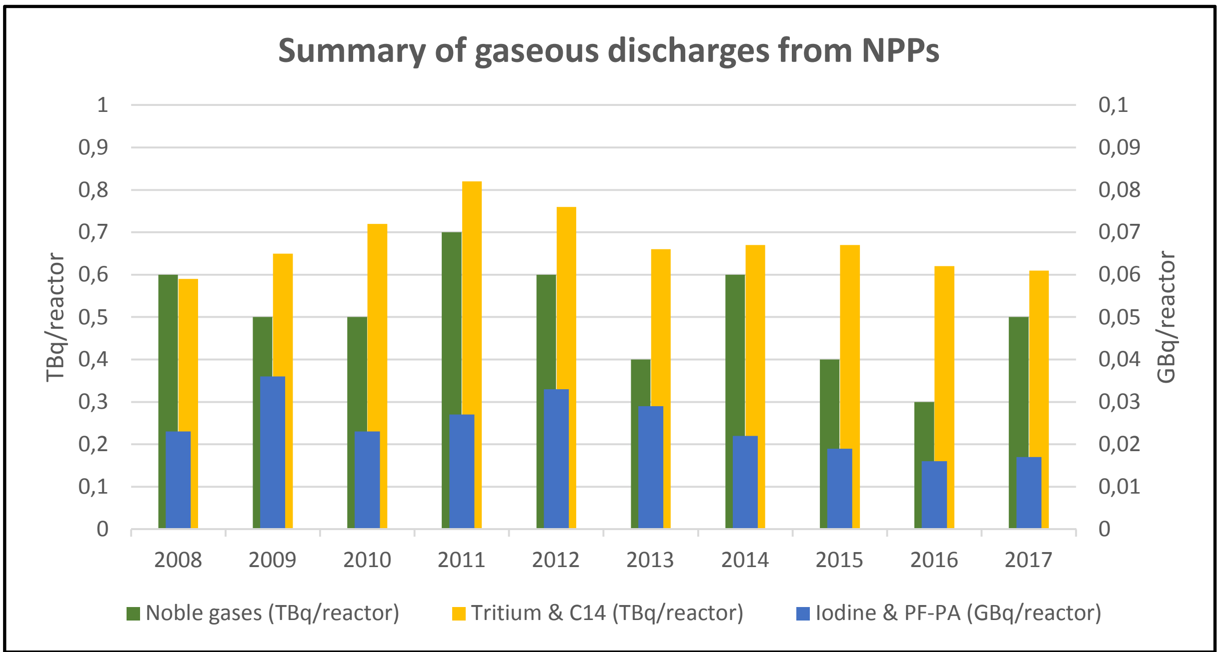
$\alpha_G$, $\beta_G$, $\gamma_G$ activity = total $\alpha$, $\beta$, $\gamma$ activity

### 4.1.2 Regulation monitoring of NPP gaseous discharges

Table 15: Regulation monitoring of NPP gaseous discharges

| ORIGIN AND NATURE | REGULATION SAMPLING AND INSPECTION TO BE PERFORMED BY THE LICENSEE |
|---|---|
| Continuous measurement with recording of $\beta_G$ activity in each stack | |
| **CONTINUOUS DISCHARGES** (ventilation) | Instantaneous weekly gas sample - analyses: $\gamma$ spectrometry (noble gases)<br>Continuous tritium sampling and weekly analyses<br>Continuous sampling of halogen gases – weekly analyses: $\gamma_G$, $\gamma$ spectrometry<br>Continuous sampling of aerosols – weekly analyses: $\alpha_G$, $\beta_G$, $\gamma$ spectrometry<br>Continuous sampling of $^{14}C$ – quarterly analyses (currently being deployed) |
| **COMBINED DISCHARGES** (drainage of tanks, of air from reactor buildings, etc.) | Sampling prior to discharge of:<br>• gases – analyses: $\gamma$ spectrometry (noble gases), $^3H$<br>• halogen gases – analyses: $\gamma_G$, $\gamma$ spectrometry<br>• aerosols – analyses: $\alpha_G$, $\beta_G$, $\gamma$ spectrometry |

### 4.1.3 Summary of discharges from NPPs (2008-2017)



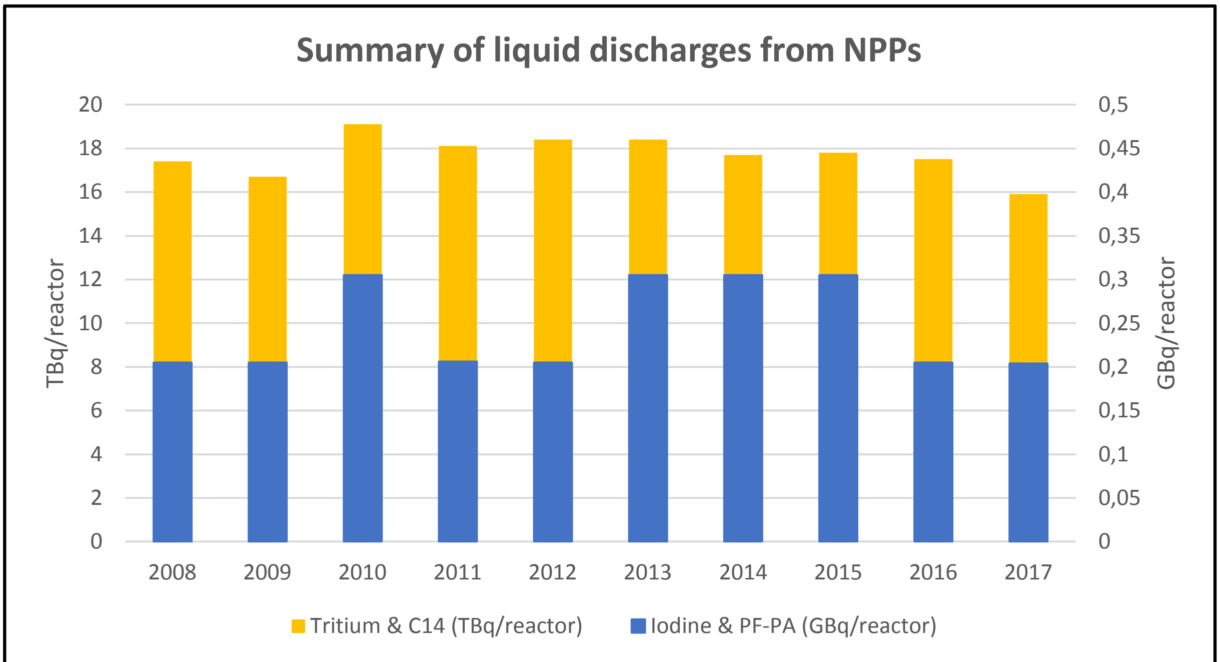




Figure 13: Summary of discharges from NPPs in TBq and GBq per plant unit (2008 – 2017)

PF: other fission products / PA: other activation products

### 4.2. Nature of environmental monitoring around the NPPs

Table 16: Nature of environmental monitoring around the NPPs

| Environment monitored or type of monitoring | Nuclear power plant |
|---|---|
| Air at ground level | • 4 stations continuously sampling atmospheric dust on fixed filter with daily measurements of total β activity ($\beta_G$). γ spectrometry if $\beta_G$ > 2 $mBq/m^3$.<br>• for each of the stations, γ spectrometry on the monthly grouping of daily filters<br>• 1 continuous sampling station under the prevailing winds with weekly measurement of tritium ($^3H$) |
| Ambient radiation | • 4 monitors at a distance of 1 km with continuous measurement and recording<br>• 10 monitors with continuous measurement at the site limits (monthly readings)<br>• 4 monitors at a distance of 5 km with continuous measurement |
| Rain | • 1 station under the prevailing wind (continuous sampling) with measurement of $\beta_G$ and $^3H$ on bi-monthly mixture |
| Environment receiving liquid discharges | • Sampling in the river and upstream at mid-discharge, for each discharge (riverside NPP), or sampling after dilution in cooling water and bi-monthly sampling at sea (coastal NPP): measurement of $\beta_G$, potassium (K) and $^3H$<br>• Continuous sampling of $^3H$ (daily average mixture)<br>• Annual sampling in the aquatic sediments, fauna and flora, with measurement of $^3H$, $^{14}C$ and γ spectrometry |
| Groundwaters | • 5 sampling points (monthly check) with $\beta_G$, K and $^3H$ measurement |
| Soil | • 1 annual sample of the surface layer of the soil with γ spectrometry |

| | |
|---|---|
| Plants | • 2 grass sampling points (monthly check) γ spectrometry. Periodic measurements of $^{3}H$, carbon 14 ($^{14}C$) and total carbon<br>• Annual campaign on the main agricultural crops with measurement of $^{3}H$, $^{14}C$ and total carbon, plus γ spectrometry. |
| Milk | • 2 sampling points (monthly check) with γ spectrometry and annual measurement of $^{14}C$ and $^{3}H$. |

## *4.3. Monitoring exposure of the population and the environment, a few illustrations*

**The French national network of environmental radioactivity monitoring (RNM)**

Article R.1333-25 of the Public Health Code provides for the creation of a national network of environmental radioactivity monitoring (RNM) with a two-fold aim:

- information transparency by making these environmental monitoring results available to the public along with information on the radiological impact of nuclear activities in France;
- ensuring the quality of the environmental radioactivity measurements by instituting a system of laboratory approvals delivered by ASN resolution.

On 2nd February 2010 the RNM launched a website presenting the results of environmental radioactivity monitoring and information on the impact of the nuclear industry on health in France. If they are to be input into the RNM's database, the measurements must be taken by laboratories approved by ASN.

In order to be approved, the laboratories must simultaneously meet two conditions such as to guarantee the reliability of the measurements:

- International Standard ISO/CEI 17025;
- inter-laboratory comparison tests organised by IRSN.

Since 2010, the website www.mesure-radioactivite.fr gives everyone completely transparent access to the 300,000 measurements taken annually in France (which in 2016 comprised almost 2 million data), in the various environmental compartments (air, water, soil, fauna and flora) and in food products. The www.mesure-radioactivite.fr website is the only one of its kind in Europe and enables everyone to familiarise themselves with the radioactivity monitoring carried out where they live.

**The TELERAY network**

TELERAY is a set of monitors for measuring ambient gamma radioactivity, which are permanently linked to a centralised supervision system via a data transmission network. This set of sensors spread over French territory, including the French overseas departments, regions and collectivities (DROM-COM), enables IRSN to permanently monitor the radiological situation on behalf of the citizens and the public authorities. It also has a warning function in the event of discharges over French territory or more distant locations: thus, if an abnormal level of radioactivity is detected, an alarm is immediately sent to the person on call (24h/24h).

The TELERAY network was created in 1991 and has been completely modernised since 2011, including the monitors, the data transmission network and the supervision system. IRSN has revised coverage both nationwide and close to the nuclear facilities which are the potential sources of risk. This more particularly entailed an increase in the number of monitors in the built-up areas within a radius of 10 to 30 km around the nuclear facilities. The network contains about 420 monitors across the country.

# APPENDIX 5 - Bibliography

## 5.1. Documents


/1/ Convention on Nuclear Safety (CNS), September 1994.

/2/ Guidelines regarding National Reports under the Convention on Nuclear Safety, IAEA - INFCIRC/572/Rev.6, January 2018.

/3/ Convention on Nuclear Safety – National Report for the Second Extraordinary Meeting

/4/ Annual reports from the Nuclear Safety Authority (ASN).

http://www.asn.fr/Informer/Publications/Rapports-de-l-ASN

/5/ EDF – The Inspector General's Report on Nuclear Safety and Radiation Protection

/6/ CEA – Annual reports on nuclear safety and radiation protection

http://www.cea.fr/Pages/surete-securite/priorite-securite-surete.aspx

/7/ ILL - Annual reports.

https://www.ill.eu/fr/a-propos-de-ill/documentation/annual-report/

/8/ IRSN – Report on the radiological state of the French environment from 2015 to 2017: https://www.irsn.fr/FR/expertise/rapports_expertise/Documents/environnement/IRSN-ENV_Bilan-Radiologique-France-2015-2017.pdf


## 5.2. Websites

The abovementioned documents, or at least the key points of their content, as well as other relevant information concerning the subject of this report are available on the Internet. The following sites may in particular be consulted:

- Légifrance: www.legifrance.fr
- ASN: www.asn.fr
- IRSN: www.irsn.fr
- SFRO: www.sfro.org
- CEA: www.cea.fr
- EDF: www.edf.fr
- ILL: www.ill.fr
- Andra: www.Andra.fr
- IAEA: www.iaea.org
- French national network of environmental radioactivity monitoring (RNM): www.mesure-radioactivite.fr

## APPENDIX 6 – List of main abbreviations

Table 17: List of main abbreviations

| | |
|---|---|
| AIP | Activity important for protection |
| ALARA | As Low As Reasonably Achievable. |
| ANDRA | French national radioactive waste management agency |
| AP-913 | Advanced Process 913 – Equipment reliability optimisation method |
| ASG | Steam generators feedwater system |
| ASN | Autorité de Sûreté Nucléaire (French nuclear safety authority) |
| BNI | Basic nuclear installation |
| CCC | (CEA) Crisis coordination centre |
| CEA | French Alternative Energies and Atomic Energy Commission |
| CFSI | Counterfeit, Fraudulent and Suspect Items (IAEA definition) |
| CIRES | (ANDRA) Industrial centre for collection, storage and disposal |
| CLI | Local Information Committee |
| CMS | Flood safety level |
| CODIRPA | Steering committee for managing the post-accident phase of a nuclear accident or radiological emergency situation |
| COFRAC | French accreditation committee |
| COFSOH | Steering Committee for Social, Organisational and Human Factors |
| CSA | (ANDRA) Aube waste disposal facility |
| CSPRT | French High Council for Technological Risk Prevention |
| DAC | Creation authorisation decree |
| DBE | Design-Basis Earthquake |
| DBNI | Defence Basic Nuclear Installation |
| DCN | (EDF) Nuclear Fuel Division |
| DEN | (CEA) Nuclear Energy Division |
| DGSCGC | General Directorate for Civil Security and Emergency Management |
| DPN | (EDF) Nuclear Operation Division |
| DPNT | (EDF) Nuclear and Thermal Generation Division |
| DSSN | (CEA) Nuclear Security and Safety Division. |
| DUS | Ultimate backup diesel generator set |

| | |
|---|---|
| ECOT | (EDF) Plant unit conformity examination programme |
| ECS | Stress Test |
| ECURIE | European Community Urgent Radiological Information Exchange |
| EDF | Électricité de France |
| EIP | Elements Important for Protection |
| ELC | Local emergency team |
| EPRI | Electric Power Research Institute |
| ESE | Events Significant for the Environment |
| ESR | Events Significant for Radiation protection |
| ESS | Events Significant for Safety |
| ETC-N | (EDF) national emergency technical support team |
| FARN | Nuclear rapid intervention force |
| FCE | (CEA) Central experience file |
| FRAMATOME | Formerly AREVA-NP, NSSS maker |
| GE LLS | Ultimate backup generating set |
| GPEC | Succession planning |
| GPE | Advisory Committee of experts |
| GPESPN | Advisory Committee of Experts for Nuclear Pressure Equipment |
| GPR | Advisory Committee of Experts for Nuclear Reactors |
| GPU | Advisory Committee of experts for Plants |
| HCTISN | High Committee for Transparency and Information on Nuclear Security |
| HERCA | Head of the European Radiological Protection Competent Authorities |
| IAEA | International Atomic Energy Agency |
| ICPE | Installations classified for protection of the environment |
| IGN | (CEA) General and nuclear inspectorate |
| ILL | Laue-Langevin Institute |
| IMS | Integrated safety Management System |
| INSAG | (IAEA) International Nuclear Safety Group |
| IRRS | Integrated Regulatory Review Service |
| IRSN | French Institute for Radiation Protection and Nuclear Safety |
| ITER | International Thermonuclear Experimental Reactor |
| MDEP | Multinational Design Evaluation Programme |
| MPS | Main Primary System |

| | |
|---|---|
| MSNR | Nuclear Safety and Radiation Protection Mission |
| MSS | Main Secondary System |
| NPE | Nuclear Pressure Equipment |
| NPP | Nuclear Power Plant |
| OEF | Operating experience feedback |
| OHF | Organisational and Human Factors |
| OPECST | Parliamentary Office for the Evaluation of Scientific and Technical Choices |
| ORANO | Formerly AREVA-NC, fuel cycle company |
| ORSEC (plan) | Disaster and emergency response organisation (plan) |
| OSART | Operational Safety Review Team |
| PAR | Passive hydrogen autocatalytic recombiners |
| PCC | (EDF) controls command post |
| PCD | Strategic management command post |
| PCD-L | (CEA) Local strategic management command post |
| PCD-N | (EDF) National emergency director |
| PCL | (EDF) Local command post |
| PCM | (EDF) Resources command post |
| PNGMDR | National radioactive materials and waste management plan |
| PPE | Multi-year energy programme |
| PPI | Off-site emergency plan |
| PSA | Probabilistic safety assessment |
| PSR | Periodic safety review |
| PTR (tank) | Fuel storage pools cooling tank |
| PUI | On-site emergency plan |
| PWR | Pressurised water reactor |
| QSE (System) | (CEA/DEN) Integrated Management System “Quality, health, security, safety, environment” |
| RANET | (IAEA) Response and Assistance Network |
| RCC | Design and construction rules |
| RFS | Basic safety rules |
| RGE | General operating rules |
| RHF | (Laue-Langevin Institute) High-flux reactor |
| RJH | Jules Horowitz Reactor |

| | |
|---|---|
| RNM | French national environmental radioactivity monitoring network |
| RPS | Preliminary safety analysis report |
| SAMG | Severe Accident Management Guidelines |
| SG | Steam Generator |
| SGDSN: | General Secretariat for Defence and Civil Protection |
| SGTR | Steam generator tube rupture |
| SISERI | Ionising radiation exposure monitoring information system |
| SOH | (EDF) approach to take account of Socio-Organisational and Human aspects |
| SSE | Safe Shutdown Earthquake |
| STE | Operating Technical Specifications |
| UNIE | (EDF) Operation Engineering Unit |
| UNSCEAR | United Nations Scientific Committee on the Effects of Atomic Radiation |
| USIE | Unified System for information Exchange in Incidents and Emergencies |
| WANO | World Association of Nuclear Operators |
| WENRA | European Nuclear Regulators’ Association |