AUTORITÉ DE SÛRETÉ NUCLÉAIRE

NUCLEAR POWER PLANTS GOING BEYOND 40 YEARS:

ASN position on the conditions for the continued operation of the 900 MWe nuclear reactors beyond their 4th periodic safety review

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Summary

ASN position

ASN POSITION

What is a periodic safety review? How is the 4th periodic safety review of the 900 MWe reactors different ?

In France, the authorisation to create a nuclear installation is issued by the Government, on the basis of an ASN opinion. This authorisation is issued without time limit. An in-depth review of the installation, called the "periodic safety review" is carried out every 10 years to assess the conditions for its continued operation for a further 10 years.

EDF's thirty-two 900 MWe reactors are the oldest ones in operation in France. Their 4th periodic safety review is of particular significance, because their design was based on the assumption of an operating lifetime of 40 years. Extending operations beyond this period means that these design studies must be updated and some equipment replaced.

This periodic safety review is also an opportunity to complete the implementation of the safety improvements resulting from the ASN requirements issued after the Fukushima-Daiichi nuclear power plant accident.

How does EDF carry out the periodic safety review of its reactors?

As licensee, EDF is responsible for the safety of the nuclear power plants in France. It therefore defines and implements programmes to improve the safety of its reactors.

The 900 MWe reactors are all designed according to a similar model. This is why the studies carried out and the modifications decided on generally apply to all these reactors. This is covered by the generic part of the periodic safety review.

In addition to the issues concerning all the 900 MWe reactors, account must also be taken of the particularities of each NPP, with its own specific environment, for example on the coast or on a river. Therefore, the safety improvement measures decided on generically for all the reactors are supplemented by provisions particular to each nuclear installation: this is covered by the specific part of the periodic safety review.

The generic phase of the 4th periodic safety review of the 900 MWe reactors was completed at the end of 2020. This periodic safety review process will be carried out on each reactor and run until 2031.

What is ASN's position regarding the generic phase of the 4th periodic safety review of the 900 MWe reactors?

ASN underlines the ambitious objectives of the 4th periodic safety review of the 900 MWe reactors and the substantial work carried out by EDF for its generic phase. It also underlines the scale and scope of the modifications planned by EDF, the implementation of which will constitute significant safety improvements. These improvements more specifically concern control of the risks linked to hazards (fire, explosion, flooding, earthquake, etc.), the safety of the fuel spent fuel pool and management of accidents with core melt.

During the examination process, EDF undertook to supplement its technical file in order to address most of the points raised by ASN.

In fine, ASN orders the implementation of the major safety improvements planned by EDF as well as a number of additional measures it considers to be necessary in order to achieve the objectives of the periodic safety review.

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The measures planned at the generic phase of the periodic safety review, as well as those that will be defined by the studies specific to each site, shall be implemented on each reactor in order to enable it to continue to operate. ASN asks EDF to carry out most of the safety improvements before the periodic safety review conclusions report is submitted and, in practice, during the ten-yearly outage of each reactor. The other improvements shall be completed no later than five years following the submission of this report. This period is extended to six years for the first reactors, that is those for which the submission of the periodic safety review conclusions report is scheduled before 2022.

This staggered time-line is linked to the scale of the work to be done on each reactor, in particular given that it is to be performed simultaneously on several 900 MWe reactors. It takes account of the capacity of the industry to perform them with the required level of quality, as well as the corresponding need to train to handle the effects of these changes.

Given the scope of the modifications envisaged under the periodic safety review, EDF has taken specific organisational measures to improve the modifications design and performance activities, the drafting of the operational documentation and how it builds on the lessons learned from experience feedback.

ASN asks EDF to report annually on the actions taken to comply with the requirements and their deadlines, as well as the industrial capacity of both itself and the outside contractors to carry out the modifications to the installations on-time.

ASN considers that the provisions planned by EDF, supplemented by the answers to the provisions ordered by ASN, will enable the periodic safety review objectives to be met and bring the safety level of the 900 MWe reactors more in line with that of the more recent reactors (third generation), notably:

- by checking, cross a broad perimeter, that the reactors comply with the safety rules that apply to them;
- by improving how "hazards" (earthquake, flooding, explosion, fire, etc.) are dealt with. The reactors could also handle more severe hazards than those hitherto considered;
- by limiting the radiological consequences of the accidents studied in the safety analysis report. This will significantly reduce the occurrence of situations requiring population protection measures (sheltering, evacuation, ingestion of iodine);
- by improving the provisions for managing accident situations affecting spent fuel pools;
- by reducing the risk of an accident with core melt and mitigating the consequences of this type of accident, more specifically by minimising situations which would require depressurisation of the containment and by reducing the risks of containment basemat melt-through by the corium consisting of molten nuclear fuel, steel and concrete. These provisions will thus lead to a significant reduction in environmental releases during this type of accident.

Following the generic phase of the periodic safety review, ASN considers that all the provisions planned by EDF and those it itself stipulates, open up the prospect of continued operation of the 900 MWe reactors for a further ten years following their 4th periodic safety review.

AGEING MANAGEMENT AND CONFORMITY OF THE INSTALLATIONS

What are ageing management and conformity of the installations important?

The actions that contribute to maintaining conformity and to ageing management (surveillance, maintenance, inspection, processing of any anomalies detected, equipment replacement), ensure that the installations comply with the safety rules that apply to them. These actions are to be taken on a daily basis.

Reactor conformity with the baseline safety requirements, in other words all the rules regulatingthe safe operation of the installation, is an essential precondition for safety. Checking compliance with the baseline safety requirements is a fundamental objective of the periodic safety reviews.

At the time of their 4th periodic safety reviews, the reactors will have been operating for about forty years. Their operation beyond this periodic safety review therefore requires updating of the design studies and equipment replacements. Particular attention must be given to unreplaceable components such as the reactor pressure vessel and the containment

What provisions has EDF made for the 4th periodic safety review of the 900 MWe reactors?

The 4th periodic safety review is an opportunity to re-analyse the conformity of certain equipment or systems, such as the electrical power sources.

EDF intends to implement a programme to examine the conformity of the reactors, notably to verify the correct application of the existing preventive maintenance programmes. EDF has also supplemented its actions by field visits conducted by multi-disciplinary teams, in certain rooms containing systems required in an accident situation.

EDF has also undertaken to conduct particular tests on systems important for safety, to supplement the steps designed to verify that conformity of the reactors is maintained.

EDF has also adopted an approach to manage equipment ageing and obsolescence, which contributes to maintaining reactor conformity. This approach is based on a generic analysis of ageing and its consequences and on a local analysis specific to each reactor, on the occasion of its ten-yearly outage.

EDF demonstrated the ability of the reactor vessels presenting no flaw to operate for a further 10 years following their 4th ten yearly outage, taking account of the evolution of the characteristics of the materials. Inspections will be carried out on each reactor during the ten-yearly outage, to ensure that there are no prejudicial flaws in the steel. For certain reactor vessels, for which previous inspections showed that there were manufacturing flaws, specific studies will be performed before the ten-yearly outage of each of the reactors concerned.

Finally, EDF has undertaken to correct any previously identified deviations with safety consequences no later than the 4th ten-yearly outage of each reactor. The anomalies detected during the ten-yearly outage will be corrected as soon as possible, taking account of their importance for safety.

What is ASN's position?

The EDF programme for checking the conformity of its reactors during their 4th periodic safety review, supplemented by ASN's requests, is satisfactory. It will enable the review's objectives to be met.

In addition to the original provisions, ASN more specifically asks EDF:

- to carry out further tests to check the correct operation of certain systems required in the event of an accident, notably the steam generators emergency water supply system;

- to speed up the deployment of the modifications to the installations in order to ensure that the means designed to recirculate borated water in the event of an accident will be able to perform their functions.

These various points are the subject of prescriptions in ASN's draft resolution.

EDF will have to pay particular attention to its implementation of the programme to check the conformity of the reactors. ASN therefore intends to conduct specific inspections on each of the reactors, notably during the ten-yearly outage.

What hazards are the nuclear power plants designed to withstand?

The NPPs are designed to be able to withstand various hazards, originating either inside or outside the installation, and which may directly or indirectly cause damage to equipment and structures important for safety.

The installations must thus notably be able to withstand the following hazards:

- hazards originating inside the installation: fire, explosions, failure of pressure equipment, falling loads, flooding caused by a pipe rupture, etc.;
- hazards of natural origin: earthquakes, lightning, flooding, extreme meteorological or climatic conditions, such as heat waves or tornadoes;
- hazards caused by nearby industrial activities and transport routes: explosions, emissions of hazardous substances, accidental airplane crashes.

What provisions has EDF made for the 4th periodic safety review of the 900 MWe reactors?

During the course of the periodic safety review, EDF reassessed the severity of the hazards to be considered, taking account of changing knowledge and, should such a hazard occur, demonstrated that the reactor could be shut down and then maintained in a safe state for a long period of time.

More specifically, for climatic hazards, EDF has set up a watch system to collect data about heat waves and rising sea levels, and to reassess the severity of the corresponding hazards.

In addition, this periodic safety review is an opportunity to deploy the "hardened safety core" of safety provisions ordered by ASN in 2012 following the Fukushima Daiichi NPP accident. These provisions will be able to cope with certain hazards (earthquake, flood, etc.) of extreme intensity, going beyond the level hitherto adopted.

Most of the hazard studies are site-dependent and will be completed during the periodic safety review phase specific to each reactor. This is for instance the case with the seismic resistance reassessment studies of the installations.

The studies already carried out have identified a number of necessary modifications, such as the elimination of certain water ingress paths in the event of extremely heavy rain, the installation of grilles to protect against projectiles caused by strong winds, the adoption of measures to enhance the reliability, in the event of fire, of the switchover between off-site electrical power sources and the addition of a hydrogen leak detection system in the batteries charging rooms, as this is a gas liable to cause an explosion.

EDF also checked that the particular environmental conditions liable to be generated in a hazard situation are acceptable in those premises where actions are to be carried out. It has undertaken to complete its demonstration concerning the capacity to reach these premises and to carry out the actions required for all accidents, including those leading to core melt, within the allocated time.

What is ASN's position?

ASN underlines the considerable work done by EDF to update all the hazard studies, whether originating inside or outside the installation. The methods used by EDF to define the hazard levels are acceptable. All of the modifications resulting from these studies represent a significant improvement in the management of hazard-related risks and will enable the objectives of the periodic safety review to be met.

However, following its examination, ASN considers that, in addition to the provisions initially planned, EDF must in particular include the following in the 4th periodic safety review of the 900 MWe reactors:

- study of the ability of the installations to withstand even higher temperatures;
- identification of the most sensitive equipment which, in the event of a fire or explosion, is essential for reactor safety and the definition of measures to reduce its risk of failure.

These various points are the subject of prescriptions in ASN's draft resolution.

ACCIDENT SITUATIONS WITHOUT CORE MELT

What is an accident without core melt?

An accident without core melt is an accident during which the nuclear fuel is damaged little if at all. It may however lead to releases of radioactivity into the environment. Managing these accidents helps prevent core melt.

The reactor safety case covers both accidents resulting from a single failure (for example a primary system break) and accidents resulting from multiple, combined failures (for example loss of on-site and off-site electrical power supplies).

What provisions has EDF made for the 4th periodic safety review of the 900 MWe reactors?

EDF has decided to update its safety case to take account of developing knowledge and move towards environmental radioactivity release levels which do not require that population protection measures (sheltering, evacuation, ingestion of iodine) be taken.

During the generic phase of the periodic safety review, EDF examined all the studies associated with the various accidents. EDF more specifically assessed the effects of physical phenomena not so far considered in the safety case, such as deformation of nuclear fuel assemblies.

EDF intends to modify its installations to mitigate the consequences of certain accidents. Modifications are notably planned to limit the quantity of radioactive water released into the environment in the event of a steam generator tube rupture accident.

What is ASN's position?

The modifications planned by EDF will improve the management of incident and accident situations without core melt and thus also improve the prevention of accidents with core melt.

They will also lead to a reduction in the radiological consequences of the accidents studied in the safety analysis report. This will significantly reduce the occurrence of situations requiring population protection measures.

EDF will need to continue with its efforts to minimise the radiological consequences of the steam generator rupture accident, in which these radiological consequences are the most significant.

The results of these studies and the modifications planned by EDF, supplemented by the requests from ASN, will be such as to meet the objectives set for this periodic safety review.

ACCIDENT SITUATIONS AFFECTING THE SPENT FUEL POOL

What are the consequences of accidents that can affect the spent fuel pool?

Accidents can affect the water level in the spent fuel pool, or its cooling, and thus damage the fuel.

What provisions has EDF made for the 4th periodic safety review of the 900 MWe reactors?

During the ten-yearly outage, EDF intends to install a water make-up system and a diversified ultimate water source, as well as an additional system for cooling the spent fuel pool.

For the purposes of this periodic safety review, EDF broadened the scope of the accident situations studied for the spent fuel pool. These studies led to the proposal of modifications, such as the addition of fire protection screens or the addition of automation systems to close certain valves if the water level in the pool were to fall.

EDF finally demonstrated that a crash by a light aircraft would not compromise cooling of the fuel assemblies in the spent fuel pool.

What is ASN's position?

The additional means planned by EDF will represent major improvements to the safety of the spent fuel pools.

These means, most of which are part of the "hardened safety core", will significantly reduce the risk of the fuel assemblies no longer being under water and, in most situations considered, will ensure that a final state is reached with no boiling of the pool after an accident. In situations for which such a state could not be reached with the means adopted in the safety case, EDF shall define measures to improve the prevention of these situations, along with post-accident management provisions enabling such a state to be reached in the long term.

The results of these studies carried out by EDF, and the modifications planned, supplemented by the requests from ASN, will enable the objectives set for this periodic safety review to be met.

ACCIDENT SITUATIONS WITH CORE MELT

What is an accident with core melt?

Core melt is the most severe accident that can occur in a nuclear reactor. This involves melting of the nuclear fuel, which can then melt through the reactor vessel and entail a considerable release of radioactivity into the concrete containment (in the form of aerosols, gas and radioactive water).

Releases of radioactivity into the environment are then inevitable owing to the leakage from this containment. Releases are particularly significant when the air pressure in the containment is such that it has to be depressurised in order to avoid damage to the reactor building. Radioactive releases into the ground are also possible if the mixture called "corium", consisting of molten nuclear fuel, steel and concrete melts through the basemat of the reactor building.

What provisions has EDF made for the 4th periodic safety review of the 900 MWe reactors?

EDF has set the objective of avoiding long-term environmental effects in the event of an accident with core melt. To do this, EDF intends to modify its installations in order to:

- be able to evacuate the heat, produced by the core, outside the containment, without having to depressurise it. This provision significantly mitigates the radioactivity releases into the air;
- be able to cool the corium which melted through the reactor vessel at the bottom of the reactor building and thus avoid concrete basemat melt-through. This provision notably mitigates the pollution of the groundwater.

To do this, EDF intends to implement means to manage such an accident more efficiently. These provisions will involve the installation of new systems during the ten-yearly outage (including new pumps, new pipes, new heat exchangers) as part of the "hardened safety core", modifications to the reactor pit and certain adjacent premises, as well as mobile means deployed by EDF's nuclear rapid intervention force (FARN).

Finally, EDF intends to implement provisions to mitigate leaks of contaminated water outside the reactor building and the fuel building in the event of an accident with core melt and to provide means to reduce contamination of the water present in the reactor building after an accident with core melt. In order to minimise the magnitude and the duration of contamination in the event of a leak of contaminated water outside the buildings, EDF will also - for each site - study the means of limiting the off-site dissemination of radioactive substances, through the soil and groundwater.

What is ASN's position?

ASN underlines the considerable work already done by EDF to mitigate the consequences of accidents with core melt and the ambitious nature of the corresponding modifications programme. This programme will allow major advances in safety and will meet the objectives set for this periodic safety review.

However, following its examination process, ASN considers that EDF must take further steps to manage an accident with core melt, more particularly :

- the reinforcement of certain concrete walls in areas where the corium would spread;
- means for injecting an additional volume of borated water into the reactor building.

These various points are the subject of prescriptions in ASN's draft resolution.

CONTROLLING THE ENVIRONMENTAL IMPACTS OF THE INSTALLATIONS

What are the environmental impacts of the nuclear power plants?

The normal operation of NPPs has impacts on the environment. This more particularly involves water intake, effluent discharges, detrimental effects owing to noise and vibration, the creation of dust, odours, the dispersal of pathogenic micro-organisms and the production of waste.

The environmental impacts are specific to each site.

What provisions has EDF made for the 4th periodic safety review of the 900 MWe reactors?

The generic phase of the periodic safety review allowed the definition of the actions to be taken for each reactor, in order to reassess the control of environmental impacts. EDF thus defined the scope of the inspections and studies to be carried out, for example on the chemical and radiological characterisation of the soil.

What is ASN's position?

ASN considers that the analysis and inspection programme planned by EDF needs to be expanded. EDF shall in particular carry out additional conformity checks, by comparison with those performed during routine operations, notably in the light of the best available techniques. These additional checks more particularly concern the equipment used to treat effluents or condition waste.

ASN also asked EDF to consolidate the installations' impact assessments using the format currently required by the Environment Code and to identify improvements such as to mitigate the environmental impacts.

These various points are the subject of prescriptions in ASN's draft resolution.