AUTORITÉ DE SÛRETÉ NUCLÉAIRE

FOLLOW-UP TO THE FRENCH NUCLEAR POWER PLANT STRESS TESTS

UPDATE OF THE ACTION PLAN OF THE FRENCH NUCLEAR SAFETY AUTHORITY (ASN)

DECEMBER 2017

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Key:

General recommendation resulting from the 2012 Peer Review

Peer Review:

Recommendation resulting from the 2nd extraordinary meeting of the Convention on Nuclear Safety (CNS) 2012.

CNS:

Recommendation specific to France, resulting from the 2012 peer review

ASN prescription or letter
ECS (stress test) / ASN letter

State of progress of requests submitted by ASN
Progress: Study expected before…

INTRODUCTION

Background and conclusions of the 2013 and 2015 ENSREG seminars

On 26 April 2012, one year after the Fukushima Daiichi nuclear power plant accident, a joint statement by ENSREG and the European Commission concluded the stress tests conducted on the European nuclear power plants (NPPs). This statement emphasised the need to implement an overall action plan to ensure that these stress tests would be followed by safety improvement measures implemented in a consistent manner in each country.

The ENSREG global action plan required the nuclear safety regulator of each member country to publish a national action plan by the end of 2012. In December 2012, ASN, the French nuclear safety authority, published the action plan for France[1]. The national action plans then underwent a peer review which concluded with a seminar organised by ENSREG in Brussels, in April 2013.

For France, the seminar summary report in particular emphasized the comprehensive nature of the action plan presented, the importance that ASN attaches to the transparency of the stress tests process, the ambitious nature of the content and the implementation times for the measures to improve safety in the NPPs decided on in the wake of the Fukushima Daiichi NPP accident, and the consideration given to organisational and human factors, including conditions regarding the use of subcontractors.

Following the seminar organised by ENSREG in the spring of 2013, the decision was taken to produce a report, two years later, on the implementation of the measures carried out in each country, on the occasion of a new seminar organised by ENSREG in 2015. For France, this update mainly concerned the progress of the measures initiated for the various prescriptions issued by the safety regulator (text in red).

Following this 2nd seminar, the decision was taken to adopt a simplified European level peer review process. It consists in updating the initial action plan and publishing it on the ENSREG site, no later than at the end of 2017. The updated action plan will once again be presented on the occasion of a meeting of the Working Group WG1 of ENSREG.

In this context, this document follows the same structure as the national action plans drawn up by ASN in 2012 and 2015. Moreover, in accordance with the guidelines defined by the ENSREG members for the updating of the action plans, France has voluntarily decided to present the transposition of the WENRA reference levels for the existing reactors to its regulatory framework.

The main changes in the national action plan for France established by ASN

ASN has supplemented the prescription it issued in 2012 by a set of resolutions dated 21 January 2014 aiming to clarify certain design provisions of the *"hardened safety core"* (see § 1.1.1). ASN notes that to date EDF has met all the regulatory deadlines. These additional prescriptions led to the examination of several dossiers, with a view to their review by the ASN Advisory committees, since 2015. These examinations should continue in 2018 in order to look

[1] http://www.french-nuclear-safety.fr/Information/News-releases/European-stress-tests-ASN-publishes-its-national-action-plan

in detail at the various studies carried out by EDF and enable ASN to issue a position statement on them.

The summary reports for France, resulting from the seminars organised by ENSREG in 2013 and 2015, underlined the ambitious nature of the deadlines for implementation of the measures to improve the safety of the NPPs decided on following the Fukushima-Daiichi NPP accident.

To allow for the constraints associated with the engineering of these major works and the need to introduce the corresponding safety improvements as early as possible, their implementation is planned in three phases:

- Phase 1 was completed in 2015 with the deployment of operational mobile means;
- Phase 2 is in the course of deployment and will be completed in 2021;
- Phase 3 will then be implemented in conjunction with the periodic safety reviews.

The rest of this document specifies the various measures engaged on these subjects.

ASN will continue to be particularly vigilant in monitoring the implementation of all the prescriptions it has issued and which are presented below. It will also continue to be actively involved at an international level, particularly in the works undertaken at the European level on the management of nuclear or radiological emergency situations.

1 FOLLOW-UP OF THE RECOMMENDATIONS RESULTING FROM THE EUROPEAN PEER REVIEW

Following the Fukushima-Daiichi NPP accident, ASN issued a number of resolutions on 5 May 2011 asking the licensees of major nuclear facilities to conduct stress tests.

These were carried out on the basis of specifications which were consistent with the ENSREG specifications developed for the European stress tests.

The results of these stress tests were presented to the Advisory Committees for Reactors and for Laboratories and Plants which met on 8, 9, 10 November 2011, and ASN issued a position statement on them, on 3 January 2012. This position was itself examined under the European stress tests which were completed in April 2012.

On the basis of the opinion of the Advisory Committee and the conclusions of the European stress tests, ASN issued prescriptions in a series of resolutions dated 26 June 2012 requiring EDF to set up:

- firstly,
  - a hardened safety core of material and organisational provisions aimed at:
    a) preventing an accident with fuel melt, or limit its progression,
    b) limiting large-scale radioactive releases,
    c) enabling 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) which, using mobile means external to the site, can intervene on a nuclear site in a pre-accident or accident situation.
- and secondly,
  - a set of corrective actions or improvements (notably the acquisition of additional communication and radiological protection means, the implementation of additional instrumentation, extensive consideration of internal and external hazard risks, improvements to the management of emergency situations),
  - studies of modifications and additional means enabling ASN to issue a position statement on future safety options.

ASN notes that to date EDF has met its undertakings and all the regulatory deadlines that have reached term.

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

Generally speaking, ASN requests are part of a continuous process to improve safety with regard to the targets set for the 3rd generation reactors and aim in addition to be able to cope with situations far beyond those normally considered for this type of installation.

These requests are issued in application of the defence-in-depth approach and as such concern measures to prevent and mitigate the consequences of an accident, based on both additional fixed means and external mobile means planned for all the installations on a site beyond their initial design basis.

Given the nature of the works requested, the licensee must carry out studies for the design, construction and installation of new equipment which first of all require time and secondly a schedule to optimise their implementation on each NPP. Insofar as these major works are carried out on nuclear sites which are in service, it is also necessary to ensure that the safety of the power plants is not reduced during the work phases.

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): deployment of temporary or mobile measures to enhance protection against the main situations of total loss of the heat sink ("H1 situations") or of the electrical power supplies ("H3 situations"):

- reinforcing the existing on-site emergency equipment (pumps, generator sets, hoses, etc.),
- installing medium-capacity ultimate backup diesel-generator sets,
- reinforcing the earthquake (SSE) resistance and flood resistance (maximum thousand year flood) of the emergency management premises,
- installing tappings for connecting mobile equipment, particularly the FARN's equipment,
- deployment of the FARN,
- implementing an automatic reactor trip in the event of an earthquake,
- installing electrically backed-up level measurement instrumentation in the pools.

These temporary or mobile measures have been taken.

More specifically, since 31 December 2015, the gradually deployed 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). Operations can begin on a site within 12 hours following mobilisation of the teams.

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

- installation of a large-capacity ultimate backup diesel-generator set, including the construction of a dedicated building before 31 December 2018,
- setting up of a dedicated ultimate water source,
- setting up of an ultimate water makeup source for each reactor (on the PTR reactor cavity and spent fuel pit cooling and treatment system and the steam generators emergency feed water supply systems) and each pool,
- reinforcing the earthquake resistance of the containment venting filter,
- installation of sodium tetraborate baskets to reduce the emission of gaseous iodine in a severe accident situation on reactors that do not have SIC (silver-indium-cadmium alloy)

control rod clusters,

- installation of the first protections against extreme flooding (high-intensity rainfall and earthquake-induced rupture of tanks) in addition to the existing protected volume measures,
- implementation of means for detecting reactor vessel melt-through or the presence of hydrogen in the containment,
- installation of the first devices which, in the event of a break in the transfer tube or the pool compartment drainage pipes, prevent exposure of the fuel assemblies during handling and enable them to be placed in a safe position using the emergency manual controls,
- reinforcing the operating teams so that they are capable of managing all the extreme situations studied in the stress tests,
- construction on each site of an emergency centre capable of withstanding extreme external hazards (functionally independent in an emergency situation).

On the various sites, EDF has begun to implement a large part of the final measures recalled above, more particularly the construction of buildings intended to house the high-capacity ultimate back-up diesel generator sets, to raise the volume protection, to detect reactor vessel melt-through and the presence of hydrogen, to install the sodium tetraborate baskets in the reactor building sumps and to provide for an ultimate heat sink. ASN authorised these modifications and is monitoring their implementation through its inspections.

Phase 3 (as of 2019 on the occasion of the periodic safety reviews): this phase supplements phase 2, in particular to improve the level of coverage of the potential accident scenarios considered. EDF indicates that these means have also been defined with a view to continuing operation of the reactors beyond forty years:

- removal of the residual heat by the steam generators by means of an independent ultimate backup feed water system supplied by the ultimate heat sink,
- addition of a new makeup pump on the primary reactor coolant system,
- finalisation of the ultimate makeup connections, through fixed systems, to the steam generator auxiliary feed water supply system, to the PTR tank and to the spent fuel pool,
- 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),
- implementation of a solution for flooding the reactor pit to prevent corium melt-through of the basemat.

These works are in line with the investigation being carried out into the proposals for improvement of safety on the occasion of the various periodic safety reviews.

ASN position concerning the hardened safety core

The setting up of this hardened safety core, and the provisions of phases 2 and 3 in particular, requires validation of the design hypotheses for the material provisions, verification that the solutions proposed by the licensee will meet the safety objectives set and that they are technologically achievable.

On the basis of the files transmitted by EDF and the studies carried out, ASN asked its Advisory Committee for reactors (GPR) to submit its opinion on the more important points of these files. To date, three meetings of the Advisory Committee have been held:

Extreme natural hazards (GP1)

The GPR was consulted on 28 January and 10 February 2016 concerning the definition and justification of the natural hazard levels adopted by EDF for the hardened safety core of the PWRs. On the basis of the stress tests specifications, the natural hazards considered are: earthquake, flooding and “other natural hazards”. This review allowed the definition of the hazard levels to be considered for the design of the hardened safety core and, on certain points, led ASN to ask EDF for clarification.

Accident management (GP2)

The examination presented on 2 February 2017 focused primarily on the strategies for management of accidents that can occur on the reactor and pool and on the functional adequacy of the equipment (new or existing) for these accidents.

Severe accident management (GP3)

The examination presented on 7 July 2016, focused on the new measures proposed by EDF to mitigate the short and long-term consequences of a core meltdown accident.

The GPR gave its opinion on the principle of these modifications, in relation to the objective of integrating the lessons learned from the Fukushima-Daiichi NPP accident and the reduction in the difference in the level of safety between the reactors in operation and the safety objectives adopted for generation 3 reactors.

In this respect, the following were examined:

- the measures adopted to remove the residual heat from the reactor containment and the functional and design requirements of the systems used (containment venting-filtration system, containment ultimate spraying system, etc.),
- the measures adopted by EDF to limit as far as reasonably possible the risk of basemat melt-through in the event of a core melt accident,
- the accident situations covered by the measures (robustness against hazards, situations that might be excluded, etc.),
- the optimisation of the measures adopted to limit as far as reasonably possible radioactive releases into the environment and the possibility of cliff-edge effects during the progression of an accident.

This review enabled ASN to validate the principle of the new measures proposed by EDF in order to mitigate the consequences of a core-melt accident; on certain points, ASN asked EDF for clarifications and additional studies.

Planned examination for the reactors in operation

ASN will issue a position statement on the basis of the files to be transmitted by EDF to clarify the design of the systems and their implementation procedures. To date, a further four review meetings to examine these files by the Advisory Committee for reactors are envisaged:

Severe accidents

The GPR will be consulted concerning the additional elements ASN asked EDF to provide following the GPR meeting of July 2016 and concerning the baseline safety requirements concerning severe accidents drawn up by EDF on the occasion of the periodic safety reviews.

Projected date of meeting: early 2019

Demonstration of accident coverage

ASN asked EDF to identify the main accident situations covered by the hardened safety core according to the various deployment phases, the corresponding safety objectives, the control strategy planned for these situations and the means provided for to support this strategy. On the basis of the files to be transmitted by EDF, ASN will ask the GPR for its opinion.

Projected date of meeting: 2019

Ability to manage complex accident situations

The Fukushima-Daiichi NPP accident highlighted the difficulties inherent in the management of a nuclear accident under extreme conditions (destruction of part of the facilities, loss of backup and operational control systems, intervention in an irradiating environment, management of any contaminated waters, etc.). Appropriate management of the accident is dependent on the possibility of making efficient use of robust equipment and on the management of the teams dealing with the situation. The GPR will be consulted on the questions relating to the effectiveness of the material and organisational measures implemented by EDF on each NPP site.

The following will be presented at this meeting of the GPR:

- the organisational and managerial measures planned by EDF to cope with a complex accident situation (in particular the prioritised management of the different types of action to be carried out on the NPP site, the procedures and the operational control guides, the interfacing between the site's means and the means of the FARN),
- the sufficiency and robustness of the fixed and mobile equipment,
- the measures planned for human intervention in degraded conditions, the interfacing between each site's own resources and the FARN resources, and the management of contaminated waters.

Projected date of meeting: 2019

Summary of stress tests

It would in principle seem necessary to hold a GPR meeting, in the same way as for a periodic safety review, to assess the actions resulting from the stress tests.

Projected date of meeting: 2019

Ongoing examination of the Flamanville 3 EPR reactor

For the EPR reactor currently under construction in France, the definition of the extreme natural hazards to be considered for the hardened safety core was examined within the framework of GP1. These subjects are mainly tackled within the context of the (ongoing) examination of the application for authorisation to commission this reactor.

1.1 NATURAL HAZARDS

1.1.1 Hazard frequency

Peer Review: *The use of a return frequency of 10-4 per annum (0.1g minimum peak ground acceleration for earthquakes) for plant reviews/back-fitting with respect to external hazards safety cases.*

CNS: *Re-evaluating the hazards posed by external events, such as earthquakes, floods and extreme weather conditions, for each NPP site through targeted reassessment of safety.*

Recommendation specific to France resulting from the 2012 peer review

The review team recommends that ASN consider introducing probabilistic studies on the seismic hazard in France for the design of new reactors and for the next seismic hazard reviews for reactors in operation in order to have information on the probability of the event (annual frequency of occurrence) and to establish more robust bases for defining the design-basis earthquake.

ASN position and progress

The methodology used in France to assess external natural hazards is based essentially on a deterministic approach. The most penalising historical event based on a given period of observation - usually one hundred or one thousand years – is considered, to which large conventional margins are added. This approach is supplemented by probabilistic safety assessments (PSA) based on a systematic investigation of the accident scenarios to evaluate the probability of them leading to unacceptable consequences.

The external hazards are periodically reassessed in the periodic safety reviews conducted every 10 years. Moreover, the external hazards, particularly earthquakes and flooding, were the subject of a targeted reassessment as part of the stress tests conducted in France in 2011.

In view of the available comparative data and the improvements made to the reactors during the periodic safety reviews, implementation of the chosen methodology for earthquakes and flooding leads to a very demanding level of safety for the identification of the need for and nature of the modifications considered.

With regard to earthquakes, the methodology currently used to determine the seismic risk in France complies with the methodology and criteria prescribed by the IAEA. In accordance with the IAEA recommendations, it notably sets a minimum overall site response spectrum of 0.1 g with infinite frequency. Within the framework of the ongoing periodic safety reviews (third safety reviews of the 1300 MWe plant series), ASN has asked EDF to supplement this approach by the use of probabilistic methods to complement the seismic hazard analysis.

In 2013, the methodology proposed by EDF (to draw up an experimental seismic probabilistic safety assessment for the Saint-Alban NPP) was reviewed by meetings of the Advisory Committee, which concluded that work needed to be continued to achieve a method that was usable for the forthcoming periodic safety reviews. The Advisory Committee more specifically underlined the need for additional analyses concerning the seismic hazard assessment and the definition of the various equipment and structure failure modes and the extent of the equipment that must be covered by fragility curves taking into account the various failure modes.

ASN moreover ensures that the overall seismic design or justification process for the facilities, with regard to the definition of the hazard and the design and inspection methods for the specific equipment and structures, is conservative and cautious. Where seismic risks are concerned, the safety case comprises these two separate steps (the definition of the hazard at the design stage and the control of systems, structures and components (SSC)); the conservatism of the anti-seismic justification approach must be assessed on the basis of these two steps. A specific feature of the French approach in the anti-seismic domain consists, as a conservative measure, in not voluntarily using methods that allow the impact of the earthquake on the equipment and structures to be minimised, even if these methods are founded on experimental or scientific bases (for example, the non-use or partial use of behaviour coefficients). The conservatism introduced by this decision allows a prudent definition of the first areas of the facility that would be affected by an earthquake so that their reinforcement can be requested.

In addition, within the framework of the post-Fukushima measures, ASN has asked EDF to implement a hardened safety core of material and organisational provisions aimed at:

- preventing an accident with fuel melt, or limiting its progression,
- limiting large-scale radioactive releases,
- enabling the licensee to perform its emergency management duties.

Through a set of resolutions dated 21 January 2014, ASN set the seismic hazard to be considered for the SSC of the hardened safety core, defined by a response spectrum, as:

- encompassing the safe shutdown earthquake (SSE) for the site, plus 50%,
- encompassing the probabilistic site spectra with a return period of 20,000 years,
- and taking into account the particular site effects, in particular the nature of the soil, in its definition.

For the new hardened safety core SSC, the licensee adopts a spectrum higher than the response spectrum defined above.

ASN has therefore introduced a probabilistic component with a return period of 20,000 years into the definition of this hazard.

With regard to the flood risk, ASN published guide n° 13 in 2013 concerning[2] how to address the external flood risk for nuclear facilities. The principles adopted for the drafting of this guide follow on from those of RFS I.2.e[3] and the approach resulting from experience feedback from

[2] http://www.french-nuclear-safety.fr/References/ASN-Guides-non-binding/ASN-Guide-No.-13

[3] *Basic safety rule n° 1.2.e. of 12/04/1982 concerning consideration of the risk of flooding of external origin*

the Blayais site flood in 1999. This guide substantially reinforces the recommendations concerning the protection of BNIs against flooding with respect to basic safety rule RFS 1.2.e. The hazards to be taken into consideration are defined on the basis of in-depth knowledge of the different areas concerned, hydrology and meteorology in particular; the guide thus recommends considering 11 different hazards. It is based on deterministic methods, incorporating margins and combinations integrated into the hazards, taking into account a "probabilistic" exceedance target of less than 10^{-4} per year.

With regard to the other extreme climatic conditions, the return period considered for definition of the hazard is more variable.

As part of the design approach for the hardened safety core, EDF specified the hypotheses it was adopting for hazards other than earthquakes and flooding. The GPR was consulted on 28 January and 10 February 2016 regarding the risk levels of the extreme natural hazards considered for the hardened safety core.

ASN notes that a WENRA sub-group has been set up to define a methodological framework which could be utilised in the reference levels for consideration of natural hazards. ASN and the IRSN are active members of this sub-group.

State of progress: in 2013 and in 2014, ASN completed the following:

It set the seismic level of the hardened safety core SSC (envelope of deterministic criteria and a probabilistic definition with a return period of 20,000 years);

It published a new guide on how to address the external flood risk for nuclear facilities;

It adopted a position on the approach proposed by EDF for the probabilistic seismic safety assessments;

It examined the necessary changes in the regulations to integrate the new WENRA reference levels for external hazards.

In 2015 and 2016, ASN studied the proposals made by the licensees concerning the hazard levels to be adopted for external natural hazards and the dimensioning of the hardened safety core. It issued a position statement on these proposals and additional requests for certain sites or for the definition of certain climatic hazards. It asked the licensees to deploy the hardened safety core without delay, incorporating dimensioning margins.

1.1.2 Secondary effects of seismic events

Peer Review: *The possible secondary effects of seismic events, such as flood or fire arising as a result of the event, in future assessments.*

The indirect (secondary) effects of seismic events have been examined as of the second 10-yearly outage of the 900 MWe reactors during the periodic safety reviews. They were the subject of French stress tests concerning: the "seismic interaction"[4] approach, the loss of the off-site electrical power supplies, the conditions of site access after an earthquake, the fire and explosion risks induced by an earthquake, and the flooding risks induced by an earthquake (failure of dams, embankments, systems or equipment). The analysis of this work led ASN to

[4] *The purpose of the "seismic interaction" approach is to prevent damage to a necessary item in the event of an earthquake by an item or structure not subject to any seismic-resistance requirement.*

set the following prescriptions and formulate requests in addition to those expressed during the periodic safety reviews, more particularly to study the behaviour of these structures beyond their design baseline requirements.

ASN prescription

ECS - 11: Robustness of the Fessenheim and Tricastin embankments

Before 31 December 2013, the licensee will send ASN a study stating the level of seismic robustness of the embankments and the other structures protecting the facilities against flooding and, according to this level of robustness, presenting:

- the consequences of a failure of these structures,
- the technical solutions envisaged to protect the equipment of the hardened safety core which is the subject of the prescription [ST-1].

State of progress:

The licensee submitted the summary of its studies at the end of 2013. These required additional analyses, more specifically including surveys of the *in situ* structures to ascertain that the studies accurately reflected the structures such as they actually exist. ASN thus tasked IRSN, its technical support organisation, with an appraisal of these elements relating to the robustness of the embankments and other protective structures to earthquakes.

In November 2015, ASN considered that the demonstration of the flood protection stability in the event of an earthquake, adopted for the hardened safety core, embankments and other protective structures needed to be supplemented for the Fessenheim and Tricastin NPPs.

In the light of the additional data transmitted by EDF, ASN considered in May 2016 that the demonstration of the flood protection stability in the event of an earthquake adopted for the hardened safety core, embankments and other flood protection structures for the Fessenheim NPP, was confirmed for the hardened safety core earthquake level adopted by EDF.

With regard to the protective embankments for the Tricastin NPP installations, the additional data transmitted by EDF in the second half of 2017 was examined by ASN.

At the request of the ASN Commission, EDF was called to a hearing on 26 September 2017 and provided additional data. ASN considers that these data do not make it possible to rule out the risk in the short term. Consequently, in a resolution of 27 September 2017, ASN required that EDF temporarily shut down the four reactors of the Tricastin NPP as rapidly as possible.

EDF is required to supplement its geotechnical investigations in order to make a more detailed characterisation of the composition of the part of the embankment concerned and, before the reactors are restarted, make the necessary reinforcements to ensure the embankment's ability to withstand the maximum earthquake included in the nuclear safety case.

Areva was also given a hearing by the ASN Commission on 26 September 2017 regarding the consequences of a failure of a part of the embankment on the facilities it operates on the Tricastin site. ASN prescribes the measures appropriate to the potential risks faced by the Areva facilities. It thus asked for upgrading of the means to mitigate the consequences of chemical releases for the W and Comurhex 1 facilities. The resumption of activities in Comurhex 1, which is at present shut down, is dependent on this upgrade.

ASN reclassified the significant event notified by EDF as **level 2** on the **INES** scale.

ASN prescription

ECS - 9: Reinforcement of the seismic interaction approach

No later than 31 December 2012, the licensee shall take the necessary steps to prevent equipment whose operational availability is required for the safety demonstration from being damaged by other equipment items in the event of an earthquake.

Before 31 December 2013, the licensee shall present ASN with the results of the application of this approach, along with the intermediate results, before 30 June 2013.

State of progress:

In addition to applying the seismic interaction approach already in effect since the second ten-yearly reactor outages (and which has already been subject to ASN inspections), EDF has extended its approach to include additional configurations, such as certain site preparation phases. This new baseline is gradually coming into effect on the sites after an assimilation phase to allow the personnel to embrace the change in practices.

An addition, EDF has drawn up specific guides for the sites offering internal inspection guidelines for the seismic interaction approach to take account of beyond design-basis situations.

ASN regularly holds inspections on these topics in order to monitor the correct deployment of this approach.

ASN prescription

ECS - 12: Verification of the seismic design basis of the fire-fighting system

Before 30 December 2012, the licensee shall submit to ASN:

- a study evaluating the resistance to a safe shutdown earthquake (SSE) of the structures and equipment contributing to nuclear safety of the fire sectoring, fire detection and fixed extinguishing systems, subject to an operating basis earthquake resistance requirement,
- for items for which the ability to withstand the SSE cannot be proven, a programme of modifications to guarantee protection of fire safety functions in the event of an SSE.

State of progress:

EDF has submitted the required studies and proposed a programme of modifications aiming to ensure the seismic resistance of this equipment to these increased levels. These modifications will be carried out during the periodic safety reviews of the reactors concerned.

ASN letter to EDF further to the meeting of the Advisory Committee for reactors in November 2011: CODEP-DCN-2012-020754 of 26 June 2012.

Seismic resistance of hydrogen systems and lines carrying hydrogen

Application of the safe shutdown earthquake (SSE) design requirement to the hydrogen systems and integration of the "seismic interaction" approach for lines carrying hydrogen in the nuclear island is scheduled (in progress on the N4 plant series).

Fleet request-04: ASN asks you to speed up application of the SSE design-basis requirement to hydrogen systems and the implementation of the "seismic interaction" approach for lines

carrying hydrogen. Before the end of 2012, you will send me a revised implementation schedule.

Fleet request-05: ASN asks you to guarantee the SSE resistance of this equipment and to supplement the future baseline requirements accordingly.

State of progress:

EDF has transmitted a programme of seismic reinforcement for these lines. The upgrade deadlines have on average been met 3 years earlier than specified in the initial programme (the work is finished on the CP0 & N4 plant series and will be completed in 2017 on the CPY series, 2018 on the P4 series and 2020 on the P'4 series).

Flooding caused by an earthquake

For the Gravelines site, the retaining walls along the sides of the intake channel need to remain stable in order to guarantee the heat sink flow. This point was assessed on the occasion of the 3rd periodic safety reviews.

Request GRA-07: ASN asks you to perform additional studies to examine the behaviour of this channel beyond the SSE, for the fixed-level earthquakes used in the design sizing of the hardened safety core.

State of progress:

The studies have demonstrated the stability of the intake channel to the SSE.

For the Flamanville, Paluel and Penly sites, EDF has studied design-basis flood scenarios such as a flood caused by loss of integrity of the raw water ponds (SEA – demineralisation plant water supply system). EDF considers that the stability of the ponds is guaranteed for an earthquake larger than the SSE.

ASN considers that EDF needs to guarantee the ability of these ponds to withstand an earthquake larger than the SSE, in particular as they are relied on as the ultimate make-up source.

Request FLA-08 PEN-08 PAL-08: ASN asks you to justify the leaktightness of these ponds for an earthquake larger than the SSE, and for the fixed-level earthquakes used in the design sizing of the hardened safety core.

State of progress:

These points will be verified as part of the validation of the choice of ultimate heat sink required for deployment of the hardened safety core on the Flamanville, Penly and Paluel sites.

Risk of emptying of a channel onto the site

For the Tricastin, Fessenheim and Bugey NPPs, where the heat sink is at a higher elevation than the site platform, there is a risk of a major leak in the event of rupture of the cooling systems (CRF) of the facilities connected to it.

Even though, during the investigation, EDF stated that the valves can in all situations isolate the system from the heat sink, a study programme was initiated in order to improve the robustness of these shut-off valves up to a beyond-baseline level.

Request TRI-13 FSH-13 BUG-13: ASN asks you to take account, in the above-mentioned study, of all elements (sensors, automation, valves, part upstream of valves, etc.) designed to guarantee stoppage of emptying of the channel onto the site in the event of failure of the cooling system.

State of progress:

The studies tranmsitted by EDF will be analysed as part of the examination of the hardened safety core.

1.1.3 Protected volume approach

Peer Review: *The use of a protected volume approach to demonstrate flood protection for identified rooms or spaces.*

Following the flooding of the Blayais site in 1999, EDF put in place a protected volume perimeter[5] 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 responses to the observations made by ASN, which ASN judged to be satisfactory.

Within the framework of the stress tests, ASN has set the following prescriptions.

ASN prescription

ECS - 4: End of the Blayais OEF work (Blayais, Bugey, Cruas, Dampierre, Gravelines, Penly, Saint-Laurent-des-Eaux, Tricastin sites)

Before 31 December 2014, the licensee shall carry out work to protect the facilities against flooding, as mentioned in note ETDOIL080038 G.

State of progress: Work completed

ASN prescription

ECS - 5: Conformity of the protected volume

No later than 30 June 2012, the licensee shall carry out work to restore the conformity of the protected volume mentioned in report D4550.31-12/1367- Revision 0. The licensee shall implement the organisation and the resources as described in the above-mentioned document D4550.31-06/1840 revision 0 of 12/10/2007 to ensure that, with the passage of time, the protected volume retains its efficiency as assigned in the safety case.

State of progress:

The conformity restoration work was done on 30 June 2012. In addition, EDF has updated its baseline requirements for the periodic internal inspection of the protected volume.

[5] *The protected volume perimeter, which encompasses the buildings containing equipment capable of guaranteeing the safety of the reactors, was defined by EDF such as to ensure that an influx of water from outside this perimeter does not lead to flooding of the premises situated inside this perimeter.*

1.1.4 Advanced warning

Peer Review: *The implementation of advanced warning systems for deteriorating weather, as well as the provision of appropriate procedures to be followed by operators when warnings are made.*

The licensee has taken operational measures to protect the sites from extreme meteorological conditions (flooding, extreme heat, extreme cold, low water, etc.) more specifically including alert systems in the event of a foreseeable hazard (failure of a retaining structure upstream of the site, riverside or coastal flooding, possibly combined with extremely high winds, rainfall) and agreements with outside organizations such as Météo France and the Prefecture. ASN checked that these systems were operational during the targeted inspections carried out in 2011. The conclusions of these inspections led ASN to issue the following prescription for the Cruas and Tricastin sites.

ASN prescription

ECS - 7: Measures to cope with site isolation in the event of flooding (Cruas, Tricastin sites)

Before 31 December 2012, the licensee shall demonstrate to ASN that it has implemented an organisation and resources able to deal with site isolation in the event of flooding.

These measures serve to overcome the lack of resources and provide for the monitoring of certain meteorological and hydrological parameters, among other things. The use of special operating rules is decided on the basis of predetermined meteorological or hydrological criteria (monitoring of river levels or sea level) to allow the safe shutdown of the reactors.

State of progress: Action completed.

1.1.5 Seismic instrumentation

Peer Review: *The installation of seismic monitoring systems with related procedures and training.*

Recommendation specific to France resulting from the 2012 peer review

The seismic instrumentation could be improved to reach a level corresponding to the state of the art. It is recommended that a revision of the corresponding basics safety rule RFS 1.3.b (1984) be considered.

The operating conditions of the seismic instrumentation installed on the sites were specifically verified by ASN during the targeted inspections conducted in 2011. The findings led ASN to set prescriptions obliging the seismic instrumentation to be brought into conformity with the recommendations of RFS I.3.b[6]. ASN moreover asked EDF to conduct a comparative study of the seismic instrumentation currently used in France with that used internationally, to determine whether the French instrumentation is still suitable for measuring the seismic hazard or whether it needs to be replaced, in the light of more recent scientific knowledge.

[6] *Basic safety rule I.3.b 08/06/1984 concerning seismic instrumentation.*

ASN prescription

ECS - 8: Conformity of seismic instrumentation with RFS 1.3.b

Before 30 September 2012, the licensee shall check the conformity of its facilities with the provisions of basic safety rule I.3.b, the application of which is stipulated in the safety analysis report. The licensees shall submit to ASN an exhaustive summary of this review and the corrected deviations, plus a plan of action listing the correction time-lines for any remaining deviations.

State of progress: Actions completed.

ASN letter to EDF further to the meeting of the Advisory Committee for reactors in November 2011: CODEP-DCN-2012-020754 of 26 June 2012.

Fleet - 09: ASN asks you, before 30 June 2013, to carry out a study to compare the seismic instrumentation currently used in France with that used internationally. This study shall enable you to determine whether the instrumentation used in France is still suitable for measuring the seismic hazard or whether it needs to be replaced, in the light of the most recent scientific knowledge.

By the same deadline, you will present the conclusions you draw from your study and will, as necessary, propose an appropriate plan of action along with time-lines.

State of progress:

The EDF studies have been transmitted. ASN considers that the technology used enables these equipment items to fulfil their assigned safety function satisfactorily.

Revision of RFS I.3.b

ASN will also consider revising the basic safety rule in the light of the results of EDF's ongoing seismic instrumentation assessment.

State of progress:

In view of the files submitted by EDF, the work done to restore conformity of the nonconforming instrumentation and the fact that the safety function of this measurement is a simple threshold measurement, ASN considers that updating of the basic safety rule relative to the seismic instrumentation is not a priority.

1.1.6 Specific inspections and verifications of facilities

Peer Review: *The development of standards to address qualified plant walkdowns with regard to earthquake, flooding and extreme weather – to provide a more systematic search for non-conformities and correct them (e.g. appropriate storage of equipment, particularly for temporary and mobile plant and tools used to mitigate beyond design basis (BDB) external events).*

At the request of ASN, the licensee has set up processes for detecting deviations during normal reactor operation, periodic checks, maintenance operations, conformity reviews and safety assessments during the periodic safety reviews. These processes particularly concern the material and organisational measures implemented in the event of an earthquake, flooding, or other hazards. These processes for systematically searching out deviations have resulted in

hazard protection reinforcements. For example, in 2009 EDF informed ASN of the presence of noncompliant plugs on metal gratings in the operating buildings of several 900 MWe reactors. Correction of these deviations was completed in August 2010. More recently, in November 2012, EDF informed ASN of a deviation in earthquake resistance concerning the electrical cabinets of some of the 900 and 1300 MWe reactors. If these cabinets were to fall in the event of an earthquake, they could affect important electrical cabinets, some of which monitor the state of certain parameters necessary for incident operation after an earthquake. The licensee has undertaken to take compensatory measures in these NPPs to protect the important equipment against falls by these cabinets.

Following the Fukushima-Daiichi NPP accident, ASN conducted a series of targeted inspections applying specific inspection guides, for which its conclusions and the ASN requests can be consulted on its website (http://www.french-nuclear-safety.fr/). These requests, which are associated with specific time-lines, concern deviations relative to earthquake resistance, protection against flooding and other hazards. These requests are specifically monitored by ASN, and their implementation is verified during future targeted or routine inspections.

Furthermore, the stress tests gave the licensee the opportunity to conduct specific investigations into the condition of its facilities, including on-the-ground verifications of the actual condition of the facility.

Finally, the order of 7 February 2012[7] reinforced the requirements applicable to the search for and processing of deviations; these regulatory provisions entered force on 1 July 2013. At the end of 2014 or in early 2015, ASN will also publish a guide explaining the new requirements introduced by the order of 7 February 2012 concerning the processing of the deviations, more specifically with regard to the maximum time allocated for their correction.

State of progress:

Guide n°21 concerning the processing of conformity deviations was published in January 2015. Routine maintenance of the facilities and the inspections carried out by ASN are still bringing to light seismic resistance flaws on certain equipment, leading ASN to ask EDF to reinforce its organisation devoted to the detection and effective correction of such deviations.

1.1.7 Assessment of margins with respect to the flood risk

Peer Review: *The analysis of incrementally increased flood levels beyond the design basis and identification of potential improvements, as required by the initial ENSREG specification for the stress tests.*

For the various hazards considered for each site, the licensee presented the margins between the flood level reached and the level of the protections, within the framework of the current design, and drew conclusions regarding the additional measures to be taken, where applicable. The licensee has also studied several situations which it considers to be representative for evaluating the cliff-edge effects. These situations use assumptions that go beyond the design basis. This work gave rise to the following recommendation to reinforce the robustness of the installations in order to prevent the cliff-edge effects associated with heavy rainfall, or the failure of equipment on the site as a result of an earthquake.

[7] *Order of 7 February 2012 setting out the general rules applicable to basic nuclear installations.*

ASN prescription

In addition to the prescription on the hardened safety core presented in point 1.2, ASN also issued a specific prescription to EDF relating to the protection of the facilities against flooding beyond the baseline requirement.

ECS - 6: Reinforcement of protection against flooding

Before 31 December 2013, the licensee shall present ASN with the modifications it intends to make, before 31 December 2017, to reinforce the protection of the facilities against the risk of flooding beyond the baseline requirement in effect on 1 January 2012, for example by raising the protected volume to protect against situations of total loss of the heat sink or electrical power supplies, for the beyond-design-basis scenarios, more particularly maximum rainfall and flooding induced by the failure of on-site equipment under the effect of an earthquake.

State of progress:

- 31/12/2013: Presentation of modifications, in accordance with the prescription.
- 31/12/2014: Completion of the modifications on the Tricastin and Paluel sites.
- 31/12/2015: Completion of the modifications on the Blayais, Bugey, Cattenom, Cruas, Golfech and Nogent sites.
- 31/12/2016: Completion of the modifications on the Chooz, Fessenheim, Penly, Saint-Laurent-des-Eaux and Flamanville sites.

Forecast schedule

- 31/12/2017: Completion of the modifications on the Belleville, Chinon, Civaux, Dampierre, Gravelines and Saint-Alban sites.

Recommendation specific to France resulting from the 2012 peer review

The peer review team recommends performing a comparative study of the rain hazard as defined firstly according to ASN requirements and secondly according to the methodologies used by the other European countries.

ASN notes that a WENRA sub-group has been set up to define reference levels for natural hazards. ASN and the IRSN are active members of this sub-group. ASN will examine the conclusions of this sub-group's work and update its regulatory requirements if necessary.

1.1.8 Assessment of margins with respect to natural hazards

Peer Review: *In conjunction with recommendation 2.1 and 3.1.7, the formal assessment of margins for all external hazards including, seismic, flooding and severe weather, and identification of potential improvements.*

Recommendation specific to France resulting from the 2012 peer review

The peer review team confirms ASN conclusion on the need to conduct additional studies to determine complete and systematic design criteria and an assessment of the safety margins with respect to extreme climatic conditions.

ASN indicates in the report that the licensees have been asked to conduct analyses for these types of climatic phenomena which are linked to the flood risk. It has been recommended that

these additional studies should also include tornados, heavy rainfall, extreme temperatures and the relevant combinations of extreme climatic conditions. The peer review team recommends considering extreme meteorological conditions in the definition of the hardened safety core.

Within the framework of the stress tests, the licensee assessed the margins with respect to the seismic and flood risks. 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. The analysis of the additional studies has led ASN to set prescriptions and make the requests detailed below.

These additional requests concern complements to the margin assessments, and the reinforcement of the robustness of facilities beyond their current design basis. ASN has favoured the application of modifications that effectively improve the safety of the facilities over detailed studies of margins which can be completed subsequently.

ASN prescription

ECS - 1: Defining the structures and components of the *"hardened safety core"*, including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

Wording of the prescription and state of progress: See § 1.2

Comments: This prescription aims to give the facilities the means of coping with extreme situations. The licensee has submitted the requirements applicable to this hardened safety core to ASN. In order to define these requirements, the licensee adopts significant fixed margins in relation to the requirements applicable on 1 January 2012. The systems, structures and components (SSC) included in these measures shall be maintained in a functional state, in particular for the extreme situations studied for the stress tests. These SSC shall be protected against the internal and external hazards induced by these extreme situations, for example: falling loads, impacts from other components and structures, fires, explosions.

ASN prescription

ECS - 13: Study of the implementation of reactor trip in the event of an earthquake

Before 31 December 2012, the licensee shall submit to ASN a study of the advantages and drawbacks of implementing automatic reactor trip in the event of seismic loading, enabling the reactor to be shut down to the safest state, if the seismic level corresponding to a spectrum with half the amplitude of the design response spectrum of the site is exceeded.

State of progress:

EDF has examined the advantages and drawbacks of implementing a system of reactor trip in the event of an earthquake, and has decided to implement such a system. The modification was presented by the licensee and was approved by ASN.

ASN prescription

ECS - 15: Heat sink design review

Before 30 June 2012, the licensee shall produce and submit to ASN an overall review of the design of the heat sink with regard to hazards having an impact on the flow and quality of water and the risk of clogging of the heat sink.

State of progress:

EDF has submitted these studies. This point was reviewed by the Advisory Committee for reactors (GPR) and ASN issued a position statement (letter CODEP-DCN-2014-040468 of 23 October 2014): EDF proposed several changes which bring about an improvement in the monitoring of heat sinks and their protection against external hazards. ASN nevertheless considered that further improvements are required, more particularly in the identification of hazards and their combinations, in the requirements applicable to equipment for dealing with a massive influx of clogging debris, in the operational control documents and maintenance programmes, and in the monitoring of functions important for safety in the pumping station.

In addition, as part of the implementation of a hardened safety core, EDF is building an alternate heat sink, based on either artesian wells or existing tanks, whose seismic behaviour will be verified for earthquakes beyond the initial design-basis of the facilities (hardened safety core level earthquake).

ASN letter to EDF further to the meeting of the Advisory Committee for reactors in November 2011: CODEP-DCN-2012-020754 of 26 June 2012.

All – 14: ASN asks you to submit, for all sites, studies supplementing the stress tests, taking account of the snow-related risks, applying the specifications set by ASN for the meteorological conditions.

All – 15: ASN asks you to carry out a study that also takes account of the specific nature of gusting winds for all sites, before 31 December 2012.

All – 16: ASN asks you to consolidate the windspeed value to be considered in the studies on the indirect effects, before 31 December 2012.

ASN also asks you to check that, for winds of about 200 kph, the only projectiles to be considered are cladding sheets which are not liable to damage outdoor safety-related equipment (IPS) because of their very low rigidity.

All – 17: ASN asks you to present a more precise definition of extreme hail loading and to conduct a more detailed analysis of the resistance of the equipment on all of the sites.

Fleet – 18: ASN asks you to carry out studies to ensure that an "extreme lightning" loading be defined on the basis of all available operating experience feedback and taken into account for the reactors in operation, with regard to the equipment needed to manage H1, H3 and severe accident situations.

State of progress:

EDF has submitted the design baseline requirement for the hardened safety core against extreme external hazards other than earthquakes and flooding. This subject was reviewed by the GPR on 28 January and 10 February 2016. This review allowed definition of the hazard

levels to be adopted for the design of the hardened safety core. ASN issued a position statement on this subject in 2016 and asked for additional clarification on certain points.

ASN letter to EDF to define the orientations of the third periodic safety review of the 1300 MWe reactors, ref ASN CODEP-DCN-2011-00677 of 3 May 2011

Prevention against the effects of climatic hazards: the licensee will reassess the risks induced by external hazards of climatic origin (heat waves, lowest safe water level, frazil ice, extreme winds, extreme flooding, etc.). ASN has also asked the licensee to take into consideration the external risks induced by tornados.

ASN will supplement its position according to the recommendations in the external hazards guide to be defined by WENRA.

With regard to the hazards associated with the flood risk (heavy rainfall in particular), the beyond-design-basis margins were analysed as part of the stress tests. This analysis led ASN to oblige the reinforcement of protection of the facilities against flooding beyond the current baseline requirement (see § 1.1.7)

EDF has submitted the design baseline requirement for the hardened safety core against extreme external hazards other than earthquakes and flooding. This subject was reviewed by the GPR on 28 January and 10 February 2016 as mentioned above and was the subject of a number of additional requests from ASN.

Recommendation specific to France resulting from the 2012 peer review

The licensee has made an approximate estimate of the safety margins for earthquakes beyond the design-basis earthquake. A more systematic assessment requested by ASN and carried out on the basis of a probabilistic safety assessment or an assessment of the safety margins would be appreciated.

ASN letter to EDF further to the meeting of the Advisory Committee for reactors in November 2011: CODEP-DCN-2012-020754 of 26 June 2012.

All – 02 ASN asks you to include an assessment of the robustness of the facilities to a seismic risk beyond the design baseline in the next periodic safety reviews. This assessment will aim on the one hand to periodically analyse the risks of a beyond baseline cliff-edge effect, on the basis of updated data and, on the other, to identify the works, structures and equipment necessary for safe shutdown of the reactor and requiring further reinforcement.

ASN asks you by the end of 2012 to specify and justify the methods for assessing seismic robustness beyond the design baseline that you will implement during the forthcoming periodic safety reviews and how they are to be applied per unit, site or plant series.

State of progress:

In response to this request, EDF transmitted guides for verifying the seismic behaviour of equipment beyond their design basis requirements. These guides are currently being examined by ASN.

EDF will also carry out seismic probabilistic safety assessments during the 4th periodic safety reviews of its 900 MWe reactors.

Fleet – 03 ASN asks you to propose an action plan within six months for a more detailed assessment of seismic margins, to complete the review of equipment liable to be susceptible to cliff-edge effects and initiate the necessary corrective measures.

State of progress:

In 2014 and 2015, EDF transmitted various documents. The methods to verify the seismic margins transmitted in the above answer will be implemented to check the SSC of the hardened safety core as and when it is implemented on the facilities (according to the various installation phases presented in §1). They are currently being examined by ASN.

1.2 LOSS OF THE SAFETY SYSTEMS

On completion of the stress tests, ASN considered that continuation of operation of the facilities examined required an increase in their robustness to extreme situations beyond the existing safety margins as quickly as possible. Consequently, ASN was required to issue the following prescription, the scope of which satisfies several of the peer review's recommendations, as well as the following recommendation resulting from the second extraordinary meeting of the Convention on Nuclear Safety.

CNS: *Upgrading safety systems or installing additional equipment and instrumentation enhance the ability of each nuclear power plant to withstand an unexpected natural event without access to the electrical power grid for an extended period of time, including for an external event affecting multiple units.*

ASN prescription

ECS - 1: Defining the structures and components of the *"hardened safety core"*, including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

I. Before 30 June 2012, the licensee shall propose to ASN a hardened safety core of robust material and organisational measures designed, for the extreme situations studied in the stress tests, 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.

II. Within this same time-frame, the licensee shall submit to ASN the requirements applicable to this hardened safety core. In order to define these requirements, the licensee adopts significant fixed margins in relation to the requirements applicable on 1 January 2012. The systems, structures and components (SSC) which are included in these measures shall be maintained in a functional state, in particular for the extreme situations studied in the stress tests. These SSC shall be protected against the internal and external hazards induced by these extreme situations, for example: falling loads, impacts from other components and structures, fires, explosions.

III. For this hardened safety core, the licensee installs SSC that are independent and diversified in relation to the existing SSC, in order to limit common mode risks. If applicable, the licensee shall justify the use of undiversified or existing SSC.

IV. The licensee shall take all necessary steps to ensure that the emergency organisation and resources are operational in the event of an accident affecting all or some of the facilities on a given site.

To this end, the licensee includes these steps in the hardened safety core defined in § I. of this prescription and, in accordance with II of this prescription, more specifically sets requirements concerning:

- the emergency situation management premises, so that they offer considerable resistance to hazards and remain accessible and habitable at all times and during long-duration emergencies, including in the event of radioactive releases. These premises shall enable the emergency teams to diagnose the status of the facilities and control the resources of the hardened safety core,
- the availability and operability of the mobile means vital for emergency management,
- the means of communication essential to emergency management, in particular comprising the means of alerting and informing the emergency teams and the public authorities and, should this prove necessary, the arrangements for alerting the population if the off-site emergency plan is triggered in reflex phase by delegation from the Prefect,
- the availability of parameters used to diagnose the status of the facility, as well as meteorological and environmental measurements (radiological and chemical, inside and outside the emergency situation management premises) enabling the radiological impact on the workers and general public to be evaluated and predicted,
- the active dosimetry resources, radiation protection measuring instruments and individual and collective protective means. These means shall be available in sufficient quantity by 31 December 2012.

State of progress:

A specific meeting of the GPR was held on 13 December 2012 to give its opinion on:

- the objectives associated with the hardened safety core and its functional perimeter,
- the initiating events considered when defining the hardened safety core and their levels,
- the choices adopted when considering the events that these initiating events induce on the facility and the hardened safety core,
- the implementation conditions for the hardened safety core, more specifically the facility states in which it can be used,
- the requirements associated with the equipment of the hardened safety core,
- the methods and criteria used to demonstrate compliance with the requirements,
- the consideration of organisational and human factors in the implementation of the hardened safety core provisions,

- the emergency management provisions planned to meet the requirements of the hardened safety core.

The GPR concluded on the need to supplement the functional perimeter of the hardened safety core and to detail the design hypotheses, particularly with regard to earthquakes. On this basis ASN issued additional prescriptions through a set of resolutions dated 21 January 2014.

On 30 June 2014, EDF submitted the list of new and existing equipment items intended to form part of the hardened safety core, the general hypotheses for the design, construction, verification, qualification and testing of these new or existing equipment items, the seismic levels for each site in response to ASN requests of 21 January 2014. These files were examined by IRSN. Certain specific subjects were reviewed by the Advisory Committee for reactors at its meetings of July 2016 (GP3) and February 2017 (GP2).

In July 2017, ASN also issued a series of requests concerning the mitigation of the consequences of severe accidents.

1.2.1 Cooling systems and alternate heat sink

Peer Review: *The provision of alternative means of cooling including alternate heat sinks. Examples include steam generator (SG) gravity alternative feeding, alternate tanks or wells on the site, air-cooled cooling towers or water sources in the vicinity (reservoir, lakes, etc.) as an additional way of enabling core cooling.*

None of the French reactors in operation has an alternate heat sink. The Flamanville 3 EPR reactor will have an alternate heat sink.

During the stress tests and at the request of ASN, the licensee analysed situations entailing loss of heat sink and loss of electrical power supplies to the reactors, going beyond the situations studied in the current baseline requirements, more specifically considering scenarios which, on the one hand, have a lasting effect on all the reactors on a site and which can, on the other, be induced by an earthquake or external flooding, including of a level greater than that considered in the current baseline requirements. These additional studies have led ASN to issue the following prescriptions and formulate requests.

ASN prescription

ECS - 16.I: Emergency water supply resources

I. Before 30 June 2013, the licensee shall present ASN with the intended modifications for installing technical backup devices for long-term removal of residual heat from the reactor and the spent fuel pool in the event of loss of the heat sink. These devices must meet the requirements concerning the hardened safety core presented in prescription [ECS-1] above. Pending the commissioning of the ultimate backup electrical power supplies mentioned in paragraph II of prescription [ECS-18], these devices must be kept functional in the event of prolonged and complete loss of the electrical power supplies, using temporary electrical systems if necessary.

State of progress:

The modifications have been presented for all sites. The technical feasibility of some of them is currently being analysed, more specifically to assess the productivity of certain groundwater resources.

ASN prescription

ECS - 16.II: Emergency water make-up in the reactor coolant system when it is open

II. Before 31 December 2012, the licensee shall present ASN with the modifications it intends to make for the installation, before 31 December 2013 unless specifically justified, of systems to ensure the injection of borated water into the reactor core in the event of total loss of site electrical power supplies when the reactor primary coolant system is open.

Before 30 June 2013, the licensee shall propose final requirements to ASN for these provisions and shall indicate whether or not they are part of the hardened safety core.

State of progress:

ASN gave its consent for the installation on the 900 MWe reactors of a fixed system comprising an electric motorised pump connected to the EAS and RIS systems. It is electrically powered by the new electricity generating set installed in response to prescription ECS-18.III (see § 1.2.9) allowing the injection of borated water. The implementations of these modifications is now complete. On the other plant series, EDF explained that the existing system allows the injection of borated water into the reactor coolant system in these situations.

For the deployment of the hardened safety core, a new pump will be installed to ensure reactor coolant make-up in these situations. It will have its own specific instrumentation and control. This new pump and its connection to the sumps will also be used by EDF to allow prevention of basemat melt-through in the event of a severe accident. The system as a whole shall be able to function after an earthquake and in severe accident conditions with total core melt.

ASN prescription

ECS - 17: Reinforcement of the facilities to manage long-duration situations of total loss of heat sink or total loss of electrical power supplies

No later than 31 December 2013, the licensee shall examine the requirements assigned to the equipment needed to manage total loss of heat sink or total loss of electrical power situations, with regard to temperature resistance, resistance to earthquakes, flooding and the effects induced on the facility by these hazards.

Before 31 December 2013, the licensee shall submit a summary of this review to ASN, along with proposals for changes to the baseline safety requirements and the resulting facility reinforcements in order to deal with these situations, in particular for long-duration scenarios.

State of progress: Studies received.

Control of situations of total loss of heat sink or total loss of electrical power supplies is supported by the hardened safety core. The integration of the requirements with regard to temperature resistance, earthquake resistance, flooding and the effects these hazards induce

on the facility is described in EDF's reply concerning the general approach to the design of the hardened safety core, submitted in June 2014.

This file was the subject of an initial examination and was presented to the Advisory Committee for reactors. Since then, EDF has clarified certain of the intended design, construction and operating choices. These aspects are examined by ASN in a GPR meeting or through specific examinations.

With regard to the need for changes in the baseline requirements, this will be examined in the normal process of the periodic safety reviews. ASN will ensure that these changes are consistent with the new WENRA reference levels for external hazards.

1.2.2 Electrical power sources

Peer Review: *The enhancement of the on-site and off-site power supplies. Examples include adding layers of emergency power, adding independent and dedicated backup sources, the enhancement of the grid through agreements with the grid operator on rapid restoration of off-site power, additional and/or reinforced off-site power connections, arrangements for black start of co-located or nearby gas or hydro plants, replacing standard ceramic based items with plastic or other material that are more resistant to a seismic event. Another example is the possible utilization of generator load shedding and house load operation for increased robustness, however, before introducing such arrangements the risks need to be properly understood.*

During the stress tests, ASN analysed situations with loss of electrical power supplies to the reactors going beyond the situations covered by the current baseline requirements, in particular considering scenarios which, on the one hand have a lasting effect on all the reactors on a site and which, on the other hand, could be caused by an earthquake or external flooding, including of a level higher than that considered in the current baseline requirements. This led ASN to set the following prescriptions and formulate requests in addition to the commitments taken by the licensee.

ASN prescription

ECS - 18.II: Additional electrical power supply means

As early as possible, given the constraints of fleet-wide deployment, and in any case before 31 December 2018, the licensee shall - for each reactor on the site - install an additional electrical power supply capable of supplying the systems and components of the hardened safety core as per prescription [ECS-1] if the other off-site and on-site electrical power supplies are lost.

These systems must meet the requirements concerning the hardened safety core as per prescription [ECS-1].

State of progress: Deployment in progress on all sites. Completion deadline of 31/12/2018.

ASN prescription

ECS - 18.III: Installation of provisional emergency electrical power supplies pending installation of the means required by prescription ECS – 18.II

In the meantime, and no later than 30 June 2013, the licensee shall install a temporary system on each reactor for supplying:

- the I&C (Instrumentation and Control system) necessary in the event of loss of the off-site and on-site electrical power supplies,
- the control room lighting.

State of progress:

As at 30 June 2013, the licensee has installed temporary ultimate backup diesel-generator sets on each reactor.

EDF commitment given in the stress test reports submitted on 15 September 2011

The robustness of the associated electrical equipment to the situations envisaged further to Fukushima experience feedback will be consolidated up to a seismic level of 1.5 times the safe shutdown earthquake (SSE). Modifications will be proposed if necessary

State of progress: Items transmitted as at 31/12/2012.

For the equipment outside the hardened safety core, the seismic resistance complies with the baseline safety requirements redefined for the periodic safety reviews, on the basis of methods that include margins. The hardened safety core components will be verified on the basis of the safe shutdown earthquake level prescribed by ASN for the hardened safety core and on the basis of codified methods or realistic deterministic methods. If seismic margins are not available, the components concerned shall be replaced. This verification will be carried out as and when the hardened safety core is implemented in accordance with the different phases presented in §1.

Lastly, the mobile means that the FARN may bring in (see point 1.2.13) shall notably include emergency diesel generator sets and lighting systems.

1.2.3 Electric backup batteries

Peer Review: *The enhancement of the DC power supply. Examples include improving the battery discharge time by upgrading the existing battery, changing/diversifying battery type (increasing resistance to common-mode failures), providing spare/replacement batteries, implementing well-prepared load shedding/staggering strategies, performing real load testing and on-line monitoring of the status of the batteries and preparing dedicated recharging options (e. g. using portable generators).*

Electric batteries provide and guarantee continuity of the electrical supply to certain key equipment items in the event of loss of the off-site electrical power supplies and when the emergency generator sets are not operating. The protection, capacity and life of these batteries were specifically studied within the framework of the stress tests. ASN had to set the following prescriptions and requests and the peer review led to a recommendation on this subject.

Recommendation specific to France resulting from the 2012 peer review

The peer review team recommends that ASN should also consider the possibility of recharging the batteries before they are completely discharged in the event of total loss of electrical power supplies, and the already envisaged increase in their capacity.

ASN prescription

ECS - 18.I: Increased battery life

I. Before 30 June 2012, the licensee shall present ASN with the modifications it intends to make before 31 December 2014 in order to significantly increase the operating life of the batteries used in the event of loss of the off-site and on-site electrical power supplies.

ASN letter to EDF further to the meeting of the advisory committee for reactors in November 2011: CODEP-DCN-2012-020754 of 26 June 2012.

All – 24: ASN also asks you to study the advantages and drawbacks of installing a device making it possible to recharge the batteries used in the event of total loss of electrical power supplies.

State of progress and future time-lines:

The operating life of the batteries has been increased from 1 hour to 2 hours (completion of works at end of 2014) and at the end of June 2013 the licensee installed temporary ultimate backup diesel generator sets (ensuring minimum instrumentation & control and control room lighting) pending the installation by the end of 2018 of ultimate backup diesel generator sets capable of withstanding the design-basis conditions of the hardened safety core.

1.2.4 Operational and preparatory actions

Peer Review: *Implementation of operational or preparatory actions with respect to the availability of operational consumables. Examples include, ensuring the supply of consumables such as fuel, lubrication oil, and water and ensuring adequate equipment, procedures, surveillance, drills and arrangements for the resupply from off-site are in place.*

The actions to be implemented further to a large-scale event are of a material and organisational nature. Aspects studied with particular attention include the autonomy of the sites in all circumstances - especially further to an event leading to site isolation - the bringing in of outside resources, and personnel training. These aspects were verified during targeted inspections carried out in 2011. In the course of these inspections ASN identified deviations that led to specific requests (the inspection follow-up letters can be consulted on the ASN website: http://www.french-nuclear-safety.fr/). ASN also issued the following prescriptions and requests.

ASN prescription

ECS - 1: Defining the structures and components of the *"hardened safety core"*, including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

Wording of the prescription and state of progress: See §1.2

Comments: The material and organisational provisions included in the hardened safety core must enable the licensee to fulfil its emergency management duties. Implementing these

provisions implies training the personnel and integrating appropriate modifications on the sites to facilitate their deployment.

ASN letter to EDF further to the meeting of the advisory committee for reactors in November 2011: CODEP-DCN-2012-020754 of 26 June 2012.

All – 19: ASN asks you to improve the reliability of the on-site stocks of fuel and oil, as well as their resupply in all circumstances, such as to ensure an autonomy of at least 15 days for all the reactors of a site. ASN asks you to submit a corresponding action plan to it within two months, along with the associated schedule.

State of progress:

This subject undergoes verification as part of ASN normal inspection activities. The FARN has set up an organisational structure and means for supplying consumables to sites where access conditions have been impaired.

1.2.5 Instrumentation and measuring

Peer Review: *The enhancement of instrumentation and monitoring. Examples include separate instrumentation and/or power sources to enable monitoring of essential parameters under any circumstances for accident management and the ability to measure specific important parameters based on passive and simple principles.*

During the stress tests, complementary studies were conducted to examine the robustness of the instrumentation & control necessary for diagnosis and guidance of the operating team during electrical power failure. The conclusions of this work led ASN to issue the following prescriptions and requests, and in particular the inclusion of the technical instrumentation for emergency management in the *"hardened safety core"*. They were also the subject of observations during the peer review.

Recommendation specific to France resulting from the 2012 peer review

The instrumentation must undergo qualification for the environmental characteristics prevailing during severe accidents and for external hazards, and its electrical power supply must be guaranteed (the spent fuel pool instrumentation shall be included in the hardened safety core). […]

The instrumentation that detects entry into a severe accident situation is not available from the control room. […]

For the reactors in service, operation of the instrumentation necessary in a severe accident situation cannot be guaranteed in the event of an earthquake because it is not qualified for earthquakes. This instrumentation should be added to the hardened safety core. […]

ASN has asked the licensees to include the equipment necessary for emergency situation management in the hardened safety core.

ASN prescription

ECS - 1: Defining the structures and components of the *"hardened safety core"*, including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

Wording of the prescription and state of progress: See §1.2

Comments: ASN has asked the licensees to include the equipment and instrumentation necessary for emergency situation management in the hardened safety core.

ASN prescription

ECS - 19: Redundancy of instrumentation for detecting reactor vessel melt-through and hydrogen in containment

I. As early as possible, given the constraints of cross-fleet deployment, and in any case before 31 December 2017, the licensee shall install redundant means in the reactor pit to detect vessel melt-through as well as in the containment to detect the presence of hydrogen.

Instrumentation in the control room shall indicate corium melt-through of the vessel.

State of progress:

- 31/12/2016: Implementation of redundant means for the Blayais, Bugey, Chinon, Cruas, Dampierre, Fessenheim, Gravelines, Saint-Laurent, Tricastin, Belleville, Flamanville, Paluel, and Saint-Alban sites
- 31/12/2017: Deadline for the implementation of redundant means for the Cattenom, Chooz, Civaux, Golfech, Nogent and Penly sites.

II. Before 31 December 2013, the licensee shall propose final requirements to ASN for these provisions and shall indicate whether or not they are part of the hardened safety core.

State of progress:

Studies submitted, the modification application deadlines are maintained and partially deployed mid-2017.

ASN prescription

ECS – 18 I: Increased battery life

ECS – 18 II: Ultimate backup diesel generator sets

Wording of the prescription and state of progress: See § 1.2.2 and § 1.2.3

Comments: For the reactor fleet in service, the batteries supply power for the instrumentation & control necessary for diagnosis and for guiding the operating team during an electrical power failure. The ultimate backup diesel generator sets shall guarantee the resupply of the minimum instrumentation and control necessary for the information required in core melt situations.

ASN prescription

ECS - 20: Reinforcement of pool condition instrumentation

I. Before 30 June 2012, the licensee shall present ASN with the modifications to be made, for measuring both the condition of the fuel storage pool (temperature and water level in the spent fuel pool) and the radiological atmosphere in the fuel building hall.

State of progress:

Information submitted on 30/06/2012. ASN has formulated additional requests relative to the instrumentation for managing hardened safety core situations, through a set of resolutions dated 21 January 2014.

II. Pending their implementation:

- By 31 December 2012 at the latest, the licensee shall provide its national emergency organisation with charts indicating the times to reach boiling point in the event of total loss of cooling, according to the residual power of the fuel stored in the spent fuel pool.
- No later than 31 December 2013, the licensee shall ensure that level measurement in the event of total loss of electrical power supplies is available.

State of progress:

The charts are available and pool level measurement has been modified to benefit from an electrical power backup.

1.2.6 Improvement in safety at shutdown and in the different reactor states

Peer Review: *The enhancement of safety in shutdown states and mid-loop operation. Examples of improvements include, reducing or prohibiting mid-loop operation, adding dedicated hardware, procedures and drills, the use of other available water sources (e. g. from hydro-accumulators), requiring the availability of SGs during shutdown operations and the availability of feed water in all modes.*

During the stress tests, ASN analysed situations with loss of heat sink and loss of electrical power supplies to the reactors, going beyond the situations considered in the current baseline requirements. It considered all the states of reactors and fuel storage pools, and scenarios which firstly have a lasting effect on all the reactors on a site and secondly could be caused by an earthquake or external flooding, including of a level higher than that considered in the current baseline requirements. For each of these situations, the times before the fuel becomes exposed in the event of loss of the cooling systems and the electrical supplies have been evaluated. ASN issued the prescriptions detailed in § 1.2.1 to § 1.2.5 and made the following requests, in addition to the commitments made by the licensee.

ASN prescription

ECS – 16 II: Emergency water make-up in the reactor coolant system

Wording of the prescription and state of progress: **See § 1.2.1**

Comments: This system ensures the injection of borated water into the reactor core in the event of total loss of on-site electrical power when the reactor coolant system is open.

EDF is initially making provisions on each reactor to allow the injection of borated water by connecting mobile means to tappings installed for that purpose (completion at end of 2015), a function that will be ensured in a second phase by fixed equipment of the hardened safety core.

ASN letter to EDF further to the meeting of the advisory committee for reactors in November 2011: CODEP-DCN-2012-020754 of 26 June 2012.

All – 30: ASN asks you to integrate into the accident operations procedures and the severe accident management documents - including the severe accident management guidelines in particular - 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.

State of progress:

EDF has responded to this request. The elements relating to the operational management of these equipment items were examined by ASN prior to the implementation of the modifications to permit the injection of borated water and within the framework of the requests for modification of emergency management, also submitted to ASN.

EDF commitment given in the stress test reports submitted on 15 September 2011

Several changes in accident operating management shall be made according to the different reactor states.

State of progress:

ASN has agreed to the implementation of a change in accident management in situations of total loss of electrical power supplies.

The licensee can also call upon the resources of the FARN liable to intervene simultaneously on all the installations of a site.

1.2.7 Reactor primary coolant pump seals

Peer Review: *The use of temperature-resistant (leak-proof) primary pump seals.*

Correct functioning of the reactor coolant pump (RCP) seals, when the reactor is in operation or in hot shutdown state, requires cooling by continuous injection of pressurised water. For the 900 MWe plant series reactors, if the off-site electrical power supplies and the on-site emergency generator sets are lost while in either of these states, pressurised water injection is ensured by a pump common to a pair of reactors. The analysis of the different cases of loss of electrical power supplies has led ASN to make the following requests.

ASN letter to EDF further to the meeting of the advisory committee for reactors in November 2011: CODEP-DCN-2012-020754 of 26 June 2012.

900 MWe – 22: ASN asks you to present it with a safety case within six months, as well as any necessary modifications, to ensure simultaneous injection at the RCP seals on two neighbouring reactors of the 900 MWe plant series, in the event of loss of off-site electrical power supplies and of the on-site emergency generator sets.

All – 23: ASN asks you to submit to it within six months the safety case for avoidance of the onset of a severe accident following deterioration of the RCP seals, in a situation involving loss of off-site electrical power supplies and all internal electrical sources (including the LLS) on a site.

State of progress:

The licensee has finalised the installation of high-temperature seals capable of withstanding loss of cooling for an extended period.

EDF has also studied the installation of a passive device for protecting seal No.1 of the reactor coolant pumps in the event of loss of the electrical power supplies. Qualification of this device is in progress.

At the same time, EDF is qualifying the high-temperature seals in order to define the chosen solution in 2018.

1.2.8 Ventilation

Peer Review: *The enhancement of ventilation capacity during SBO to ensure equipment operability.*

Many items of equipment cannot function in the medium and long term if they, or the premises in which they are situated, are not ventilated or cooled. As improving the robustness of certain items of equipment required for cooling the reactor or the spent fuel pool is part of the hardened safety core, this also implies that the robustness of their means of ventilation must also be considered. These aspects formed the subject of an investigation presented to the Advisory Committee for reactors on 13 December 2012.

Furthermore, at the end of the stress tests ASN issued the following prescriptions and requests.

ASN prescription

ECS - 17: Reinforcement of the facilities to manage lasting situations of total loss of heat sink or total loss of electrical power supplies

Wording of the prescription and state of progress: See § 1.2.1

Comments: the problems related to ventilation will be examined during the review of the measures proposed by EDF for the hardened safety core and in response to this prescription.

At the request of ASN, EDF has identified the hardened safety core equipment and its supporting equipment (i.e. equipment whose failure compromises operation of the hardened safety core) and the requirements applicable to these items of equipment. Operation of the hardened safety core support functions shall be ensured in hardened safety core conditions, as and when it is put in place.

ASN letter to EDF further to the meeting of the Advisory Committee for reactors in November 2011: CODEP-DCN-2012-020754 of 26 June 2012.

All – 28: With regard to total loss of heat sink situations, ASN asks you to examine the means of ultimately restoring sustainable cooling of the reactors and pools, calling on the lessons learned from the Fukushima accident.

State of progress:

This safety function shall be ensured by the hardened safety core on the basis of an alternate heat sink and ultimate backup diesel generator sets. EDF intends to install new systems more

specifically to remove reactor heat via the steam generators, inject water into the pool and cool by means of a mobile system.

1.2.9 Main and emergency control rooms

Peer Review: *The enhancement of the main control room (MCR), the emergency control room (ECR) and emergency control centre (ECC) to ensure continued operability and adequate habitability conditions in the event of a station black-out (SBO) and in the event of the loss of DC (this also applies to Topic 3 recommendations).*

Total loss of electrical power supplies (loss of the off-site sources and the on-site diesel generators), also called station black-out (SBO), is a situation taken into account in the severe accident management guidelines. This situation leads to the loss of the dynamic containment ensured by the ventilation systems, and particularly the main control room ventilation function and this ventilation's filtration via iodine trap. Permanent habitability of the control room is guaranteed, unless the reactor containment U5 venting system filter is opened. Habitability can be temporarily compromised if the U5 system is used, or if there are large releases of toxic substances from outside the site. In this respect, the licensee has planned to reinforce the electrical back-up of control room ventilation and filtration by an ultimate backup diesel generator (GUS). Pending implementation of this modification, the Nuclear Rapid Response Force (FARN, see §1.2.13) will deploy means to ensure the electrical back-up of these equipment items for the damaged reactor.

The emergency rooms (security block – BDS, emergency equipment stores, etc.) were designed without specific regulatory requirements concerning flooding and earthquakes. The BDS is temporarily uninhabitable after opening the U5 system filter.

ASN has therefore issued the following prescriptions, which more particularly require the emergency management rooms to be included in the *"hardened safety core"* and operating control of the facilities to be guaranteed after hazardous substance releases.

ASN prescription

ECS - 1: Defining the structures and components of the *"hardened safety core"*, including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

Wording of the prescription and state of progress: See § 1.2

Comments: The emergency management rooms, the availability of parameters used to diagnose the status of the facility, the communication means necessary for emergency management, and the meteorological and environmental measurements shall be included in the hardened safety core.

As part of phase 2 of hardened safety core implementation, EDF shall build a local emergency management centre on each site that withstands the hardened safety core situations (the first local emergency management centre will be built for the commissioning of the EPR). In the interim, the existing emergency management premises have undergone seismic reinforcement.

ASN prescription

ECS - 18.II: Additional electrical power supply means

Wording of the prescription and state of progress: See § 1.2.2. The definitive ultimate backup diesel generator sets shall be built by the end of 2018.

Comments: The “ultimate backup” generator sets planned by the licensee for the hardened safety core, shall more particularly ensure power for the minimum necessary reactor instrumentation and control from the control room, for control room lighting and for the ventilation-filtration system.

ASN prescription

ECS - 18.III: Installation of provisional emergency electrical power supplies pending installation of the means required by prescription ECS – 18.II

Wording of the prescription and state of progress: See § 1.2.2. These equipment items have been in place on each of the reactors since 30 June 2013.

Comments: The diesel generator sets planned by the licensee shall ensure power for the minimum necessary reactor instrumentation and control in the event of total loss of the electrical power supplies and of control room lighting.

Other ASN prescriptions concerning severe accident management

ECS - 29: Reinforcement of the U5 venting-filtration system ("sand-bed filter")

Before 31 December 2013, the licensee shall submit to ASN a detailed study of the possible improvements to the U5 venting-filtration system, taking account of the following points:

- resistance to hazards,
- limitation of hydrogen combustion risks,
- efficiency of filtration in the case of simultaneous use on two reactors,
- improved filtration of fission products, in particular iodine,
- radiological consequences of opening the device - in particular for accessibility of the site - and the radiological atmosphere of the emergency premises and control room.

State of progress:

As part of the response to prescription ECS 1, EDF transmitted the study of a solution at the end of 2014, avoiding the use of the U5 filter in a severe accident situation. These elements were analysed by the GPR meeting of 7 July 2016 and led to additional requests on the part of ASN.

ASN prescription

ECS - 31: Modifications to ensure facility management further to releases

Wording of the prescription: See § 1.3.12

Comments: This prescription provides for the production of a file presenting the planned modifications on the site to ensure that in the event of a release of dangerous substances or opening of the U5 venting-filtration system, the operation and monitoring of all the facilities on the site is guaranteed until a sustainable safe state is reached.

State of progress:

The implementation of the hardened safety core provides for the construction on each site of a building allowing emergency management in an accident situation. The first emergency management centre to be built is planned for the Flamanville site. The examination relative to this emergency management centre will be carried out as part of the commissioning authorisation of the Flamanville 3 EPR reactor. This centre will include means of protection and communication for the emergency teams. A number of operations will still have to be carried out in the control room. The ultimate backup diesel generator set shall enable the ventilation-filtration function to be maintained in the control room and in the containment annulus (for the 1300 MWe and N4 reactors).

1.2.10 Spent fuel pool

Peer Review: *The improvement of the robustness of the spent fuel pool (SFP). Examples include reassessment/upgrading SFP structural integrity, installation of qualified and power-independent monitoring, provisions for redundant and diverse sources of additional coolant resistant to external hazards (with procedures and drills), design of pools that prevents drainage, the use of racks made of borated steel to enable cooling with fresh (unborated) water without having to worry about possible recriticality, redundant and independent SFP cooling systems, provision for additional heat exchangers (e. g. submerged in the SFP), an external connection for refilling of the SFP (to reduce the need for an approach linked to high doses in the event of the water falling to a very low level) and the possibility of venting steam in a case of boiling in the SFP.*

CNS: *Installing additional equipment and instrumentation in spent fuel pools to ensure cooling can be maintained or restored in all circumstances, or performing additional technical evaluations to determine if additional equipment and instrumentation are needed.*

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 the following prescriptions.

ASN prescription

ECS - 18.II: Additional electrical power supply means

Wording of the prescription and state of progress: See § 1.2.2

Comments: The diesel generator sets planned by the licensee will power a pump that can draw water from the water table or large-capacity ponds, with the complete set-up constituting an ultimate make-up system specific to each reactor.

ASN prescription

ECS - 16.I: Emergency water supply resources

Wording of the prescription and state of progress: See § 1.2.1

Comments: These emergency water make-up resources must ensure lasting removal of residual heat from the reactor and the spent fuel pool in the event of loss of the heat sink.

State of progress:

The planned means were examined by the GP2.

ASN prescription

ECS - 20: Reinforced spent fuel pool condition instrumentation

Wording of the prescription and state of progress: See § 1.2.5

ASN prescription

ECS - 21: Additional measures to prevent or mitigate the consequences of a fuel transport package falling in the fuel building.

(Bugey and Fessenheim sites)

Before 31 December 2012, the licensee shall send ASN a study of the consequences of an accident involving a fall by a spent fuel transport package, including in the extreme situations studied by the stress tests. A study of possible additional measures to prevent or mitigate the consequences of this fall shall be presented before 31 December 2013.

State of progress:

- End 2012: deadline for transmission of study of consequences of accidental fall by a packaging, in accordance with the prescription.
- June 2013: transmission of study of additional measures envisaged for the Bugey site, in accordance with the prescription.
- End 2013: transmission of study of additional measures envisaged for the Fessenheim site, in accordance with the prescription.

ASN issued a position statement on these studies in the first quarter of 2016 and requested some clarifications.

ASN prescription

ECS - 22: Reinforcement of the measures to prevent accidental rapid draining of the fuel storage pools

Before 30 June 2012, the licensee shall present ASN with the modifications to be made to its facilities in order to reinforce prevention of the risk of accidental draining of the fuel building pool:

- measures to prevent complete and rapid siphon emptying of the pool in the event of rupture of a connected pipe,
- automation of isolation of the cooling system intake line.

The measures to prevent complete and rapid siphon emptying of the pool in the event of rupture of a connected pipe have been taken in accordance with the prescription.

ASN gave its consent for implementation of automation of isolation of the cooling system intake line, in 2014 for the 1300 MWe plant series, in 2016 for the 900 MWe plant series and in 2017 for the N4 plant series.

State of progress:

- 31/12/2016: Implementation of automation of isolation of the cooling system intake line for the 900 and 1300 MWe plant series.
- 31/12/2017: Deadline for implementation of automation of isolation of the cooling system intake line for the N4 plant series.

These points were examined by the GP2.

ASN prescription

ECS - 23: Placing a fuel assembly in safe position during handling

Before 30 June 2012, the licensee shall submit to ASN a 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 being handled in the fuel building, before the ambient conditions no longer allow access to the premises.

State of progress:

Studies submitted by EDF. These were examined at a meeting of the Advisory Committee for reactors in February 2017.

EDF has also verified the reliability of operation of the fuel storage building steam outlet by the operators in the event of loss of the electrical power supplies.

ASN prescription

ECS - 25: Reinforcement of the provisions for managing a transfer tube leak

Before 31 December 2012, the licensee shall submit to ASN a study of the possible changes to equipment or operating conditions in order to prevent exposure of the assemblies during handling, as the result of a break in the transfer tube between the pools in the reactor and fuel buildings or in the compartment drainage pipes.

State of progress:

EDF has identified two possible material modifications to prevent exposure of the fuel assembly during handling in the event of a break in the transfer tube. These modifications will contain the leaks from the transfer tube and thereby stop potential emptying of the various compartments of the pools.

EDF then initiated a programme to qualify the materials used for the two modifications envisaged to guarantee satisfactory retention of the fluid from a break in the transfer tube. At the end of 2016, neither of the two modifications had been definitively adopted.

At the same time, EDF is carrying out mechanical strength studies on the transfer tubes with respect to the “hardened safety core” earthquake (SND) in order to assess the displacements induced on the civil engineering penetration sleeves.

Depending on the results of these studies, EDF will propose its chosen solution.

Before 31 December 2012, the licensee shall present ASN with the possible changes to equipment or operating conditions to be made before 30 June 2013, in order to prevent the rapid loss of water inventory above the stored fuel assemblies, as a result of a break in the transfer tube between the pools in the reactor and fuel buildings or in the compartment drainage pipes.

State of progress:

As at 30 June 2013, EDF has taken organisational measures (by modifying the administrative lock-out conditions for valves to guarantee their positions) in order to prevent exposure of the fuel assembly during handling in the event of a break in the transfer tube.

1.2.11 Separation and independence of the safety systems

Peer Review: *The enhancement of the functional separation and independence of safety systems. Examples include the elimination of full dependence of important safety functions on auxiliary systems such as service water and the introduction of an alternate source of cooling.*

Pursuant to the international recommendations, the French regulations applicable in the field of nuclear safety, more particularly article 3.1 of the BNI order of 7 February 2012, provide for the implementation of successive and sufficiently independent levels of defence, and a cautious design approach integrating sizing margins and whenever necessary ensuring redundancy, diversification and adequate physical separation of items important for protection that fulfil functions necessary for the nuclear safety case. Prior to the publication of this order, these requirements were frequently integrated into the analyses performed by ASN and the IRSN.

In addition to the already applicable requirements, the principles of separation and independence are part of the requirements associated with the equipment constituting the hardened safety core. Furthermore, the licensee must take account of the risks of common mode failure between the existing equipment and the new equipment installed as part of the hardened safety core, while seeking its diversification and independence.

ASN prescription

ECS - 1: Defining the structures and components of the *"hardened safety core"*, including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

Wording of the prescription and state of progress: See § 1.2

Comments: The licensee proposed to ASN a hardened safety core of robust material and organisational provisions, including systems that are independent and diversified with respect to the existing systems in order to limit common mode risks.

On 21 January 2014 ASN issued a series of resolutions specifying design provisions for the hardened safety core and reaffirmed the principle of electrical independence between the existing systems and the material provisions of the hardened safety core.

ASN prescription

ECS - 16.I: Emergency water supply resources

Wording of the prescription and state of progress: **See § 1.2.1**

1.2.12 Accessibility

Peer Review: *The verification of assured flow paths and access under SBO conditions. Ensure that the state in which isolation valves fail and remain, when motive and control power is lost, is carefully considered to maximize safety. Enhance and extend the availability of DC power and instrument air (e. g. by installing additional or larger accumulators on the valves). Ensure access to critical equipment in all circumstances, specifically when electrically operated turnstiles are interlocked.*

Numerous provisions are made to guarantee access to the premises and facilitate interventions in the event of total loss of the electrical power supplies. Their robustness must however be increased in the event of loss of heat sink or combination with the loss of electrical power supplies. These conclusions have led ASN to set the following prescriptions that more particularly require an increase in the robustness of the electrical power supplies and a verification of the feasibility of accident management measures for the situations studied in the stress tests.

ASN prescription

ECS - 1: Defining the structures and components of the *"hardened safety core"*, including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

Wording of the prescription and state of progress: **See § 1.2**

Comments: Setting up a hardened safety core of material and organisational provisions, combined with enhanced requirements, has led the licensee to perform an additional verification of the robustness and accessibility of these material provisions considering the hazards and effects induced by an earthquake or flood beyond the current baseline safety standard.

ASN prescription

ECS - 18.II: Additional electrical power supply means

Wording of the prescription and state of progress: **See §1.2.2**

Comments: The diesel generator sets planned by the licensee will notably ensure power for the ventilation-filtration of the control room and ventilation-filtration of the annulus (1300/N4 plant series).

Other ASN prescriptions concerning severe accident management

ECS - 35.I and II: Feasibility of emergency management actions in extreme situations

I. No later than 31 December 2012, the licensee shall define the human actions required for management of the extreme situations studied in the stress tests. It shall check that these actions can effectively be carried out given the intervention conditions likely to be encountered in such scenarios. It shall for instance take account of the relief of the emergency teams and the logistics necessary for the interventions. It shall specify any material or organisational adaptations envisaged. On the deadline date, the licensee shall transmit a summary of the results of this work and the envisaged measures. On 30 June 2012, the licensee shall send ASN an interim report.

II. Before 31 December 2012, the licensee shall send ASN a list of the necessary emergency management skills, specifying whether these skills could be provided by outside contractors. The licensee shall provide proof that its organisation ensures the availability of the necessary skills in an emergency situation, including if outside contractors are used.

State of progress:

EDF has transmitted the human actions required for management of the extreme situations studied in the stress tests, along with the measures planned to ensure the availability of specialised teams capable of intervening on the sites. EDF presented ASN with a methodology for determining the personnel numbers permanently present on a nuclear site to deal with an extreme situation.

ASN issued a position statement in 2017 and asked EDF for further explanations, in order to improve the overall approach for verifying the correct definition of the personnel numbers for management of extreme situations. This subject will be examined by the GPR in 2019 when the hardened safety core management procedures become available.

1.2.13 Mobile equipment

Peer Review: *The provision of mobile pumps, power supplies and air compressors with prepared quick connections, procedures, and staff training with drills. Mobile devices are intended to enable the use of existing safety equipment, enable direct feeding of the primary or secondary side, allow extended use of instrumentation and operation of controls, allow effective fire-fighting, and ensure continued emergency lighting. The equipment should be stored in locations that are safe and secure even in the event of general devastation caused by events significantly beyond the design basis (this also applies to Topic 3 recommendations).*

The emergency procedures, which will incorporate the new measures identified in the stress tests, provide for the use of mobile equipment situated either on or off the site, and whose availability and operability must be guaranteed. ASN has set the following prescriptions with respect to these mobile material provisions.

ASN prescription

ECS - 1: Defining the structures and components of the *"hardened safety core"*, including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

Wording of the prescription and state of progress: See § 1.2

Comments: The licensee must ensure the availability and operability of the mobile means vital for emergency management. This point is verified during inspections.

ASN prescription

ECS - 30: Storage of mobile means.

[…]

III. No later than 30 June 2013, the licensee shall store its mobile resources necessary for emergency management in appropriate premises or zones able to withstand the SSE and flooding in the event of the flood safety margin level being reached.

State of progress:

This measure, implemented by EDF, is checked as part of the ASN inspections.

ASN prescription

ECS - 36: The nuclear rapid intervention force (FARN)

I. Before 30 June 2012, the licensee shall present ASN with the measures it intends to take in order to provide specialised teams capable of relieving the shift crews and deploying emergency response resources in less than 24 hours, with operations starting on the site within 12 hours following their mobilisation. This system may be common to several of the licensee's nuclear sites.

These teams shall be sized so that they can respond on all the reactors of the site and have measuring instruments that can be deployed as of their arrival. The licensee shall specify the organisation and sizing of these teams, in particular:

- the activation criteria,
- the tasks incumbent upon the teams,
- the material and human resources at their disposal,
- the personal protective equipment,
- the system put into place to ensure the maintenance of these material resources and their permanent operability and availability;
- the training of their staff and the skills currency process.

II. On 31 December 2012, this organisation will be deployable for intervention on a reactor on the site. It shall be able to intervene simultaneously on all the reactors of the site by the end of 2014.

III. Before 30 June 2012, the licensee shall also present the measures for adapting the organisation to simultaneous intervention on several of its nuclear sites.

State of progress:

- The facility modifications for connection of the emergency mobile resources brought in by the FARN were specifically examined by ASN and the IRSN and deployed on all the sites at the end of 2015.
- 31/12/2012: the FARN organisation is deployable for intervention on one reactor of a site, for all the sites.
- 31/12/2014: deployment of the organisation capable of intervening simultaneously on all the reactors of a given site (all sites except Gravelines).
- 31/12/2015: deployment of the organisation capable of intervening simultaneously on the six plant units of the Gravelines site.

Comments: The FARN is more specifically tasked with deploying emergency response resources within 24 hours and has its own mobile resources. The ramp-up of this organisation is monitored and checked during inspections. Deployment of the FARN and personnel recruitment are in accordance with the regulatory schedule.

Since 01/01/2016, the FARN has been capable of intervening on 6 reactors on a given site in less than 24 hours, with operations starting on a site 12 hours after mobilisation.

1.2.14 Protection of the systems

Peer Review: *The provision for a bunkered or "hardened" system to provide an additional level of protection with trained staff and procedures designed to cope with a wide variety of extreme events including those beyond the design basis (this also applies to Topic 3 recommendations).*

The aim of defining a hardened safety core of material and organisational measures is to implement an additional level of protection. ASN has set the following prescription with this in mind.

ASN prescription

ECS - 1: Defining the structures and components of the *"hardened safety core"*, including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

Wording of the prescription and state of progress: **See § 1.2**

1.2.15 Multiple accidents

Peer Review: *The enhancement of the capability for addressing accidents occurring simultaneously on all plants of the site. Examples include assuring preparedness and sufficient supplies, adding mobile devices and fire trucks and increasing the number of trained and qualified staff (this also applies to Topic 3 recommendations).*

Analysis of the management of multiple accidents affecting all or some of the reactors of a given site simultaneously has called into question the previously implemented material and organisational provisions. In this context ASN has issued the following prescriptions.

ASN prescription

ECS - 1: Defining the structures and components of the *"hardened safety core"*, including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

Wording of the prescription and state of progress: See § 1.2

Comments: The licensee shall take all necessary steps to ensure that the emergency organisation and resources are operational in the event of an accident affecting all or some of the facilities on a given site.

The emergency centres forming part of the hardened safety core shall be built on each site; the material resources of the hardened safety core are installed on each reactor.

ASN prescription

ECS - 32: Multiple plant unit emergency organisation

Before 31 December 2012, the licensee shall reinforce its material and organisational measures to take account of accident situations simultaneously affecting all or some of the facilities on the site.

State of progress:

Action completed. The modified on-site emergency plan (PUI) baseline has been deployed on all EDF sites since 15 November 2012. It takes into account accident situations simultaneously affecting several facilities on a given site.

This modified baseline PUI has been applied by all the sites since 13 November 2014. It more specifically takes account of deployment of the FARN's human and equipment capacity for intervention on a 6-unit site and the local emergency resources (§1.2.13).

ASN prescription

ECS - 36: The nuclear rapid intervention force (FARN)

Wording of the prescription and state of progress: See § 1.2.13

Comments: This organisation must be suitably sized to be able to intervene simultaneously on all the reactors.

ASN letter to EDF further to the meeting of the Advisory Committee for reactors in November 2011: CODEP-DCN-2012-020754 of 26 June 2012.

All – 30: ASN asks you to integrate into the accident operations procedures and the severe accident management documents, including the severe accident management guidelines in particular, 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.

State of progress: See § 1.2.6

1.2.16 Inspection of equipment and training programmes

Peer Review: *The establishment of regular programs for inspections to ensure that a variety of additional equipment and mobile devices are properly installed and maintained, particularly for temporary and mobile equipment and tools used for mitigation of BDB external events. Development of relevant staff training programmes for deployment of such devices.*

The checks carried out by the licensee to verify the presence, operability and maintenance of the equipment and other material provisions are required by the regulations applicable to nuclear facilities, and are themselves subject to regular inspections by ASN.

The correct implementation of the monitoring and maintenance programmes and the training of the teams were examined during targeted inspections carried out by ASN in 2011. During these inspections, ASN identified deviations that resulted in specific requests (the inspection follow-up letters can be consulted on the ASN website: http://www.french-nuclear-safety.fr/); in 2012, ASN conducted dedicated inspections to check that the requests made further to the 2011 inspections had been taken into account. The findings led ASN to issue a prescription requiring lasting conformity of the protected volume.

Finally, with respect to deployment of the FARN, ASN carried out several inspections to verify the provisions guaranteeing the availability of FARN's mobile resources.

ASN prescription

ECS – 36: The Nuclear Rapid Response Force (FARN)

Wording of the prescription and state of progress: See § 1.2.13

Comments: The FARN is more specifically tasked with implementing the emergency response means in less than 24 hours and has its own mobile resources, the nature, maintenance and organisation of which guarantee their operability and availability.

ASN prescription

ECS - 5: Conformity of the protected volume

Wording of the prescription: See § 1.1.3

State of progress:

On certain sites, protection of the facilities against flooding is dependent on the installation of mobile equipment. Compliance with this prescription more particularly requires the implementation of a specific monitoring programme and increased training of the personnel concerned.

These aspects are checked in the course of the normal inspection programme for the facilities.

1.2.17 Additional studies in areas where uncertainties remain

Peer Review: *The performance of further studies in areas where there are uncertainties. Uncertainties may exist in the following areas:*

- *The integrity of the SFP and its liner in the event of boiling or external impact.*
- *The functionality of control equipment (feed water control valves and SG relief valves, main steam safety valves, isolation condenser flow path, containment isolation valves as well as depressurisation valves) during the SBO to ensure that cooling using natural circulation would not be interrupted in a SBO (this is partially addressed in recommendation 3.2.10).*
- *The performance of additional studies to assess operation in the event of widespread damage, for example, the need for different equipment (e.g. bulldozers) to clear the route to the most critical locations or equipment. This includes the logistics of the external support and related arrangements (storage of equipment, use of national defence resources, etc.).*

The stress tests analysis of the robustness of the facilities in the event of loss of the electrical power supplies or the heat sink revealed, in addition to the safety enhancement measures mentioned earlier, the need to analyse certain phenomena in more detail. This particularly concerns the long-term operating reliability of certain equipment items, the examination of reactor coolant pump seal robustness, the study of how the behaviour of the fuel and the water in the spent fuel pool evolves over time in loss of cooling situations, and the review of the changes proposed by EDF for incident operating management. More particularly, ASN formulated the prescription mentioned below concerning the evolution over time of the behaviour of the fuel and the water present in the spent fuel pool.

These studies will be examined by ASN as and when they are submitted, with ASN and its technical support organisation primarily focusing at present on reviewing EDF's proposals for the modifications of the facilities and the setting up of the "hardened safety core" in particular.

ASN prescription

ECS - 24: Thermohydraulic development of a pool accident

Before 31 December 2012, the licensee shall submit to ASN a study of the evolution over time of the behaviour of the fuel and the water present in the spent fuel pool, in emptying and loss of cooling situations. The licensee shall in particular evaluate the ambient radiological atmosphere in a pool boiling situation, along with the hydrogen concentrations, as a result of radiolysis, that could be reached in situations involving a loss of ventilation in the fuel building. At that time, the licensee shall propose and justify the measures that could be taken.

State of progress:

The studies submitted describe the kinetics and consequences of a pool boiling emergency. 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. They were the subject of a first examination at the GPR meeting on 2 February 2017.

1.3 SEVERE ACCIDENT MANAGEMENT

Recommendation specific to France resulting from the peer review of 2012

The main improvements to be made in order to be able to manage a severe accident caused by natural phenomena that could affect several reactors on the same site have been identified by ASN. A recommendation resulting from the peer review process will be to guarantee their implementation.

ASN position

ASN is particularly vigilant in monitoring the implementation of all the prescriptions it has issued, and the reinforcing of the baseline safety requirements, especially with regard to earthquakes, flooding and risks associated with other industrial activities. All the requirements imposed by ASN further to the stress tests have application deadlines and are legally binding.

Since summer 2012, ASN has periodically presented the progress of all these actions. For further information, go to http://www.french-nuclear-safety.fr/.

1.3.1 WENRA reference levels

Peer Review: *The incorporation of the WENRA reference levels related to severe accident management (SAM) into their national legal frameworks, and ensure their implementation in the installations as soon as possible. This would include:*

- *Hydrogen mitigation in the containment - Demonstration of the feasibility and implementation of mitigation measures to prevent massive explosions in case of severe accidents.*
- *Hydrogen monitoring system - Installation of qualified monitoring of the hydrogen concentration in order to avoid dangerous actions when concentrations that allow an explosion exist.*
- *Reliable depressurization of the reactor coolant system – Hardware provisions with sufficient capacity and reliability to allow reactor coolant system depressurization to prevent high-pressure melt ejection and early containment failure, as well as to allow injection of coolant from low pressure sources.*
- *Containment overpressure protection - Containment venting via the filters designed for severe accident conditions.*
- *Molten corium stabilization - Analysis and selection of feasible strategies and implementation of provisions against containment degradation by molten corium.*

Following publication of the TSN Act in 2006 and its application decrees, ASN wished to completely revise the general technical regulations applicable to BNIs. This approach moreover corresponds to a will for European harmonisation of nuclear safety, by incorporating in the new regulations the principles or "reference levels" developed by the Western European Nuclear Regulators' Association (WENRA).

The order of 7 February 2012 setting the general rules for basic nuclear installations takes up the WENRA reference levels that come under this level of regulatory text. The majority of the provisions of this order, published on 8 February 2012, came into force on 1 July 2013. This order also provides a foundation for several of the requirements expressed by ASN further to

the stress tests. This order was supplemented by several ASN statutory resolutions or guides published in order to continue implementation of the WENRA reference levels.

Alongside the updating of the regulations, ASN asked EDF to evaluate the effective integration of these reference levels in its facilities. It emerges that 285 reference levels are fully implemented and the 11 remaining reference levels are partially implemented.

More specifically:

- since the end of 2007, all the reactors in service are equipped with hydrogen passive autocatalytic recombiners (PAR) intended to prevent global hydrogen detonation in the reactor containment.
- the installation of redundant instrumentation dedicated to severe accident management, able to detect reactor vessel melt-through and the presence of hydrogen in the containment was initially planned for the third ten-year outages of the 900 MWe and 1300 MWe reactors, and the first ten-year outage of the 1450 MWe reactors. In accordance with the ASN prescription, deployment of these modifications has been speeded up to ensure that the reactors are equipped with redundant measurement instrumentation before 31/12/2017;
- the prevention of pressure meltdown sequences is based on voluntary opening of the pressuriser safety relief valve tandems. A hardware modification to improve pressuriser safety relief valve opening reliability, decided before the Fukushima accident and already applied on certain reactors, is planned for the next 10-year outage of each reactor. For those reactors on which the modification was not applied by the end of 2013, a provisional mobile safety means for ensuring the reliability of pressuriser safety relief valve opening is provided;
- for the reactors in service, the U5 system management rules limit the pressure in the reactor containment in the event of an accident to a value slightly below its design-basis pressure by means of an associated decompression and filtration device;
- on the Flamanville 3 EPR, the CHRS (Containment Heat Removal System) evacuates heat from the containment and controls its pressure. In the framework of the stress tests, EDF proposed adding a mobile and independent water make-up system in the reactor building, via the CHRS spray nozzles, to avoid loss of containment integrity in the event of sustained loss of the off-site electrical power supplies. In addition to the measures planned to maintain containment integrity, ASN instructed EDF to identify the existing or additional systems to be included in the hardened safety core to control pressure in the containment in the event of a severe accident and to analyse the advantages and drawbacks of the various possible systems.
- prevention of containment damage by corium is ensured by injecting primary coolant into the reactor vessel and then into the reactor pit via the opening in the vessel bottom if applicable. In addition to the provisions in effect, ASN has instructed EDF to study the feasibility of installing technical devices, such as a geotechnical containment or a system with an equivalent effect to prevent the transfer of radioactive contamination to groundwater in the event of a severe accident leading to corium melt-through of the reactor vessel.

ASN prescription

Stress test 27.I: Study of the feasibility of installing a geotechnical containment or a system with the same effect

I. Before 31 December 2012, the licensee shall send ASN a feasibility study for the installation or renovation of a geotechnical containment or equivalent technical measure to prevent the transfer of radioactive contamination to groundwater and, by means of underground flow, to the surface waters, in the event of a severe accident leading to corium melt-through of the reactor vessel

II. Before 30 June 2013, the licensee shall submit to ASN an updated hydrogeological data sheet for the site, containing the current geological and hydrogeological data.

State of progress:

- 30/06/2012: The hydrogeological data sheets for the Fessenheim, Bugey and Civaux sites have been submitted.
- 31/12/2012: The feasibility study concerning the installation of technical systems to prevent the transfer of radioactive contamination to the groundwater in the event of a severe accident leading to reactor vessel melt-through by the corium has been submitted.
- 30/06/2013: The hydrogeological data sheets for the Dampierre, Gravelines, Saint-Laurent, Chooz, Nogent, Belleville, Paluel, Cattenom, Penly, Saint-Alban, Blayais, Flamanville, Tricastin, Chinon, Golfech and Cruas sites have been submitted.

EDF has concluded that a geotechnical system at an economically acceptable cost is not feasible. ASN has examined this file jointly with other provisions currently being studied, notably those aiming to prevent basemat melt-through by putting in place new systems allowing the dry spreading of the corium in the bottom of the reactor vessel well, and possibly also in the adjacent room, then its cooling by the water from the sumps via the "EASu" (ultimate containment spray system). ASN nevertheless considers that EDF must continue its studies on this subject. In this respect, in 2016 ASN asked EDF for more detailed feasibility studies on the implementation of geotechnical containments and in July 2017 it formulated additional requests concerning the severe accident management strategy. All these complements will be examined by the advisory committee in 2018-2019.

ASN prescription

Stress test 28: EPR - Reinforcement of the provisions for controlling the pressure in the containment

Before 30 June 2012, the licensee shall present ASN with the systems specified in the preliminary safety analysis report, or any systems to be added and constituting a part of the hardened safety core in order to control the pressure in the containment in the event of a severe accident. Within the same time-frame the licensee shall send ASN a study of the advantages and drawbacks of the various possible systems.

1.3.2 Provisions for ensuring equipment resistance to severe accidents

Peer Review: *Adequate hardware provisions that will survive external hazards (e.g. by means of qualification against extreme external hazards, storage in a safe location) and the severe accident environment (e.g. engineering substantiation and/or qualification against high pressures, temperatures, radiation levels, etc.), in place, to perform the selected strategies.*

Recommendation specific to France resulting from the peer review of 2012

Several equipment items required for severe accident management are not qualified for earthquakes […].

The passive autocatalytic recombiners designed for withstanding design-basis accidents are qualified to seismic standards whereas those designed to withstand severe accidents are not […].

The hydrogen recombiners and venting filters currently used on the reactor fleet will have to be qualified for external hazards.

On the reactors currently in operation, the current baseline safety requirements do not require the equipment for mitigating the consequences of a severe accident and radioactive releases to take external hazards into account. The licensee must, in response to a prescription formulated by ASN concerning the hardened safety core, specify the hardened core equipment (existing equipment and additional countermeasures) for preventing and mitigating the consequences of a severe accident. These equipment items shall be robust to hazards beyond the current hazard level considered. For the reactors currently in operation, this applies in particular to the hydrogen recombiners and the containment pressure limiting system.

ASN and its technical support organisation are currently examining the licensee's proposal.

ASN prescription

Stress test 1: Defining the structures and components of the "hardened safety core", including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

Title of the prescription and state of progress: See § 1.2

Comments: See above.

ASN prescription

Stress test 20: Reinforcement of spent fuel pool condition instrumentation

Title of the prescription: See § 1.2.5

Comments: The spent fuel pool instrumentation must be modified to allow measurement of its status (temperature and water level) and of the radiological atmosphere in the fuel building hall.

State of progress:

The spent fuel pool level measurement system is in place and electrically backed up by the new generator sets pending their connection to the ultimate backup diesel generator set.

ASN prescription

Stress test 29: Reinforcement of the U5 venting-filtration system ("sand-bed filter")

Title of the prescription and state of progress: See § 1.2.9

Comments: The licensee has submitted a detailed study of the possible improvements to the U5 venting-filtration system, considering in particular its resistance to hazards.

EDF is going to proceed with seismic reinforcement of the U5 venting-filtration system. EDF nevertheless plans controlling the pressure in the reactor containment through an ultimate spraying system. This item was the subject of studies that were presented in 2015 and discussed at the GPR meeting of 7 July 2016.

1.3.3 Provisions for the management of severe accidents induced by a severe external event

Peer review: *The systematic review of SAM provisions focusing on the availability and appropriate operation of plant equipment in the relevant circumstances, taking account of accident initiating events, in particular extreme external hazards and the potential harsh working environment.*

In addition to the elements mentioned in § 1.3.2, ASN has instructed EDF to check that the emergency management actions planned for in extreme situations studied for the stress tests are effectively achievable. It also instructed EDF to take into consideration the industrial risks induced in extreme situations by nearby risk-prone facilities

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ASN prescription

Stress test 29: Reinforcement of the U5 venting-filtration system ("sand-bed filter")

Title of the prescription and state of progress: See § 1.2.9

Comments: This prescription provides for the performance of a detailed study into ways of improving the U5 venting-filtration system, taking into account the radiological consequences of opening the system, particularly on site accessibility. EDF has provided elements which have been analysed within the framework of the GP3.

ASN prescription

Stress test 14.I: Integration of industrial risks in extreme situations.

I. No later than 31 December 2013, the licensee shall supplement its ongoing studies with the inclusion of the risk arising from activities taking place near its facilities, in the extreme situations studied by the stress tests and in conjunction with neighbouring licensees responsible for these activities (nuclear facilities, installations classified on environmental

protection grounds or other facilities liable to constitute a hazard). By that deadline, the licensee shall propose any modifications to be made to its facilities or their operating procedures as a result of this analysis.

State of progress:

- 30/09/2012: the modification studies and proposals for the Tricastin site have been submitted
- 31/12/2012: the modification studies and proposals for the Gravelines and Saint-Alban site have been submitted
- 31/12/2013: the modification studies and proposals for the Bugey, Fessenheim, Chinon, Dampierre, Saint-Laurent, Golfech, Chooz, Nogent, Belleville, Paluel, Cattenom, Penly, Cruas, Blayais, Civaux and Flamanville sites have been submitted.

These studies are undergoing examination and the conclusions are expected in 2017.

ASN prescription

Stress test 35.I and II: Feasibility of emergency management actions in extreme situations

Title of the prescription and state of progress: **See § 1.2.12**

1.3.4 Enhancing the severe accident management guides (SAMG)

Peer review: *In conjunction with the recommendation 2.4, the enhancement of SAMGs taking into account additional scenarios, including, a significantly damaged infrastructure, including the disruption of plant level, corporate-level and national-level communication, long-duration accidents (several days) and accidents affecting multiple units and nearby industrial facilities at the same time.*

CNS**:** *Performing or planning an evaluation of the guidance that is to be used by the operator to manage emergency situations resulting from severe accidents caused by extreme natural phenomena at NPPs, including for low power and shutdown states. These documents include emergency operating procedures to prevent core damage, severe accident management guidelines to prevent containment failure, and extensive damage mitigation guidelines to address accidents that result in fires or explosions that affect a large portion of a NPP.*

Recommendation specific to France resulting from the peer review of 2012

The French severe accident management guides do not cover accidents in the spent fuel pools, nor do they include events that could affect several plant units simultaneously. The shutdown states are only included and implemented for the 900 MWe reactors; their implementation on the other plant series is planned.

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 prescriptions will lead to significant modifications in the various documents relating to severe accident management. This context has led ASN to set the following prescriptions and formulate the following requests.

ASN prescription

Stress test 1: Defining the structures and components of the "*hardened safety core*", including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

Title of the prescription and state of progress: See § 1.2

Comments: Implementation of the "*hardened safety core*" shall be accompanied by measures to ensure that the emergency organisation and resources are operational in the event of an accident affecting some or all of the facilities on a given site, which will require the preparation of specific guides relative to the various scenarios considered.

ASN letter to EDF further to the meeting of the advisory committee of experts on reactors in November 2011: CODEP-DCN-2012-020754 of 26 June 2012.

All – 30: ASN asks you to integrate into the accident operations procedures and the severe accident management documents, including the severe accident management guidelines in particular, 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.

State of progress: See § 1.2.6

ASN prescription

Stress test 14.I: Integration of industrial risks in extreme situations.

Title of the prescription and state of progress: See § 1.3.3

ASN prescription

Stress test 14.II: Coordination with neighbouring industrial operators in the event of an emergency

II. No later than 30 September 2012, the licensee shall take all steps, for example by means of agreements or detection and alert systems, to ensure that it is rapidly informed of any event liable to constitute an off-site hazard for its facilities, in order to protect its staff against these hazards and to ensure that emergency management is coordinated with the neighbouring operators.

State of progress:

- 30/09/2012: Alert system implemented on Tricastin site.
- 31/12/2012: Alert system implemented on the Gravelines and Saint-Alban sites.
- 31/12/2013: Alert system implemented on the Bugey, Fessenheim, Chinon, Dampierre, Saint-Laurent, Golfech, Chooz, Nogent, Belleville, Paluel, Cattenom, Penly, Cruas, Blayais, Civaux and Flamanville sites.

The studies of the Tricastin, Saint-Alban and Gravelines sites are undergoing examination and the conclusions are expected in the second half of 2017.

1.3.5 Validation of the severe accident management guides (SAMG)

Peer Review: *The validation of the enhanced SAMGs.*

The various documents relative to severe accident management will be validated following the usual processes established by ASN and the licensees. These processes include an independent technical analysis by IRSN, ASN technical support organisation. ASN will adopt a position regarding these documents on the basis of this analysis.

1.3.6 Severe accident simulation exercises

Peer Review: *Exercises aimed at checking the adequacy of SAM procedures and organizational measures, including extended aspects such as the need for corporate and nation level coordinated arrangements and long-duration events.*

The French regulations provide for the conducting of severe accident simulation exercises at regular intervals. Each NPP must thus carry out several exercises each year, including one in which the on-site emergency plan is deployed. Each NPP must carry out a national-scale exercise at intervals not to exceed 5 years.

The various works carried out for the stress tests considered hypotheses and new configurations that will be introduced into the severe accident simulation scenarios as and when appropriate. This context has led ASN to set the following prescription.

ASN prescription

Stress test 1: Defining the structures and components of the "*hardened safety core*", including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

Title of the prescription and state of progress: **See § 1.2**

Comments: The organisational means and equipment necessary for emergency management and included in the "hardened safety core" must be identified in the on-site emergency plans of the sites, along with their storage locations and deployment procedures. They must be tested regularly and training in their use must be provided during exercises. These points will be verified during ASN inspections.

1.3.7 Severe accident management training

Peer Review: *Regular and realistic SAM training exercises aimed at training staff. Training exercises should include the use of equipment and the consideration of multi-unit accidents and long-duration events. The use of the existing NPP simulators is considered as being a useful tool but needs to be enhanced to cover all possible accident scenarios.*

French regulations and the EDF on-site emergency plans (PUI) provide for regular and appropriate training of the personnel intervening on site, and the performance of several

exercises on each NPP each year. Thus, each section of the site's PUI (radiological and toxic safety, climatic and similar hazards safety, etc.) must undergo an overall exercise every 3 years. The number of exercises per year and per site is determined according to the number of emergency team members, as each team member must attend one PUI exercise per year. Implementation of the new material and organisational provisions will be accompanied by specific training actions to ensure their effectiveness. This context has led ASN to set the following prescriptions.

ASN prescription

Stress test 1: Defining the structures and components of the "*hardened safety core*", including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

Title of the prescription and state of progress: See § 1.2

Comments: The organisational means and equipment necessary for emergency management and included in the "hardened safety core" must be identified in the on-site emergency plans of the sites, along with their storage locations and deployment procedures. They must be tested regularly and training in their use must be provided during exercises.

ASN prescription

Stress test 10: Reinforcement of team preparation in the event of an earthquake

Before 30 June 2012, the licensee shall send ASN a training programme for the operating teams to enhance their level of preparedness for earthquake situations. This programme shall in particular include regular in-situation training exercises. This programme shall have been followed by the reactor operating personnel in charge of the seismic instrumentation rack and of the associated operating measures no later than 31 December 2012. The other site operating teams shall receive information by 31 December 2012 and shall have followed the entire programme no later than 31 December 2013.

State of progress:

- 30/06/2012: Training programme submitted to ASN;
- 31/12/2012: Deadline for training of all the personnel in charge of the seismic instrumentation rack and the operating measurements;
- 31/12/2013: Deadline for dispensing training to all the operating teams.

Actions taken.

ASN prescription

CSA – 32: Multiple plant unit emergency organisation

Title of the prescription and state of progress: See § 1.2.15

Comments: The implementation of this organisation is accompanied by specific personnel training.

ASN prescription

Stress test 35 II: Severe accident management training

III. Before 30 September 2013, the licensee shall provide the personnel concerned with the training and preparation needed to enable them to respond to particularly stressful accident situations. It shall ensure that the outside contractors liable to intervene in management of the emergency adopt similar requirements concerning the preparedness and training of their own staff.

State of progress: Action taken.

EDF has supplemented its training system for the persons mobilised under the on-site emergency plan; furthermore, feedback on the training of the FARN (nuclear rapid intervention force) personal shall be provided.

EDF is undertaking research and development into the emergency situation preparedness of operators and teams in order to modify its internal training if necessary.

EDF subcontractors do not intervene in emergency situations.

1.3.8 Extension of the scope of the severe accident management guides (SAMG) to all reactor states

Peer Review: *The extension of existing SAMGs to all plant states (full and low-power, shutdown), including accidents initiated in SFPs.*

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 prescriptions will, among other things, extend the scope of the various documents relating to severe accident management to all the reactor states. In this context ASN has asked the licensee to supplement its severe accident management procedures so that they cover all the reactor states and the spent fuel pool accident situations. The licensee has also given a commitment in this respect.

ASN letter to EDF further to the meeting of the Advisory Committee of Experts on reactors in November 2011: CODEP-DCN-2012-020754 of 26 June 2012.

All – 30: Modification of the accident operating management procedures and of the severe accident management documents.

Title of the request and state of progress: See § 1.2.6

EDF commitment given in the stress test reports submitted on 15 September 2011

Several changes in accident operating management shall be made according to the different reactor states.

Title of the request and state of progress: See § 1.2.6

1.3.9 Improvement in communication

Peer Review: *The improvement of communication systems, both internal and external, including transfer of severe accident related plant parameters and radiological data to all emergency and technical support centre and regulatory premises.*

CNS: *Improving their radiation monitoring and communications capabilities and enhancing public communications, such as via dedicated public websites.*

The improvement in means of communication has been demanded by ASN in the short term and is the subject of the following prescriptions.

ASN prescription

Stress test 1: Defining the structures and components of the "hardened safety core", including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

Title of the prescription and state of progress: See § 1.2. The additional means of communication have been procured.

Comments: The communication means vital for emergency management shall be included in the "hardened safety core". They include more specifically the means of alerting and informing the emergency team members and the public authorities. If necessary, the licensee can activate the means used to alert the populations if the off-site emergency plan (PPI) is triggered in the reflex response phase by delegation from the prefect.

ASN prescription

Stress test 30: Reinforcement of the means of communication

[…]

II. No later than 30 June 2012, the licensee sets up independent communication resources allowing direct contact between the site and the national emergency organisation defined in the interministerial directive of 7 April 2005.

State of progress: Means of communication implemented as at 30/06/2012.

1.3.10 Presence of hydrogen in places where it is not planned for in the design

Peer Review: *The preparation for the potential for migration of hydrogen, with adequate countermeasures, into spaces beyond where it is produced in the primary containment, as well as hydrogen production in SFPs.*

In an accident situation, hydrogen can be produced inside the reactor vessel during the core degradation phase due to the oxidation of fuel element cladding and other materials present in the reactor vessel, or outside the vessel during the corium-concrete interaction, and by radiolysis of the water in the spent fuel pool. The hydrogen can also come from damaged

hydrogen transport lines. On completion of the analyses, ASN set the following prescription and made the following requests.

Furthermore, on completion of the stress tests, EDF undertook to study the hydrogen explosion risk in the other peripheral buildings of the reactor containment. The study of the hydrogen risk in the annulus on the 1300 MWe reactors was examined as part of the periodic safety review associated with their third 10-year outage.

ASN prescription

Stress test 19: Redundancy of instrumentation for detecting reactor vessel melt-through and hydrogen in containment

Title of the prescription and state of progress: See § 1.2.5

ASN letter to EDF further to the meeting of the advisory committee of experts on reactors in November 2011: CODEP-DCN-2012-020754 of 26 June 2012.

Fleet-Parc–04: ASN asks you to speed up application of the safe shutdown earthquake (SSE) design-basis requirement to hydrogen systems and the implementation of the "seismic interaction" approach for lines carrying hydrogen. You will send me a revised implementation schedule before the end of 2012.

Fleet–Parc–05: ASN asks you to guarantee the SSE resistance of the hydrogen presence detectors and their shut-off valves which are located outside the reactor building, and to supplement the future safety baseline requirements to take this into account.

State of progress:

Implementation schedule submitted, the upgrading deadlines have on average been met 3 years earlier than specified in the initial programme (the work is finished on the CP0 & N4 plant series and will be completed in 2017 on the CPY series, in 2018 on the P4 series and 2020 on the P'4 series).

1.3.11 Management of large volumes of contaminated water

Peer Review: *The conceptual preparations of solutions for post-accident contamination and the treatment of potentially large volumes of contaminated water.*

ASN has checked that the industrial development work in this area is in progress. Research projects in this area have been presented under a call for research project proposals dedicated to nuclear safety and radiation protection, launched after the Fukushima-Daiichi NPP accident.

State of progress:

EDF has carried out detailed studies on this subject as part of the prescription relative to the evaluation of geotechnical containment on the sites. ASN issued a position statement on these studies in June 2016 and asked EDF for more detailed feasibility studies.

1.3.12 Radiation protection

Peer Review: *The provision for radiation protection of operators and all other staff involved in the SAM and emergency arrangements.*

CNS: *Improving their radiation monitoring and communications capabilities and enhancing public communications, such as via dedicated public websites.*

Among the technical and organisational provisions of the hardened safety core, and pursuant to the ASN prescription, the licensee must integrate the provisions necessary to ensure the availability of the active dosimetry equipment, the measuring instruments for radiation protection and the personal and collective protective equipment. Furthermore, the verification of the feasibility of the human actions prescribed by ASN must take into account the radiation protection of the persons involved. Lastly, ASN has instructed the licensee to check that it is possible to monitor and manage the facilitaties after radioactive releases while taking into account the radiation protection of the persons involved.

ASN prescription

Stress test 1: Defining the structures and components of the "hardened safety core", including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

Title of the prescription: See § 1.2

Comments: The licensee shall take all the measures necessary to ensure the availability of the active dosimetry equipment, the measuring instruments for radiation protection and the personal and collective protective equipment.

State of progress:

These items of equipment have been procured by the sites. These points have been verified in the course of ASN inspections.

ASN prescription

Stress test 31: Modifications to ensure facility management further to releases

Before 31 December 2012, the licensee shall send ASN a file presenting the planned modifications on its site to ensure that, in the event of release of dangerous substances or opening of the U5 venting-filtration system, operation and monitoring of all the facilities on the site are guaranteed until a long-term safe state is reached; the corresponding deployment schedule shall also be provided.

State of progress:

The licensee has submitted the dose estimates for different scenarios and different parties involved in emergency management. The instrumentation specific to the hardened safety core shall be put in place along with the hardened safety core.

ASN prescription

Stress test 35.I and II: Feasibility of emergency management actions in extreme situations

Title of the prescription and state of progress: See § 1.2.12

Comments: The planned emergency management actions in extreme situations must be effectively achievable by the personnel under the conditions of intervention. The licensee has identified the personnel and resources necessary for emergency situation management. EDF's conclusions are currently being examined by ASN.

1.3.13 On-site emergency management premises

Peer Review: *The provision of an on-site emergency centre protected against severe natural hazards and radioactive releases, allowing operators to stay onsite to manage a severe accident.*

CNS: *Upgrading regional, off-site and on-site emergency response centres*.

The emergency premises (emergency management centre (BDS) and emergency equipment stores) were designed when there were no applicable regulatory requirements relative to flooding and earthquakes. The BDS is temporarily uninhabitable after opening the U5 system filter.

ASN has therefore set the following prescriptions which make it mandatory to include the emergency situation management premises in the "*hardened safety core*", and for them to be highly resistant to hazards and to remain accessible and habitable at all times and during long-duration emergencies, including in the event of radioactive releases. Pending the installation of new emergency premises that meet these requirements, ASN has instructed the licensee to guarantee the design of the existing emergency premises against the seismic and flooding levels of the current baseline safety requirements.

ASN prescription

Stress test 1: Defining the structures and components of the "hardened safety core", including the emergency management premises. Defining the requirements applicable to this hardened safety core.

Hardened safety core based on diversified structures and components.

Title of the prescription and state of progress: **See § 1.2**

Comments: The elements essential for management of the emergency, that is to say the emergency management premises, the material resources required for emergency management, the means of communication and the essential technical and environmental instrumentation, shall be included in the hardened safety core. The emergency management premises shall be designed and dimensioned for hazards beyond the current design safety baseline. They shall be accessible and habitable during long-duration emergencies and designed to accommodate the teams necessary for long-term management of the site.

On each site the licensee is going to build a local emergency management centre to meet the design-basis conditions of the hardened safety core.

ASN prescription

Stress test 30: Designing the emergency premises to withstand earthquakes and flooding

I. The licensee shall ensure that the emergency situation management premises can withstand flooding in the event of the flood safety margin level being reached. Before 30 June 2012, it shall present ASN the conclusions of this verification and any modifications considered necessary. Before 30 June 2013, it shall perform any necessary reinforcement work.

State of progress:

- 30/06/2012: The situation assessment to verify the resistance of the premises to flooding and the planned modifications have been presented to ASN. The verification showed that the emergency premises did not require additional protection against flooding

The licensee checks that the emergency management premises can withstand the safe shutdown earthquake (SSE). Before 30 June 2012, it shall present ASN the conclusions of this verification and any modifications considered necessary. Before *[Date variable according to the sites, see below*], it shall perform any necessary works.

State of progress:

- 31/06/2012: The developments and modifications necessary for the Civaux, Cruas and Flamanville sites to withstand the SSE have been carried out.
- 30/06/2013:
  - The studies performed have confirmed the SSE resistance of the emergency management premises of the Bugey, Chinon, Chooz, Dampierre, Fessenheim, Gravelines, Paluel, Penly, Saint-Alban and Saint-Laurent sites;
  - The modifications necessary to guarantee the SSE resistance of the emergency management premises of the Belleville, Cattenom, Golfech and Nogent sites have been carried out.
- 31/12/2013:
  - The modifications necessary to guarantee the SSE resistance of the emergency management premises of the Cruas and Tricastin sites have been carried out.
  - The developments allowing an emergency situation resulting from an earthquake to be managed from SSE-resistant premises have been implemented on the Civaux and Flamanville sites.

II. No later than 30 June 2012, the licensee shall set up independent communication resources allowing direct contact between the site and the national emergency organisation defined in the interministerial directive of 7 April 2005.

State of progress: See § 1.3.9, action taken.

III. No later than 30 June 2013, the licensee shall store its mobile resources necessary for emergency management in appropriate premises or zones able to withstand the SSE and flooding in the event of the flood safety margin level being reached.

State of progress: See § 1.2.13, action taken.

ASN prescription

Stress test 32: Multiple plant unit emergency organisation

Title of the prescription and state of progress: See § 1.2.15

Comments: The material and organisational provisions to take account of accident situations simultaneously affecting some or all of the facilities on the site also concern the on-site emergency management centre.

1.3.14 Support to the personnel on site

Peer review: *Rescue teams and adequate equipment to be quickly brought on site in order to provide support to local operators in case of a severe situation.*

CNS: *Upgrading regional, off-site and on-site emergency response centres*.

The licensee has planned to reinforce the current emergency organisation, particularly by setting up a Nuclear Rapid Intervention Force ("FARN" in its French acronym) with material and human resources. The FARN is a national-scale organisation specific to the licensee EDF, which will be capable of rapidly providing material and human aid to one or more sites in difficulty simultaneously. This organisation must notably allow the relief of the teams present on the site if it impossible for the normally planned relief teams to fulfil this function or to get to the accident-stricken site. ASN has set the following prescription.

ASN prescription

Stress test 36: The Nuclear Rapid Intervention Force (FARN)

Title of the prescription and state of progress: See § 1.2.13

Comments: The FARN has specialist teams capable of intervening in the areas of operational control, maintenance and logistics on a site in an accident situation. The FARN's activities can be broken down into short-term (less than 3 days) or long-term (more than 3 days) activities.

The short-term activities have the following aims:

- bring operational control skills onto the site to back up or relieve the shift team;
- bring in additional material resources, connect them up and put them into service within 24 hours;
- ensure radiological monitoring of the environment;
- bring to the site, in situations lasting more than 24 hours, the necessary logistics for correct operation of the resupplied functions.

The long-term activities have the following aims:

- deploying major equipment resources (protection of the environment, water production, radiation protection means, etc.);
- preparing for continuation of these actions beyond the first days of autonomy in the event of a long-duration emergency (including logistic resupply);
- mitigating the environmental impact of discharges, particularly by seeking to restore containment and treat the radioactive effluents;
- setting up a rear base allowing long-term management of the accident.

Activation of the FARN is decided at national level on the basis of a situation analysis. The FARN comprises a national headquarters and four regional centres situated on the Bugey, Civaux, Dampierre and Paluel NPP sites.

The FARN national HQ is attached to EDF central management situated in the Paris region and its main duties are to supervise and manage the FARN and interface with EDF top management. The regional centres report to the FARN national HQ.

The regional centres have on-call intervention columns of 14 people with the various professional skills required (processes, intervention, logistics). The equipment is stored in premises specific to each centre. Each column is capable of dealing with 2 reactors and can bring in the equipment necessary for this. Potential rear base locations are identified near the NPPs.

The FARN has transport and handling equipment, redundant telecommunication means and equipment for ensuring the resupply of water and electricity (pumps, compressors, diesel generator sets, etc.).

1.3.15 Level-2 Probabilistic Safety Assessments (Level-2 PSA)

Peer Review: *A comprehensive Level 2 PSA as a tool for the identification of plant vulnerabilities, quantification of potential releases, determination of candidate high-level actions and their effects and prioritizing the order of proposed safety improvements. Although PSA is an essential tool for screening and prioritizing improvements and for assessing the completeness of SAM implementation, low numerical risk estimates should not be used as the basis for excluding scenarios from consideration of SAM, especially if the consequences are very high.*

The contribution of the post-Fukushima approach, and particularly the setting up of the hardened safety core, is to make provisions for dealing with initiating accidents that go beyond the design basis, possibly combined accidents, irrespective of their probability of occurrence. The aim of this approach is to cover the highly improbable situations.

The widening of the coverage of the level-1 PSAs, and the development of new level-1 and 2 PSAs, are subjects that are systematically included in the reactor periodic safety reviews. The following table defines the PSAs currently available and the main categories of initiating events considered for each French reactor plant series.

Plant series	Events considered for the level-1 and 2 PSAs
900 MWe reactors (CP0-CPY)	During the preceding periodic safety reviews, EDF performed: ▪ level-1 and 2 PSAs for failures internal to the reactor, ▪ level-1 PSAs for fire (CPY series). Under the ongoing 4th periodic safety review, EDF is updating or performing: ▪ level-1 and 2 PSAs for failures internal to the reactor and the fuel building (BK) pool, for fire, internal flooding and earthquakes, ▪ level-1 PSAs for internal explosion and external hazards.

1300 MWe reactors (P4-P'4)	During the periodic safety reviews, EDF performed: ▪ level-1 and 2 PSAs for failures internal to the reactor, ▪ level-1 PSAs for failures internal to the BK building pool, ▪ level-1 PSAs for fire and internal flooding.
1450 MWe reactor (N4)	During the periodic safety reviews, EDF performed: ▪ level-1 and 2 PSAs for failures internal to the reactor, ▪ level-1 PSAs for failures internal to the BK building pool, ▪ level-1 PSAs for fire, internal flooding and certain external hazards (in progress).
1650 MWe reactor (EPR) under construction	With a view to the commissioning authorisation application, EDF has performed: ▪ level-1 and 2 PSAs for failures internal to the reactor, ▪ level-1 PSAs for failures internal to the BK building pool, ▪ level-1 PSAs for fire, internal flooding, internal explosion and external hazards (other than earthquake).

1.3.16 Studies relative to severe accidents

Peer Review: *The performance of further studies to improve SAMGs. Examples of areas that could be improved with further studies include:*

- *The availability of safety functions required for SAM under different circumstances.*
- *Accident timing, including core melt, reactor pressure vessel (RPV) failure, basemat melt-through, SFP fuel uncovery, etc.*
- *PSA analysis, including all plant states and external events for PSA levels 1 and 2.*
- *Radiological conditions on the site and associated provisions necessary to ensure MCR and ECR habitability as well as the feasibility of AM measures in severe accident conditions, multi-unit accidents, containment venting, etc.*
- *Core cooling modes prior to RPV failure and of re-criticality issues for partly damaged cores, with un-borated water supply.*
- *Phenomena associated with cavity flooding and related steam explosion risks.*
- *Engineered solutions regarding molten corium cooling and prevention of basemat melt-through.*
- *Severe accident simulators appropriate for NPP staff training.*

CNS: *Developing probabilistic safety assessments to identify additional accident management measures or changes in radiation protection measures for workers on the site that might be needed to perform necessary activities in the event of a severe accident.*

The subjects proposed by the peer review are questions that are addressed systematically during the 10-yearly periodic safety reviews. Furthermore, some questions can form the subject of comparisons with international practices at the meetings of the Advisory Committee

of Experts on reactors dedicated to the analysis of operating experience feedback from the French and foreign reactors (organised every two to three years).

On the subjects mentioned by the peer review, progress has been made in the following areas:

- the habitability of the control and emergency management rooms, see § 1.2.9,
- the level-2 probabilistic safety assessments, see § 1.3.15,
- the requirements associated with the behaviour of the equipment in severe accident situations are being examined as part of the third 10-yearly outages of the 1300 MWe reactors; a meeting of the Advisory Committee of Experts was held in the 1st quarter of 2013 to present the progress in this area (examination of the procedures for maintaining qualification over the long term),
- management of the water in the reactor pit, with regard to the benefit brought by a possible retention of corium in the reactor vessel or pit and the risk of vapour explosion (which today is still the subject of R&D work and debate between experts), is also being examined as part of the fourth 10-yearly outages of the 900 MWe reactors.

ASN has moreover set the following prescription.

ASN prescription

Stress test 27.I: Study of the feasibility of installing a geotechnical containment or a system with the same effect

Title of the prescription and state of progress: See §1.3.1.

2 MONITORING THE OTHER SUBJECTS ADDRESSED WITHIN THE FRAMEWORK OF THE CONVENTION ON NUCLEAR SAFETY

Summary of the main changes since 2014:

- France has put in place a new national response plan for major nuclear or radiological accidents whose regional application (with regard to the defence and safety zones and the *départements*) is currently in progress.
- Baseline emergency requirements integrating the lessons learned from the Fukushima-Daiichi NPP accident have been deployed on all the French NPPs; they introduce changes in emergency situation preparedness zones in terms of both geographical coverage and response actions. The off-site emergency plan (PPI) zones for the NPPs shall be extended from 10 to 20 km and the PPIs introduce an immediate evacuation measure over a radius of 5 km.
- ASN maintains its high level of international involvement at both European level and beyond. ASN actively participates, for example, in the reflections conducted by the European radiation protection and nuclear safety authorities in order to harmonise population protection measures on either side of national frontiers and participates actively in involving the civil protection authorities and more generally the government authorities in their application.

2.1 NATIONAL ORGANISATIONS

The Fukushima Daiichi NPP accident confirms that despite the precautions taken in the design, construction and operation of nuclear facilities, the possibility of an accident can never be ruled out, therefore it is necessary to plan for and regularly test the material and organisational provisions for coping with such situations. France thus wished to draw all the lessons from this disaster and has undertaken work on nuclear emergency management which has resulted in a new national response plan for a major nuclear or radiological accident, reflecting the government's determination to enforce tightened requirements in terms of safety of nuclear facilities and transport operations.

This plan is based on the existing measures, such as the alert system specific to nuclear events, the system for disseminating information around the nuclear sites, the off-site emergency plans, the on-site emergency plans and the nuclear licensees' emergency response organisation. The plan supplements the above measures to integrate hypotheses that would require a State response to reinforce the safety of the population in the event of a severe accident occurring beyond the French borders, and to cope with the possibility of radioactive material transport accidents, including at sea.

This plan was tested in June 2013 during an exercise carried out in the vicinity of a NPP, an in September 2016 during an exercise carried out in the vicinity of a fuel cycle plant. These two exercises confirmed the relevance of the plan.

2.1.1 The main actors involved in a nuclear emergency situation in France

In the event of a severe accident, an interministerial crisis committee (CIC) is set up. The relevant departments of the Ministries concerned, together with ASN, work together to advise both the Prefect at the local level and the Government, through the CIC, on the protective

measures to be taken. They provide the information and advice to enable 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.

ASN in particular relies on its technical expert, IRSN, whose Emergency Technical Centre assesses the situation. Its experts propose and regularly update the diagnosis and prognosis of the damaged facility, the dosimetric impact of the accident and the radiological consequences for the populations and the environment.

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 in the event of a radiological or nuclear emergency situation.

The CIC can comprise:

General Secretariat for Defence and National Security (SGDSN):

The SGDSN is a service reporting to the Prime Minister which is responsible for ensuring the interministerial consistency of the planned measures in the event of an accident, and for the planning and assessment of exercises. Following the Fukushima-Daiichi NPP accident, the SGDSN was mandated by the Prime Minister to ensure the interministerial coordination of the development of a National response plan for a major nuclear or radiological accident. The work, which involved all the ministries and government agencies concerned as well as the nuclear operators, ASN and IRSN, resulted in the issuing of this plan in February 2014.

The plan comprises two parts. The first part defines the different emergency situations to be taken into consideration (the plan defines eight nuclear or radiological emergency situations), the national response organisation, the roles and responsibilities of all the stakeholders and the various response strategies to implement. The second part provides a catalogue of operational measures to be implemented according to the situations encountered. Regional application of this plan is in progress under the coordination of the Ministry of the Interior.

In the event of a nuclear accident, the SGDSN ensures the secretariat of the Prime Minister's emergency management unit.

Ministry of the Interior:

To ensure the interministerial emergency management responsibilities, the Minister of the Interior is supported by the Interministerial Crisis Committee (CIC), which reports to the Ministry of the Interior. In the event of a nuclear accident, the Prime Minister requests activation of the CIC and entrusts interministerial operational management to the Minister of the Interior (as a general rule). The CIC comprises four sub-committees:

- the situation sub-committee which assesses the emergency situation,
- the forward-analysis sub-committee which identifies any factor that could complicate management of the emergency and proposes measures that can be implemented accordingly,
- the decision sub-committee which takes strategic and political decisions in the light of the local management by the Prefect,
- the communication sub-committee which prepares the communications, including press releases and the messages to be conveyed at government level.

The DGSCGC (General Directorate for Civil Protection and Emergency Preparedness) has the COGIC (French Government Emergency Management Operations Centre) and the MARN (Nuclear Risk Management Aid Committee) at its disposal. It provides the Prefect, who is responsible for the rescue operations, with material and human resources to protect persons and property;

Ministry for Solidarity and Health:

This ministry is responsible for protecting persons against the effects of ionising radiation in collaboration with the other government departments competent in radiation protection.

Ministry of Ecological and Solidarity-based Transition:

The Nuclear Safety and Radiation Protection Mission (MSNR) participates in the State's nuclear safety and radiation protection missions in liaison with the other competent departments. It contributes, in liaison with the services of the Ministry responsible for civil protection, to the development of the national emergency organisation to respond to nuclear or radioactive material transport accidents, and more generally accidents that could adversely affect human health through exposure to ionising radiation, occurring in France or liable to affect the French territory.

Ministry of the Armed Forces:

The Defence Nuclear Safety Authority (ASND) is the competent authority for overseeing the safety of secret basic nuclear installations (SBNIs), military nuclear systems (SNM) and defence-related transport operations. ASN and the ASND signed an agreement on 26 October 2009 to coordinate their efforts in the event of an accident affecting an activity controlled by the ASND and to facilitate the transition from the emergency phase managed by ASND to the post-accident phase which is the responsibility of ASN (this agreement is currently undergoing revision).

Ministry of Europe and Foreign Affairs (MEAE):

Under the "Early Notification and "Assistance" conventions and the 1987 decision of the European Council, the MEAE (Ministry of Europe and Foreign Affairs) is responsible for rapidly passing on the information received. It is also responsible for responding to requests for assistance received from third countries, if they are covered by an interministerial instruction.

The MEAE is also responsible for managing French nationals abroad (holding the plans and providing safety equipment, issuing via the embassies the relevant information and measures advocated by the French authorities, planning for evacuation if necessary, etc.), informing families and coordinating emergency situation management through its emergency response centre. Lastly, it is responsible for communications of a political nature with the IAEA, in liaison with France's member of the IAEA Board of Governors and through the French permanent representation. The information provided for in the international agreements is transmitted by ASN, as competent authority, to the international organisations (IAEA and European Union).

The Nuclear Safety Authority (ASN):

ASN participates in the management of radiological emergency situations. With the technical assistance of the IRSN, it checks the measures taken by the licensee, assists the government in all questions for which it is competent, and informs the public on the state of safety of the facility causing the emergency situation. ASN moreover acts as competent authority within the

framework of the international agreements on early notification. The duties of ASN are described in more detail in the subsequent chapters.

French Institute for Radiation Protection and Nuclear Safety (IRSN):

IRSN is ASN technical support agency. In a radiological emergency situation, IRSN works in close coordination with the licensee's technical teams to analyse the collected data and the field measurements to establish a diagnosis of the accident situation and prognoses concerning the development of the accident, the releases and their consequences on the populations and the environment. Working in collaboration with Météo France, IRSN more specifically produces simulations of the dispersion of radioactive releases which can extend to the global scale.

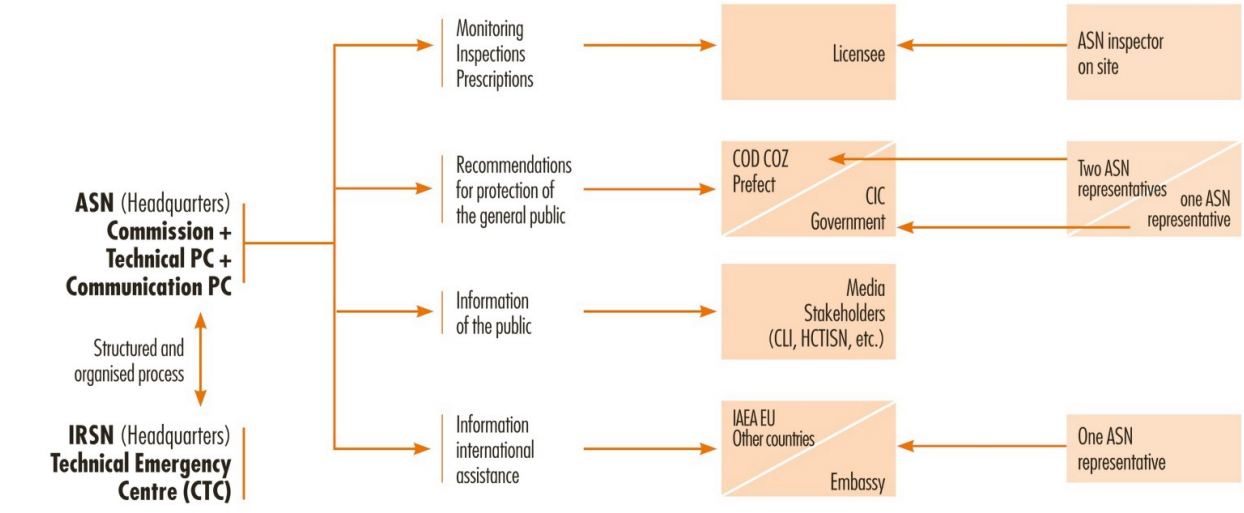
2.1.2 ASN duties in a nuclear emergency situation

Pursuant to the provisions of the "TSN Act" of 13 June 2006 on Transparency and Security in the Nuclear Field, now codified in the Environment Code, ASN is an independent administrative authority and participates in the management of radiological emergency situations for questions relating to nuclear safety and radiation protection.

Aided by IRSN expertise, it fulfils four main duties, namely:

- ensuring the validity of the measures taken by the licensee under its general oversight duties;
- advising the Government and its local representatives with regard to measures for protecting the general public and the environment;
- taking part in informing the public;
- acting as competent Authority within the framework of international conventions.

These four duties are taken up in the diagram below:



COD: Departmental Operations Centre
COZ: Zone Operations Centre
CIC: French Inter-ministerial Crisis Committee
CICNR: Inter-ministerial Committee for Nuclear or Radiological Emergencies
CLI: Local Information Committee
HCTISN: High Committee for Transparency and Information on Nuclear Security
PC: Command Post

Figure 1: The role of ASN in a nuclear emergency situation

To fulfil its duties ASN has its own emergency centre, the activation of which does not prejudge the severity of the situation, and an alert system which rapid mobilisation of its staff to the emergency centre as well as the mobilisation of IRSN, which sets up its technical emergency centre, of the DGSCGC, of SGDSN and of Météo France. The alert system, the emergency centre and the equipment it deploys are regularly tested during emergency exercises. During these exercises, ASN endeavours in particular to bring into play the exchanges of alerts and information with the European Commission, the IAEA and the EU member States (ECURIE and USIE).

2.1.3 Experience feedback to ASN from the Fukushima Daiichi NPP accident

The Fukushima Daiichi NPP accident not only confirmed the ability of ASN and its technical support organisation IRSN to mobilise their resources in a large-scale accident situation but also revealed the points that need to be improved in an emergency situation.

2.1.3.1 Large-scale mobilisation

The follow-up to the Fukushima-Daiichi NPP accident in 2011 mobilised some 200 staff members of all levels from all departments and from several regional divisions, who manned the emergency centre on a rota basis. Altogether this operation mobilised 1,000 man-days in one month.

The very high level of mobilisation of the ASN staff made it possible to man (activate) the emergency centre. The Fukushima-Daiichi NPP accident did however result in ASN dedicating a very large part of its resources to responding to requests from the various audiences, which significantly disturbed its daily functioning. The IRSN, which also activated its emergency technical centre to produce diagnoses and predictions concerning the accident and releases and to evaluate its consequences on health and the environment, likewise found that its capacities reached the point of "saturation".

ASN and the IRSN thus concluded that a nuclear accident occurring closer to hand, in Europe, would lead to the mobilisation of all their resources to respond to the needs of the French authorities, and that an accident in France would raise real difficulties in terms of human and material resources.

2.1.3.2 The importance of international coordination

During the accident, ASN participated with the United Kingdom (HSE/ONR) and Canada (CNSC) in regular audio conferences organised by the United States (USNRC). These audio conferences enabled the four nuclear safety authorities to share information quickly and efficiently and thereby improve their understanding of the accident and the source term.

Conversely, the lack of coordination between the European countries and the differences in approaches concerning the control of foodstuffs and products at national borders raised questions from the public. More generally, the lack of harmonisation of the population protection measures would lead to significant difficulties in the management of radiological emergency situations, particularly if a NPP situated near a national border was concerned.

Consequently, the nuclear safety and radiation protection authority associations WENRA and HERCA have initiated work to streamline and harmonise the actions undertaken by the safety organisations: France participates actively in this work which has allowed the implementation of the joint HERCA-WENRA approach.

A seminar addressing the HERCA-WENRA approach and attended by representatives of the nuclear safety authorities and of the heads of civil protection was held in Slovenia in 2016 in order to give recommendations to these vital players in the management of nuclear emergencies.

2.1.3.3 The predominant position of communication

The prime objective of the handling of the accident and deployment of the emergency centres in France was to inform the various audiences about the accident and its development, and of the risks run by the French population (in France and in Japan). ASN was thus in permanent contact with the ministries and the French embassy in Japan, the media, its foreign counterparts and the international organisations (ASN communication actions represented 17 press conferences, 28 press releases and 1200 information requests from the media).

ASN adapted its modes of communication so that it could cope with the streams of questions from the public. ASN organised regular press conferences and trained external service providers to respond to the large number of telephone queries.

2.1.3.4 Environmental monitoring

France has set up a national environmental radioactivity monitoring network (RNMRE) which collects and makes available to the public environmental radioactivity measurement results and documents synthesising the radiological situation in the country and evaluating the ionising radiation doses to which the general public is exposed.

This network has a website (http://www.mesure-radioactivite.fr/) which posts on line the measurements made by ASN-approved laboratories, including associative laboratories.

Giving the public access to data provided not only by the public authorities and the licensees but also by associations, contributes to transparency and reinforces the public protection measures implemented. Further to this accident, ASN and the IRSN are undertaking reflections to facilitate data exchanges between the RNMRE and IRSN's CRITER database if events arise.

2.1.3.5 The action plan relative to ASN internal organization in nuclear emergency situations

In order to get maximum benefit from the lessons learned in its management of the Fukushima-Daiichi NPP accident, ASN organised a general assessment involving all the ASN personnel. This assessment highlighted the lines of improvement concerning the material and logistic resources, the ASN emergency centre's missions and internal functioning, its deployment and ASN external relations (with the media and public, IRSN, the other public and institutional players and the international authorities).

More specifically, ASN noted the benefits of renovating its emergency centre and training its staff in post-accident management. When ASN moved to its new premises in Montrouge, it set up a new emergency centre there in March 2013, designed on the basis of the best international standards. This centre has been tested successfully in the course of some ten exercises.

2.2 OFF-SITE ORGANISATION IN EMERGENCY AND POST-ACCIDENT SITUATIONS

In the event of an accident in a nuclear facility, such as an EDF NPP, the emergency organisation is based on an on-site emergency plan (PUI) that is the responsibility of the licensee, and an off-site emergency plan (PPI) that is the responsibility of the Prefect. This organisation is tested regularly during the emergency exercises.

ASN participates in this organisation by approving the PUI and communicating the relevant information to the Prefect for the development of the PPI. ASN is also involved as a player in the emergency organisation, fulfilling the four duties conferred upon it, which are developed in 2.1.2.

2.2.1 Principles governing the emergency organisation in France

The emergency organisation implies implementing coordinated emergency plans:

- **the on-site emergency plan (PUI)**, under the responsibility of the licensee, providing for all the measures enabling the situation to be controlled at the nuclear facility level; The PUI describes the measures necessary to alert and protect the site personnel, the neighbouring population and the environment, and to control an accident and its consequences;
- **the off-site emergency plan (PPI)**, under the responsibility of the public authorities, to ensure the protection of the populations. The PPI enables the Prefect of the département to mobilise the environmental monitoring means (measurement plan) and implement - on the recommendations of ASN - population protection measures if necessary.

For the PUI of the NPPs, EDF has adopted an organisation comprising two complementary levels, one local (on site) and one national, with their respective responsibilities and duties clearly defined. This organisational set-up is applied identically on all the sites, given that the nuclear fleet is standardised, with the local level focusing on operational control of the installation while the national level looks ahead to the development of the situation.

The national emergency organisation for its part is based on constant relations between the public authorities, Government and ASN, the licensees and the technical experts.

The diagram below gives an example of national organisation for the licensee EDF and represents a simplified version of a complex organisation that also involves ministerial levels.

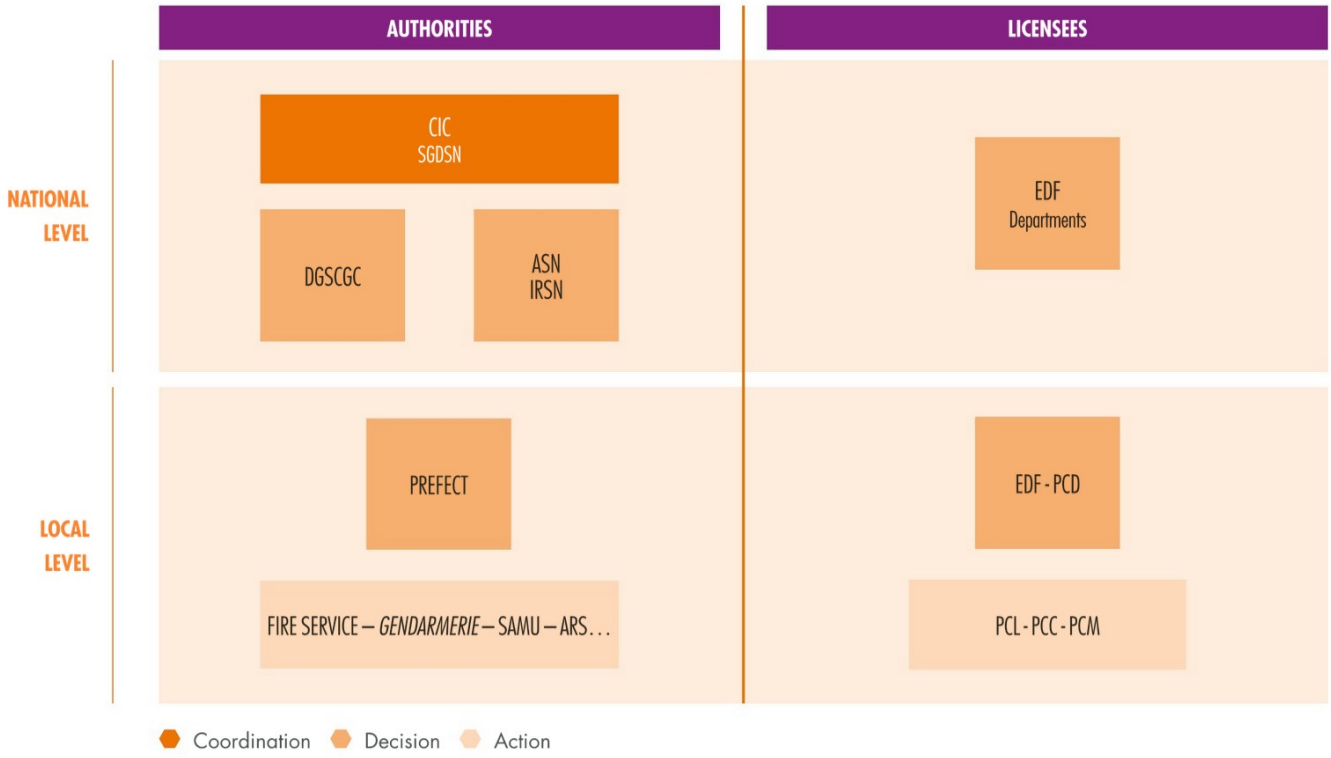


Figure 2: Emergency response organisation in an accident situation affecting a nuclear reactor operated by EDF

CIC: French Inter-ministerial Crisis Committee
SGDSN: General Secretariat for Defence and National Security
DGSCGC: General Directorate for Civil Protection and Crisis management (Ministry of the Interior)

PCD: Command and Decision Post
PCL: Local Command Post
PCC: Supervision Command Post
PCM: Resources Command Post

2.2.2 Identified areas for improvement

Further to the Fukushima-Daiichi NPP accident, the French public authorities initiated a reflection on ways of improving nuclear accident management, involving the ministries, the technical support organisations and the licensees. Some of the work areas concern the emergency plans (PUI and PPI) and are presented below.

2.2.2.1 Protection of populations

Coordination between the various population protection measures and the existing emergency planning set-ups (ORSEC and PPI plans, iodine tablet distribution, etc.) is one of the areas for improvement in emergency management.

To set out the bases of this reflection, a situation assessment has been carried out under the aegis of the Ministry of the Interior in particular. This assessment has highlighted the weaknesses in the existing systems, but also brought forward projects that can improve these systems. Interministerial work involving ASN and IRSN has been carried out over a period of two years and resulted in the production of an instruction from the Ministry of the Interior relative to the development of the national doctrine for the preparation or modification of the PPIs (off-site emergency plans) around the NPPs operated by EDF. This instruction, dated

3 October 2016 and addressed to all the Prefects of *départements* in which NPPs are situated, confirms two existing measures and adopts four new measures.

Existing measures:

- as the operational response is not limited to the zones covered by the PPIs but covers the entire national territory (for example, iodine tablets are pre-distributed in the PPI zones but the ORSEC-Iodine plans provide for distribution to the entire population),
- the relevance of the procedure for triggering the reflex phase over a two-kilometre radius for alerting the populations concerned and instructing them to take shelter and listen to the media to remain informed.

New measures:

- extension of the PPI radius (and the predistribution of stable iodine tablets) from 10 to 20 kilometres,
- preparation for immediate evacuation over a 5 km radius around the NPPs,
- as soon as the emergency phase is triggered, and pending the investigation, issuing of instructions prohibiting the consumption of foodstuffs,
- consideration of the local context by the Prefects to decide on the population protection measures.

The working group is continuing its work to study the possible changes in the PPI zones around the other BNI categories (research reactors, reactors, production plants, etc.).

2.2.2.2 Means of communication and alert

As part of the stress tests conducted in France, one of the technical prescriptions addressed by ASN to the licensee EDF concerns improved means of communication which are vital for emergency management, and comprise in particular, means of alerting and informing the emergency teams and the public authorities, and the means used to alert the populations if the off-site emergency plan (PPI) is triggered in the reflex response phase by delegation from the prefect.

These complementary means of communication and alert have been integrated by the licensee in the "*hardened safety core*" of material and organisational measures to control the fundamental safety functions in extreme situations (see Section 1).

In accordance with the ASN prescription, stand-alone communication means enabling the site to have direct contact with the national emergency organisation players (Prefect, ASN, EDF HQ in particular) have been put in place.

2.2.2.3 The international approach

This accident highlighted the difficulties that would be encountered by ASN, IRSN, and their European counterparts in managing a large-scale accident in Europe. The nuclear safety authorities have confirmed the need to plan for mechanisms of mutual assistance between authorities. Furthermore, the radiation protection authorities are currently conducting reflections (WGE emergencies, HERCA-WENRA) in order to coordinate population protection measures on either side of national frontiers (see §2.3.1).Although the authorities have already undertaken work to improve their organisation, it will still take several more years to achieve

tangible results. As set out in § 2.3, ASN is actively involved in the work conducted at European level.

ASN also takes part in the IAEA's work to improve notification and information exchanges in radiological emergency situations. It participates in defining the strategy for international assistance needs and resources, and in the development of the Response Assistance Network (RANET). ASN is also a member of the IAEA's National Competent Authorities' Coordination Group (NCACG), in which it has represented the competent authorities of Western Europe since 2005.

2.2.2.4 Post-accident phase

Pursuant to the interministerial directive of 7 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. In order to draw up the corresponding aspects of doctrine, ASN in June 2005 created the steering committee for managing the post-accident phase of a nuclear accident or radiological emergency situation (CODIRPA), for which it acts as Chair and technical secretary. ASN mandate was updated in a letter from the Prime Minister of 29 October 2014.

Numerous elements of the doctrine drawn up by the CODIRPA were incorporated into the "Major nuclear or radiological accident" national response plan sent out in January 2014, such as post-accident zoning. The CODIRPA is currently continuing with work to take account of the lessons learned from the post-accident management carried out in Japan following the Fukushima Daiichi NPP accident, but also experience feedback from emergency exercises. 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) working group.

Finally, work on the management of manufactured products, water and marine environments will be started in 2017.

2.3 INTERNATIONAL COOPERATION

2.3.1 ASN 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 conducts its international action to ensure that nuclear safety and radiation protection principles are taken into account and promoted and to share its work and experience.

To this end, article L. 592-28 of the Environment Code formalizes the activities in which ASN represents France in international bodies in its areas of competence.

Furthermore, 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."

The main objectives of ASN are:

- to develop exchanges of information with its foreign counterparts on regulatory systems and inspection practices, communicate and explain the French approach and practices and provide information on the steps taken to solve the problems encountered;
- to inform foreign States of events that have occurred in France and provide the countries concerned with all useful information about French nuclear facilities located close to their borders;
- to contribute actively to improving the rules and practices at European and international levels and to take an active part to harmonizing and enhancing of nuclear safety and radiation protection principles and standards;
- to implement the requirements concerning nuclear safety and radiation protection, in particular within the framework of international conventions of IAEA;
- to participate in the international committees that produce the scientific syntheses and the recommendations stemming from them.

Relying upon 30 bilateral agreements with other regulators, ASN is encouraging bilateral technical meetings in order to exchange on a wide range of issues related to various challenges in terms of safety and radioprotection.

2.3.2 International action at European level

ENSREG

Further to the Fukushima Daiichi NPP accident, ASN issued a set of resolutions dated 5th May 2011 asking the licensees of major nuclear facilities to perform stress tests.

These were carried out on the basis of specifications consistent with ENSREG specifications. This approach also concerned the Flamanville EPR reactor No.3, currently under construction.

In France, the stress tests approach 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 EU specifications with two extensions: the study carried out in France concerned all nuclear facilities (including research and fuel processing facilities); the specifications were supplemented by requirements related to the use of subcontracting.

In addition to the stress tests, ASN conducted a campaign of inspections targeting additional topics related to the Fukushima Daiichi NPP accident: they comprised issues such as conformity of the licensee's equipment and organization deployed in accordance 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, as rapidly as possible.

At the European level, the results of these stress tests were examined by a peer review carried out under the supervision of the ENSREG in April 2012.

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 four highest-priority CEA research reactors (OSIRIS, Phenix and Masurca, RJH). These measures will significantly reinforce the safety margins of the facilities beyond their design-basis levels.

In 2014, The European Union (EU) Council amended the 2009 Nuclear Safety Directive to incorporate lessons learned following the accident at the Fukushima Daiichi NPP in 2011.

Recognising the importance of peer reviews in delivering continuous improvement to nuclear safety, the revised Nuclear Safety Directive introduces a European system of topical peer reviews, which started in 2017 and will be repeated every six years thereafter. The 30th Meeting of the ENSREG identified, based on an assessment performed by WENRA, ageing management for nuclear power reactors and research reactors as the topic for the first Topical Peer Review.

The first stage of the ENSREG topical peer review process was the production of a national assessment report for each country participating in the topical peer review, based on a technical specification prepared by WENRA and endorsed by ENSREG.

The French report was published in English end of December 2017 on the ENSREG website. Both English and French versions are also made public on the ASN website.

Finally ASN has been very active in piloting the steering committee for the fourth ENSREG Conference held in Brussels on 28 and 29 June 2017. This year's event was built on topics related to the European directives (2011 on radioactive waste management and 2014 revised directive on nuclear safety) and issues such as long-term operation, licensing or supply chain control. The ENSREG Conference illustrated the consensus regarding continuous improvement of nuclear safety, a priority shared by multiple stakeholders as well as the need for effective communication and public participation. The conference also allowed all participants to contribute to the debate and to share their expectations related to nuclear safety.

WENRA

One of the objectives of WENRA (Western European Nuclear Regulators' Association), an informal club created in 1999 on initiative of the ASN chairman, is to develop a harmonized approach to nuclear safety and radiation protection issues and their regulation in Europe.

A significant contribution to this objective was the publication, in 2006, of a report on harmonization of reactor safety in WENRA countries. This report addressed the nuclear power plants in operation and it included "Safety Reference Levels" (SRLs), which reflected expected practices to be implemented in the WENRA countries. The SRLs were updated twice in 2007 and again in 2008.

The SRLs have been established for greater harmonization within WENRA countries raising the level of nuclear safety in Europe by their implementation in the national regulatory framework and in the nuclear power plants.

In the long term, the full WENRA 2014 reference levels for existing reactors will therefore be considered in the instructions or inspections through their transposition into national regulations.

ASN has continued its pivotal action in facilitating WENRA work, as much through its coordination of the technical secretariat until June 2016 as through the chairing of the RHWG until April 2017. In France, the number of SRLs already transposed into published national requirements, checked in mid-2017, is 219 already transposed out of a total of 342, and represents an overall progress rate of 64%.

HERCA

HERCA (Heads of European Radiological Protection Competent Authorities), an association formed by 55 radiation protection competent authorities from 31 European countries (including the 28 EU member states) has set itself the goal of developing a joint approach to radiation protection and practices and thereby contributing to a high level of radiation protection in Europe. ASN ensures the technical secretariat of the association and has been very active in defining the new approach in the field of emergency situation preparedness in coordination with WENRA.

2.3.3 International actions on the multilateral field (IAEA, EAN, G7)

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 emergency centre and is tested on the occasion of each exercise.

ASN will continue to follow the recommendations given in the nuclear safety action plan developed by the International Atomic Energy Agency (AIEA) further to the Fukushima accident, and those of the Final Summary report of the second extraordinary meeting of the contracting parties to the Convention on Nuclear Safety (CNS) (CNS/ExM/2012/04/Rev.2). This concerns the following points in particular:

- The conducting of peer reviews such as:
  - The IRRS (*Integrated Regulatory Review Service*) missions: In November 2014 ASN received an IRRS mission tasked with examining its entire scope of action (called a "full scope" mission). It received the "follow-up" mission in October 2017 which has been successful. (See link https://www.iaea.org/newscenter/pressreleases/iaea-mission-sees-improvements-to-frances-regulatory-safety-framework-areas-for-enhancement).

    ASN will moreover continue its involvement by having its experts participate in IRRS missions organised both within and outside Europe.

- The OSART (Operational Safety Review Team) missions: each year France receives an OSART mission on a nuclear power plant, and a follow-up mission for a previous OSART.

  In November 2014 the head office departments of EDF received a "Corporate OSART" mission.

  ASN will continue to make public the reports relative to these missions.

- Report on the application of international conventions: ASN will continue to make public the reports produced in application of the Convention on Nuclear Safety and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, along with the related questions and answers.

Furthermore, ASN will continue to take part in the IAEA's work to improve notification and information exchanges in radiological emergency situations. It is involved in defining the strategy for international assistance needs and resources, and in the creation of RANET (Response Assistance Network).

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 on reflections on the improvement of the international safety framework (strengthening effective implementation of relevant international conventions).

France participated to the NSSG under the Italian chairmanship in 2017, following the Japanese chairmanship of 2016.

France supported the political measures relative to management of the follow-ups to the Chernobyl accident (sarcophagus, intermediate disposal plan for the spent fuel), relative to the IAEA instruments and conventions, to the needs to coordinate the emergency situation harmonisation measures, and the measures relative to safety training and culture coordinated by the IAEA and the NEA.

Nuclear Energy Agency (NEA) of the OECD

Further to the Fukushima-Daiichi NPP accident, the NEA set up a cross-organisation working group (the Senior-level Task Group on Impacts of the Fukushima Accident) to identify the subjects that could be addressed by the NEA's various committees and working groups.

In September 2013, this working group comprising experts from the regulators and certain technical support bodies published a report entitled "*the Fukushima-Daiichi NPP accident – OECD/NEA nuclear safety response and lessons learnt*". On the basis of the conclusions of this report, complementary work is currently being carried out within the NEA technical committees on varied subjects (defence in depth, safety culture, emergency situation preparedness, etc.).

ASN continued to contribute to these various undertakings, by chairing certain groups, such as the group dedicated to defence in depth, chaired by Deputy Director General of ASN.

3 MONITORING ADDITIONAL MEASURES IMPOSED BY ASN: SUBCONTRACTING

The social, organisational and human factors, which are key elements in safety, received particular attention during the stress tests performed in France. The technical specifications produced at European level were supplemented by a section relative to the use of subcontracting which formed the subject of a specific analysis. On completion of the investigations, ASN indicated that it had identified three priorities in this area:

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

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

The end-purposes of the COFSOH are firstly to allow interchanges between the stakeholders on the difficult subject of social, organisational and human factors, and secondly to draw up documents making joint proposals to the various COFSOH members on given subjects and to propose directions for studies to undertake in order to clarify subjects that lack data or clarity.

This committee has held 12 plenary meetings since 2012, with discussions addressing the following themes: the conditions for performance of subcontracting and the relationship between the ordering customer and the subcontractors, the connection between "managed security" and "regulated security", skills management in a context of workforce renewal and the use of pertinent OHF indicators for safety assessment.

Alongside the plenary meetings which are attended by all the COFSOH participants, four working groups have been set up to address:

- **the use of subcontracting in normal operating situations: organisation and conditions of intervention;**
- **emergency situation management;**
- **the legal questions raised by the subjects addressed in the other three working groups;**
- **the connection between regulated safety and managed safety.**

In this context, the three reports published by the COFSOH cover the following areas respectively:

- **Reflections on the questions raised by the legal framework governing the use of outside contractors in BNIs in emergency situations (report published in November 2014);**
- **Advocating a positive contribution of subcontracted maintenance to nuclear safety (report published in January 2017);**

- **Advocating an approach that integrates organisational and human factors (OHF) into nuclear emergency management (report published in May 2017).**

Furthermore, the order setting the general rules relative to basic nuclear installations, called the "*BNI*" order, was signed on 7 February 2012. The provisions of this order cover the organisation and responsibilities of the BNI licensees in particular. Several articles in the "BNI" order cover subcontracting:

- The licensee must have the necessary in-house technical competence to oversee the activities that directly concern the safety of the installation.
- The licensee must establish and implement a policy that gives priority to nuclear safety and protection of the environment, disseminate this policy and ascertain that it is known, understood and applied by all the personnel required to implement it, including outside contractors' personnel.
- The activities important for nuclear safety and radiation protection of the environment, their technical controls, the verifications and assessments are carried out by persons with the necessary skills and qualifications. The licensee ascertains that the outside contractors take the necessary training measures to maintain these skills and qualifications and, where necessary, to develop them.
- The licensee takes all necessary measures to enable outside contractors to detect the deviations that concern them and report them to the licensee without delay.
- The licensee monitors the outside contractors.
- Monitoring of performance of activities important for protection by an outside contractor must be ensured by the licensee, who may not subcontract this task. This being said, in particular cases the licensee can be assisted in the monitoring, on condition that it retains the skills necessary to maintain control of said monitoring (article 2.2.3).

The regulatory provisions relative to subcontracting were supplemented by the decree of 28 June 2016 relative to the modification, final shutdown and decommissioning of basic nuclear installations and to subcontracting. This decree lays down the following provisions:

- The basic nuclear installation licensee can use outside contractors on condition that it retains the capacity to control these activities and the operation of its installation.
- To guarantee the control of activities that are important for the protection of the interests mentioned in the Environment Code, the licensee keeps the number of subcontracting levels as low as possible. When the licensee entrusts services or works important for the protection of the abovementioned interests to an outside contractor within the perimeter of its facility which is either in operation or undergoing decommissioning, they may be performed by second-tier subcontractors at the lowest.
- The licensee cannot entrust to an outside contractor the operational responsibility and oversight of a basic nuclear installation, including with regard to the handling of accidents, incidents and deviations, and emergency situation preparedness and management.
- The licensee monitors the activities important for protection of the abovementioned interests when they are performed by outside contractors. The licensee puts in place a system for transmitting information received from the outside contractors, particularly for the purpose of experience feedback.

- When these provisions cannot be adhered to in the case of an unforeseeable event affecting the conditions of performance of the activity or necessitating one-off operations, the licensee can authorise the outside contractor to use a third-tier subcontractor The licensee informs ASN beforehand, indicating the reasons for this decision.
- When the licensee is considering using an outside contractor to perform activities important for the protection of the abovementioned interests, it evaluates the bids taking into account criteria that give priority to the protection of these interests. The licensee ascertains beforehand that the companies it is considering using have the technical capability to carry out the work in question and control the associated risks.

4 TRANSPOSITION OF THE WENRA REFERENCE LEVELS FOR EXISTING REACTORS INTO THE FRENCH REGULATORY FRAMEWORK

Development of the WENRA reference levels initially began in the first half of the year 2000. In line with the commitment given by the ASN Chairman and all the other WENRA members to integrate the WENRA reference levels into their national regulatory frameworks, ASN produced an action plan to prepare the orders and ASN guides so that these reference levels could be taken into consideration. This action plan was finalised in 2006.

The publication of the act relative to transparency and safety in the nuclear field (TSN act) in 2006, creating an independent administrative authority (*Autorité de sûreté nucléaire* - ASN - Nuclear safety authority) and giving ASN competence to issue legally binding statutory resolutions, along with the publication of several decrees clarifying the TSN act in late 2007, led ASN to modify its action plan. A new road map was defined in 2008 based on the following principles:

- a ministerial order prepared in close collaboration with the Minister responsible for nuclear safety, concerning all types of nuclear installation, including installations other than pressurised water reactors;
- several ASN statutory resolutions detailing the provisions of the ministerial order;
- insofar as possible, the ASN statutory resolutions defining the requirements applicable to all types of nuclear installations and preferably indicating the expected results rather than the means of achieving them;
- the preference given to the legally-binding statutory resolutions supplemented by guides produced by ASN should such a resolution not be appropriate.

Further to the Fukushima-Daiichi NPP accident, WENRA developed an updated set of reference levels which was published in September 2014. The majority of the modifications concern themes E and F, while a new theme T relative to natural risks has been created.

ASN adapted its regulatory road map in 2015 to take these new reference levels into account. The development process takes into account the fact that certain prerequisites of different reference levels, or risks in some cases, are already included in existing texts. For example:

- The reference levels of theme P relative to the periodic safety reviews are partially covered by the TSN act, which today is codified in the Environment Code. Those reference levels which are not covered by this act shall be covered by ASN statutory resolutions concerning the periodic safety review process;
- The reference levels of theme N relative to the content of the safety reports are partially covered by the Environment Code and the decree of 2 November 2007 on the procedures relative to basic nuclear installations. The reference levels which are not covered therein are covered by an ASN statutory resolution on the content of the safety reports published on 17 November 2015;
- The majority of the reference levels relative to themes E and F are integrated in ASN Guide No. 22 on the design of pressurised water reactors published on 18 July 2017, even though some reference levels are already covered by the ministerial order.

Certain steps in the process for developing statutory resolutions or guides give rise to a detailed ASN internal report on the integration of reference levels. Furthermore, in order to have an overall view of the transposition of the reference levels, the traceability of their integration in the various published regulatory texts and guides is provided by a summary table internal to ASN.

In this context, the BNI order and the ASN statutory resolutions incorporate the WENRA reference levels into the French regulations. ASN is also preparing the transposition, into the national regulatory framework, of the external hazard reference levels which WENRA has added or modified.

Status of progress of the overhaul of the general technical regulations applicable to BNIs, as at 1st october 2017

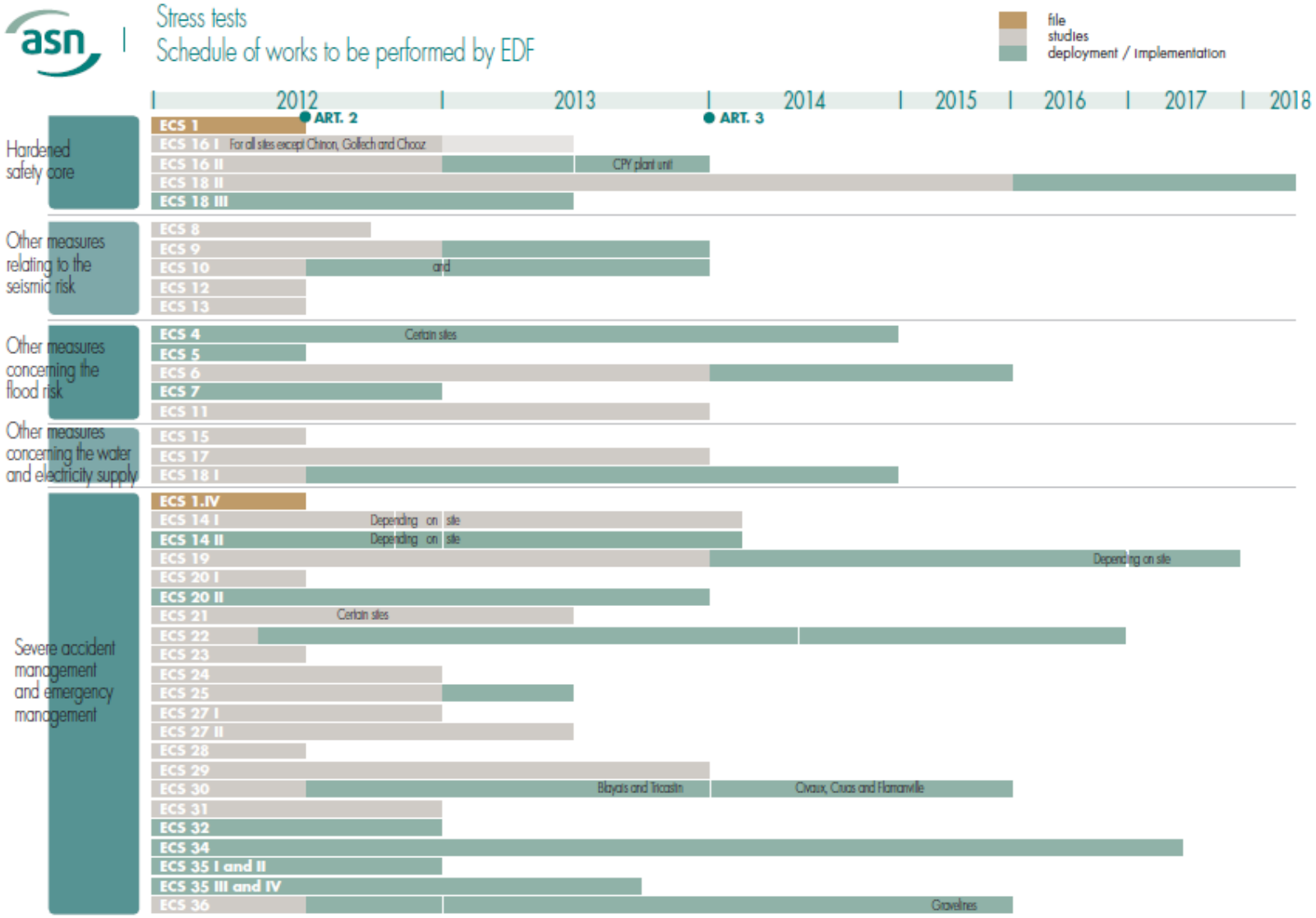
1. Covering the scope of the Order of 31/12/1999
2. Covering the scope of the Order of 26/11/1999
3. Covering the scope of the Order of 10/08/1984

★ Text concerned by the WENRA reference levels

* Title V of the BNI Order, entitled "Pressure equipment specially designed for Basic Nuclear Installations", refers to the Order of 10th November 1999 concerning the monitoring of main primary system and main secondary system operations in pressurised water nuclear reactors and the Order of 12th December 2005 concerning nuclear pressure equipment.

Drafts for modification of these Orders are currently being prepared.

5 PRESCRIPTIONS SCHEDULE DATING FROM 2012



Stress tests
licensee: EDF

Hardened safety core
Earthquake
Flooding
Water and electricity supplies
Severe accident management and emergency management

Art.2 :	Implementation schedule for all the measures
Art.3 :	Interim assessment of lessons learned from the accident
ECS - 1:	Defining the structures and components of the "hardened safety core", including the emergency management premises Defining the requirements applicable to this hardened safety core Hardened safety core based on diversified structures and components
ECS - 4:	End of the Blayais experience feedback (REX) work
ECS - 5:	Conformity of the volumetric protection
ECS - 6:	Reinforcement of protection against flooding, above the current safety baseline
ECS - 7:	Measures to cope with site isolation in the event of flooding (Cruas, Tricastin)
ECS - 8:	Conformity of seismic instrumentation with RFS1.3.b
ECS - 9:	Reinforcement of the seismic interaction approach
ECS - 10:	Reinforcement of team preparation in the event of an earthquake
ECS - 11:	Robustness of the Fessenheim and Tricastin embankments
ECS - 12:	Verification of the seismic design basis of the fire-fighting system
ECS - 13:	Study of the implementation of automatic shutdown in the event of an earthquake
ECS - 14.I:	Integration of industrial risks in extreme situations
ECS - 14.II:	Coordination with neighbouring industrial operators in the event of an emergency
ECS - 15:	Heat sink design review
ECS - 16.I:	Emergency water make up system
ECS - 16.II:	Emergency water make-up in the reactor coolant system, for shutdown states
ECS - 17:	Reinforcement of the facilities to manage long lasting situations of total loss of heat sink or total loss of electrical power supplies
ECS - 18.I:	Reinforcement of battery autonomy
ECS - 18.II:	Ultimate backup diesel generator sets
ECS - 18.III:	Installation of provisional emergency generator sets
ECS - 19:	Redundancy of instrumentation for detecting reactor vessel melt-through and hydrogen in containment
ECS - 20:	Reinforcement of pool condition instrumentation
ECS - 21:	Additional measures to prevent or mitigate the consequences of a fuel transport package falling in the fuel building Studies of the consequences of a package falling in the fuel building
ECS - 22:	Reinforcement of the measures to prevent accidental rapid draining of the pools
ECS - 23:	Placing a fuel assembly in safe position during handling
ECS - 24:	Thermohydraulic development of a pool accident
ECS - 25:	Reinforcement of the provisions for managing a transfer tube leak
ECS - 27.I:	Study of the feasibility of installing a geotechnical containment or a system with the same effect
ECS - 27.II:	Updating of the hydrogeological sheets
ECS - 28:	EPR - Reinforcement of the provisions for managing the pressure in the containment
ECS - 29:	Reinforcement of the U5 venting-filtration system ("sand-bed filter")
ECS - 30:	Designing the emergency premises to withstand earthquakes and flooding
ECS - 31:	Modifications to ensure facility management further to releases
ECS - 32:	Multiple plant unit emergency organisation
ECS - 34:	Updating of agreements with hospitals
ECS - 35. I and II:	Feasibility of emergency management actions in extreme situations
ECS - 35. III and IV:	Accident management training
ECS - 36:	FARN (Nuclear rapid intervention force)