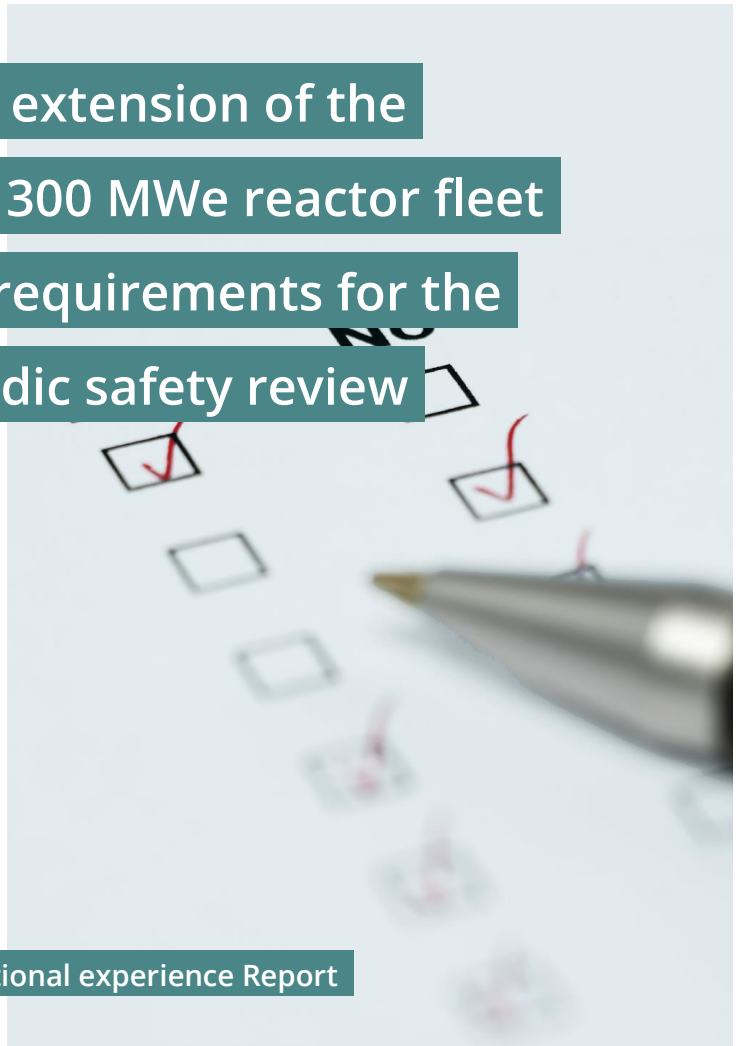
umweltbundesamt
ENVIRONMENT AGENCY AUSTRIA

Lifetime extension of the French 1300 MWe reactor fleet generic requirements for the 4th periodic safety review



Federal Ministry
Republic of Austria
Climate Action, Environment,
Energy, Mobility,
Innovation and Technology

Task 2: Operational experience Report

umweltbundesamt
ENVIRONMENT AGENCY AUSTRIA

Lifetime extension of the French 1300 MWe reactor fleet generic requirements for the 4th periodic safety review

Task 2: Operational experience Report

Manfred Mertins
Oda Becker
Yves Marignac

REPORT
REP-0935

VIENNA 2024

Project Manager Franz Meister

Authors Manfred Mertins (task leader)
Oda Becker
Yves Marignac

Layout Doris Weismayr

Title photograph © iStockphoto.com/imagestock

Contracting authority Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, Sektion VI – Klima- und Energie, Abteilung VI/8 – Allgemeine Koordination von Nuklearangelegenheiten

GZ: 2023-0.313.651

Publications For further information about the publications of the Umweltbundesamt please go to: https://www.umweltbundesamt.at/

Imprint

Owner and Editor: Umweltbundesamt GmbH
Spittelauer Laende 5, 1090 Vienna/Austria

This publication is only available in electronic format at https://www.umweltbundesamt.at/.

© Umweltbundesamt GmbH, Vienna, 2024
All Rights reserved
ISBN 978-3-99004-780-4

CONTENTS

SUMMARY

Twenty nuclear reactors of 1300 MWe installed capacity in France are now approaching forty years of operation, the end of their design life. The operator EDF intends to extend the lifetime of those plants. In France, once the design life-time of 40 years is reached, and the utility plans extending operation of a nuclear power plant (NPP) beyond its design lifetime, a comprehensive reassessment of the status of the plant is needed within the fourth periodical safety review (PSR4).

The French High Committee for Transparency and Information on Nuclear Safety (HCTISN) is organizing a public consultation process with the possibility to provide opinions on the generic phase of the PSR4, which covers topics relevant to all the 1300 MWe reactors. In case of a severe accident in a French NPP, significant impacts on Austria cannot be excluded. Therefore, Austria is participating in this consultation. For this participation, four task reports and a synthesis report have been prepared. The report at hand is task report no.2 focusing on operational experiences.

Task 2 involves recording and analysing the vulnerabilities and events identified in operational practice in order to obtain a picture of the condition of the 1300 MWe NPPs that may be of significance with regard to the planned general need for upgrades.

The number of level 1 safety-related events on the International Nuclear and Radiological Event Scale (INES) has been rising steadily for several years. It has increased by more than 30 % since 2017.

In 2020, the ASN continued to note an increase in the number of significant events for which the analysis of the causes revealed insufficient or incorrect documentation by the operating team.

The ASN's 2021 annual report states, among other things "In general, all operators of nuclear installations still need to make progress in the control of fire risk, organisation and crisis management and in monitoring the compliance of their installations with regard to ageing, deterioration and corrosion of installations, which are tending to increase."

A total of five recommendations were drawn up.

1 INTRODUCTION

Task 2 involves recording and analysing the weak points and events identified in operational practice so that a picture of the condition of the 1300 MWe NPPs is obtained, which may be of significance with regard to the planned general need for retrofitting.

At sites with several units, the system components used jointly by several units are also included in the evaluation.

Approach of task 2:

- Collection and evaluation of accident reports, site-specific inspection reports and ASN reports with particular focus on primary circuit events, I&C, safety culture and ageing phenomena.
- Evaluation of the results with regard to the completeness and appropriateness of the retrofit programme.

Conclusions are drawn on the effects of the design on safety in the case of a lifetime extension. Further comments or questions should be formulated where appropriate.

The following key areas of operational practice are addressed:

- External and internal cross-redundancy effects such as earthquakes, flooding, fire.
- Primary circuit components and systems, including steam generators and spent fuel pools.
- Safety systems, including secondary back-up systems.
- Operational experience in terms of corporate organisation, safety culture and human error.

2 OPERATION EXPERIENCE

Learning from the operating experience of the NPPs relates in particular to the following points.

Safety aspects:
Feedback from operating experience enables the relevant authorities, experts and operators to immediately recognise and address safety issues to ensure and improve the overall safety of the plant.

Technical findings:
The results from operating experience help to recognise ageing effects and adjust maintenance requirements accordingly.

The knowledge gained from operating experience serves, among other things, as a basis for decisions on necessary retrofitting, modernisation, replacement and maintenance strategies.

Personnel and knowledge management:
The knowledge gained from operating experience is used to train and prepare personnel for plant operation.

The number of level 1 safety-related events on the International Nuclear and Radiological Event Scale (INES) has been rising steadily for several years. It has increased by more than 30 % since 2017 /ASN 2019/.

In 2020, the ASN also noted an increase in the number of significant events for which the root cause analysis revealed insufficient or incorrect documentation by the operating team /ASN 2020/.

The ASN's 2021 annual report states, among other things *"In general, all operators of nuclear installations still need to make progress in the control of fire risk, organisation and crisis management, and in monitoring the compliance of their installations with regard to ageing, deterioration and corrosion of installations, which tend to increase."* /ASN 2021/

2.1 Examples of events triggered by internal effects and external hazards

Due to the deficits with regard to the design of the 1300 MWe in regard to the degree of redundancy, the diversity, spatial separation and required manual intervention by personnel, internal and external hazards can lead to beyond-design-basis events. The redundancy-wide meteorological effects (floods, heavy rain, storms, drought, etc.) are of great importance here, as the current man-made climate change is already significantly intensifying the expected developments with regard to the frequency and intensity of meteorological effects. (see more Task 3)

Internal cross-redundancy effects such as internal flooding or fires can also lead to a difficult situation. Especially in rooms through which pipes with a high water flow rate pass. In the event of a leak, burst pipe or incorrectly actuated valve, internal flooding can occur. This becomes relevant to safety if there are other safety devices in the affected room that could be disabled by the flooding (e.g. due to the occurrence of electrical short circuits). The same applies to fire incidents, which can also affect several safety systems with varying degrees of redundancy. The following examples illustrate the existing risk of such events.

Preliminary remark: The IAEA's International Nuclear and Radiological Event Scale (INES) is used to classify incidents or reportable events in nuclear facilities according to various aspects. One aspect is the amount of radioactivity released on a scale of 1 to 7. Another aspect is the safety significance, with the scale ranging from 0 to 3. An event with INES 2 therefore has a high safety significance. These aspects, which are important for the safety of the 1300 MWe reactors, are referred to below.

Examples for events triggered by internal hazards

On May 16, 2004, at around 12:15 p.m., a fire broke out in a room containing electrical cables in unit 2 of the Cattenom NPP. Firefighters intervened and declared the fire extinguished at 2:25pm. ASN deactivated its emergency center at 6pm. The incident has been classified at INES level 1. /ASN 2004/

On September 30, 2005, water was accidentally sprayed onto switch cabinets of unit 1 of the Nogent NPP, which led to an emergency power circuit being activated in the reactor at 7:20 a.m. The reactor was automatically shut down. The ASN immediately activated its national emergency center and its local representatives from the DSNR Châlons-sur-Marne went to the prefect of Aube and the Nogent-sur-Seine.

The inspection of the Nogent-sur-Seine NPP on October 3, 2005 focused on analyzing the causes and consequences of the incident involving the influx of hot water into the protection system rooms of unit 1. The inspectors identified human error that caused the drain valves of the water supply system not to close, material defects in the water drainage system and leaks that allowed water to enter the protection system rooms. An initial analysis of the incident showed that material anomalies (e.g. partially blocked drainage shafts) allowed water to enter the rooms of the reactor protection system (RPR). The incident was classified as INES 1. /ASN 2005/

On 5th April 2012, a fire on a primary pump of the Penly NPP 2, followed by a small radioactive leak into the containment broke out in the reactor building. The reactor automatically shut down. EDF teams and the local fire brigade entered the reactor building and extinguished burning oil. The event conducted EDF to put in action an emergency plan in the eventuality of fire.

Following the fire, there was an abnormal leak on the primary circuit of the reactor. This defect caused a water leak above the normal values. This leak was collected by dedicated circuits. Next morning, ASN received confirmation by EDF

that the leak in the primary pump had stopped. ASN has classified the event at the level 1 on INES scale. /IAEA 2012a/

This incident led to the scheduled outage of the reactor starting earlier and lasting longer then extended. In the light of the results of the work during the reactor outage, ASN authorized the restart of Penly reactor 2. ASN also asked the licensee to implement specific monitoring during the next operating cycle, more specifically on the primary pump lubrication system. (ASN 2013)

On February 18, 2006, at unit 2 of the Nogent-sur-Seine NPP a cooling tower's water return pipes broke and caused internal flooding. A major leak in the turbine cooling water circuit of the reactor 2 turbine into the river, causing flooding of the machine room of reactor 2 and then of reactor 1. Reactor 2 was shut down as soon as the incident began, and reactor 1 shut down automatically. Following the flooding of the machine rooms, water infiltration occurred in premises containing safety-critical equipment, without affecting this equipment. This event was classified at level 1 on the INES scale. In view of the extent of the flood, which caused major damage to the secondary (non-nuclear) parts of the plant, the inspectors asked the operator to submit a safety study before the units were put back into production. /ASN 2006a/

On October 23, 2012, an incident classified as INES 1 occurred at the Flamanville power plant. For almost six hours, a radioactive leak occurred in the primary circuit of unit 1, which was shut down for maintenance work. The water released by the leak (approx. 22 m^3) was collected in the reactor building and treated with the usual wastewater treatment systems. /LEMONDE 2012/

On June 7, 2013 at 2:05 pm, ASN was alerted to a fire in an electrical transformer at unit 1 of the Cattenom NPP. According to information provided by EDF, the racking transformer, through which the reactor is supplied with electricity in normal operation, caught fire, resulting in the release of plumes of black smoke. The reactor was immediately automatically shut down. /ASN 2013a/

On February 9, 2017, a detonation and fire broke out in the turbine hall of unit 1 of the Cattenom NPP. The fire lasted two hours. Five people were slightly injured by the fumes. EDF began shutting down the reactor on the same day. It remained off the grid until March 31. /ASN 2017a/

On October 8, 2019, a significant safety event of level 2 on the INES scale occurred in reactor 2 at Golfech NPP, which indicates non-compliance with the general operating rules during work on draining the main primary system. The reactor was shut down for refueling. An operator went into the reactor building to open a valve of the pressure vessel in accordance with regulations. The operator was interrupted in his work and the valve was not opened. Assuming that the valve was opened, the operators in the control room began the scheduled draining of the primary system.

Eight hours later it was noticed that the water level in the primary system had not changed as expected and sent again an operator into the reactor building to check the position of the pressure relief opening. He then opened the valve

without checking the steps prescribed in the general operating regulations. This opening led to uncontrolled water movement in the primary system and a drop in the water level. The actions were taken without prior assessment of the potential impact.

Due to the impaired safety functions and the potential consequences for nuclear safety, in particular in connection with errors in the management of the event and the monitoring of operating activities, and due to the fact that insufficient lessons were learned from the operating experience, the event is assessed as level 2 on the INES scale by ASN. /ASN 2019a/

Example for events triggered by external hazards

During the night of 27-28 December 1999, exceptionally bad weather conditions combined with inadequate protection measures against external flooding caused by swell, resulted in the flooding of rooms of the power plant nuclear islands and safety related systems at the Blayais NPP. (see more Tasks 3) Even though the Blayais NPP consists of four 900 MWe reactors, it showed the generic design deficits against external flooding of the French nuclear power plants at the time, including the 1300 MWe reactors. /BECKER et al. 2020/

On June 23, 2004, a storm in the Channel caused a massive influx of algae into the filter drums of the cooling circuit pumping station of the Paluel NPP. All of the plant's reactors were shut down. The incident revealed deficiencies in the function on filter drums and bar screens. The incident was classified as INES level 1. It is assumed that the phenomenon of algae proliferation is at least partly related to nitrates of agricultural origin that are washed into the sea with the runoff. The algae caused the Paluel power plant to lose 6% of its output in 2004.

The aim of the ASN inspection on July 12, 2005 was to verify the measures taken after the incident of June 23, 2004 to improve the reliability of the Paluel NPP pumping station and, more generally, to ensure the availability of the heat sink in the event of a massive influx of clogging agents into the pumping station (algae, fish fry, hydrocarbons) or in the event of flooding of the site. The inspectors examined the changes made by the Paluel plant to the operating instructions, technical and organizational improvements and changes to the maintenance programs in this context. However, the massive influx of clogging agents in 2005 shows that these measures did not eliminate the effects on reactor operation.

It has to be noted that also at the **French reactor Cruas (900 MWe) there were several clogging events**. In December 2003, the filters on heat exchangers between the component cooling system and the important service water system of Cruas-3 and -4 were clogged and hindered the operation of the residual heat removal system. EDF had to shut down the two reactors. On the night of December 1, 2009, a large amount of plant material (approx. 50 m^3 compared to a monthly average of 5 m^3) clogged the water inlet of the common pumping station of units 3 and 4 of the Cruas NPP by blocking the pre-filtration

rakes. The total loss of the heat sink of unit 4 lasted 10 hours. /BECKER et al. 2020/

Loss of off-site power supply occurred to the four reactors of the Paluel NPP on December 30, 2005 due to weather conditions (freezing rain). Between December 30 and 31, 2005, the four reactors were cut off from the power grid for less than 24 hours due to the formation of ice on the electrical transformers.

In the late morning of December 30, a large amount of ice formed on the main transformers of the Paluel NPP due to "freezing rain", which led to short circuits. The circuit breakers that protect the connecting lines between the reactors and the electricity transmission grid opened and caused minor damage to the transformers.

Island operations have been launched, and have been successful for reactor units 1, 3 and 4. However, in the case of reactor unit 2, a hardware fault in the automatic turbine speed control system led to an automatic shutdown of the reactor. Therefore, the emergency power generators had to be put into operation.

Repairs to the transformers were carried out during the night of December 30-31. By early morning on December 31, all four reactors were once again connected to the transmission grid. This event was classified at level 0 on the INES scale. It did, however, demonstrate the sensitivity of the Paluel nuclear power plant to freezing rain-type weather conditions. /ASN 2006b/

2.1.1 Conclusions and recommendation

Due to the deficits of the design of the 1300 MWe in regard to the degree of redundancy, the diversity, spatial separation and required manual intervention by personnel, internal and external hazards can lead to beyond-design-basis events. The examples presented illustrate the existing issues.

2.1.1.1 Recommendation (1): Implement Hardened Safety Core and safety upgrades before start of lifetime extension (LTE)

Relates to EDF NRO (2023a) chapter I.2.7 "Contribution of the Hardened Safety Core to the Objectives of the Re-examination"

Motivation/Observation:

Due to the deficits of the design of the 1300 MWe in regard to the degree of redundancy, the diversity, spatial separation and required manual intervention by personnel, internal and external hazards can lead to beyond-design-basis events.

The retrofit measures planned for the 1300 MWe essentially focus on eliminating weak points identified during operation, recognising problems of obsolescence and ageing in structures, systems and components, tracking them and eliminating them where possible, and on individual improvements to increase the robustness of the plant against internal and external impacts, in particular through the installation of the "Hardened Safety Core". In the event of extreme impacts that significantly exceed the design, the cooling of important components should be ensured by the Hardened Safety Core, which is more robust than the rest of the plant. ASN has called for the construction of a "Hardened Safety Core" for nuclear power plants in France /ASN 2013a/.

IRSN points out in /IRSN 2023/ that it will not be possible to realise all of the RP4 1300 changes during the shutdown periods for the ten-year inspections of the reactors.[1] It is currently reported that the 900 MWe plants are also experiencing considerable problems with the timing of the retrofit programmes. It is therefore questionable whether the planned retrofit programmes can be implemented in the planned times required to ensure plant safety.

Recommendation:

ASN should take measures to ensure that the necessary upgrades to improve the safety of the 1300 MWe reactors are carried out before the start of LTE. In particular, the "Hardened Safety Core" should be fully realised.

2.2 Findings from the operation of NPPs with significance for the safety culture (Examples)

The main issues raised of significant safety events are as follows /IRSN 2019/:

- difficulties in maintaining the conformity of installations;
- maintenance shortcomings;
- persistent defects in certain safety or support functions;
- weaknesses in the management and operation of the facilities;
- inadequate risk analysis;
- precursory events;
- international feedback of interest, which is generally dealt with, but not exhaustively and with some delay[2].

Relevant results from OSART missions were also included in the analysis (2.2.2).

[1] https://www.asn.fr/l-asn-informe/actualites/centrale-nucleaire-de-cattenom-3e-reexamen-periodique-du-reacteur-4?fbclid=IwAR3dIBJcx_x_w1JeYEeo_9A5-gzbuqI6mkd0_YKNQW1_Oy2DlpHlnClycyE

[2] IRSN has developed tools and methods for analysing experience feedback

2.2.1 Events from the operation of NPPs (with significance for safety culture and conformity)*****

Conformity issues /ASN 2017/

- Several technical anomalies detected by EDF on various equipment
  - Diesel generators auxiliary systems
  - Fire extinguishing pipes

Most of these anomalies are related to a lack of resistance to earthquake and exist since the construction of the plants.

Manufacturing "irregularities and falsifications"

- 2015:
  - Several cases of nonconformance in the products manufactured at Le Creusot
  - ASN requests inspections of past manufacturing products, which exhibit noncompliant results
- 2016: New inspections launched by AREVA
  - April 2016 Discovery of « marked files »
  - July 2016 Discovery of irregularities in « unmarked files »
- 2017: Full examination decided
  - 6000 files in the nuclear field, more than 170 people involved in examinations
- Consequences
  - The previously supervision system does not take into account the possibility of falsifications
  - ASN working group set up to identify how to adapt the control procedure to such possibilities
- Results of the working group
  - Make all players accountable (liability on supplier supervision; reliability of supervision system)
  - Adapt inspection methodologies (questioning attitude; networking on detected case)
  - Enhance data's integrity and traceability
  - Adapt communication and information tools
  - Analysis of the irregularities detected in the manufacturing files at the Creusot Forge plant for components installed in reactors in service[3]

"Following the detection of irregularities in certain manufacturing files at the Areva NP Creusot Forge plant in 2016, ASN resolution 2017-DC-0604 of 15 September 2017 ordered EDF to send ASN the review report of the manufacturing files for the components forged by the Creusot Forge plant for each reactor in

[3] ASN REPORT on the state of nuclear safety and radiation protection in France in 2018

operation and no later than two months prior to restart following its next refuelling outage.

EDF submitted the review report as required by the resolution of 15 September 2017. Certain additional clarifications will be sent to ASN during the course of 2019. The ASN examination of the deviations brought to light by this review, which began in 2017 and continued in 2018, gave rise to additional justification requests but did not reveal any deviation requiring the repair or immediate replacement of an equipment item. Requests were made for subsequent on-site inspections and representative tests to confirm the justifications provided by EDF and the corresponding elements will be examined in 2019.

Furthermore, data concerning the castings produced by the foundry on the Le Creusot industrial site, which were requested from EDF by the above-mentioned resolution, will be analysed in 2019.

In 2018, ASN finalised the examination of the file concerning the irregularity detected on the lower shell of a steam generator on Fessenheim NPP reactor 2. Following the discovery of this anomaly, ASN suspended the steam generator test certificate on 18 July 2016, the effect of which was to keep this reactor shut down. In July 2017, Areva NP transmitted a file demonstrating the mechanical strength of the component concerned."

IRSN has identified two events that highlight the need to ensure optimum operating conditions for reactors. /IRSN 2016/

Deviation from compliance at CP(Y)-series 900 MWe reactors

"At the end of 2014, EDF reported a deviation from compliance involving the design of the CCWS (component cooling water system) used for cooling some of the equipment in CP(Y)-series 900 MWe reactors.

As a result, an earthquake could cause some of the brackets supporting the CCWS pipes to fail, rupturing the pipes.

To prevent the deterioration of the reactor coolant seals, creating a break in the reactor coolant system, at least one of the following two systems is needed: thermal barriers (devices requiring the availability of the CCWS for cooling the seals) or the injection of cold water into the seals.

In the event of an earthquake, the resulting partial loss of the CCWS would lead to the loss of the CCWS section supplying the auxiliary systems, causing the two systems to shut down and therefore a break in the reactor coolant system. The loss of the CCWS would also lead to a loss of coolant in the spent fuel pool. However, the CCWS trains feeding the engineered safeguard systems would not be damaged and would still be available.

EDF should complete the work in 2018. In the meantime, EDF must make sure that shutdown of the reactor and the spent fuel pool to a safe state is possible in case of an earthquake."

Bugey 5 containment leak test

The leak test carried out on the containment of reactor 5 at Bugey nuclear power plant in 2011, during the third ten-yearly reactor safety review, revealed a higher leakage rate than previous tests. Although the leakage rate observed during the test meets regulatory criteria, the increase indicates that the containment is changing over time. ASN therefore laid down a requirement that the containment should be leak tested again within five years, rather than waiting until the next ten-yearly leak test. Pressure tests were carried out during the reactor outage for scheduled maintenance and refuelling, which began at the end of August 2015. These tests, which took place in October 2015, revealed that the containment's impermeability had deteriorated compared with the 2011 test.

Internal flooding events at the Le Blayais and the Fessenheim NPPs /IRSN 2015/

"The two events that occurred at the Fessenheim (April 2014) and Le Blayais (March 2014) nuclear power plants revealed a certain weakness in nuclear reactor electrical buildings regarding the risks of internal flooding, despite the protective measures implemented to guard against them. The events also showed that the safety documentation setting out requirements relating to the watertightness of openings was incomplete, and highlighted the limits of the preventive maintenance programme. EDF therefore began taking action to improve the safety documentation and maintenance programmes to bring its facilities into compliance.

Following IRSN's technical review, EDF defined an action plan aimed mainly at ensuring that the information in the database relating to openings subject to watertightness requirements was exhaustive and compliant, carrying out inspections of openings, and rectifying any compliance gaps detected. EDF will also update its maintenance programme.

It has undertaken to update its safety documentation, inspect and correct any compliance gaps concerning the openings of all nuclear power plant buildings for its entire reactor fleet. All compliance gaps concerning the electrical buildings of 900 MWe reactors should be eliminated by 2016. This work was scheduled to continue until 2018 for the other buildings of 900 MWe reactors and for 1300 and 1450 MWe reactor buildings."

In a resolution of 25 February 2019, ASN served EDF with formal notice to produce and save proof of qualification of the Flamanville EPR reactor equipment. [4]

"In accordance with the facility's creation authorisation decree, EDF must qualify equipment important for nuclear safety on the Flamanville EPR reactor. The purpose of qualification is to demonstrate that the equipment installed in the facility is able to function in all the conditions in which it is used (temperature,

[4] ASN Regulatory Updates April 2019

humidity, radioactivity, etc.), more specifically in the event of an accident. This qualification is primarily based on studies and tests. It must be documented and traceable as required by the order of 7 February 2012 setting the general rules for basic nuclear installations (known as the "BNI order") and must be demonstrated prior to commissioning of the facility.

Following an inspection on 24 October 2017, ASN informed EDF that the qualification of the equipment depended in particular on the processing and lifting of the qualification reservations identified by EDF and its suppliers. The ASN inspectors had more particularly observed that the traceability of the processing and lifting of these reservations was insufficient. During the course of a new inspection carried out by ASN on 5 December 2018, ASN observed the same shortcomings.

Since then, EDF has undertaken to comply with the provisions of the "BNI order" and the actions it proposes taking are considered by ASN to be satisfactory. ASN nonetheless decided to serve formal notice in order to ensure close oversight of these actions, so that equipment qualification is demonstrated within sufficiently good time prior to commissioning of the Flamanville EPR reactor.
ASN will periodically check the progress of the action plan implemented by EDF."

Deviations on the Flamanville EPR steam lines: the eight penetration welds will have to be repaired.[5]

"In a letter of 19 June 2019, ASN informed EDF that, in the light of the numerous deviations in the production of the Flamanville EPR penetration welds, they would have to be repaired.
In 2018, EDF had proposed an approach aiming to justify maintaining these welds as they were. ASN then considered that the outcome of such an approach was uncertain and had asked EDF to begin preparatory operations prior to repair of the welds located between the two walls of the reactor containment.
EDF's approach was reviewed by ASN, with technical support from IRSN, including consultation of the Advisory Committee for Nuclear Pressure Equipment (GP ESPN).
In its opinion of 11 April 2019, the GP ESPN notably considered that the nature and particularly high number of deviations in the design and production of these welds were major obstacles to the application of a break preclusion approach.
In a letter dated 7 June 2019, EDF asked ASN for its opinion on the possibility of repairing these welds in about 2024, after commissioning of the reactor. In its letter of 19 June, ASN notes that the repair of the penetration welds prior to commissioning of the reactor is technically feasible. Postponement of the repair operations until after reactor commissioning would pose a number of problems, notably with regard to demonstrating the safety of the reactor during the interim period. ASN therefore considers that repair of the welds concerned before commissioning of the reactor is the baseline solution.

[5] ASN Regulatory Updates July 2019

France's nuclear technical safety institute IRSN has confirmed that the welding problems EDF warned about on Tuesday are likely to affect mainly reactors which have had steam generators replaced since 2008, notably its older 900MWe reactors." [6]

A significant event affecting the emergency diesel generator on the Civaux, Gravelines and Paluel NPPs[7]

"A significant nuclear safety event concerning a deficiency in the earthquake resistance of the piping of the emergency diesel generator sets in the Civaux, Gravelines and Paluel NPPs was rated level 2 on the INES scale by ASN.

Each reactor has two emergency diesel generator sets, which provide redundant electrical power supply to certain safety systems in the event of the loss of off-site electrical power, more particularly in the wake of an earthquake.

The significant event concerns a risk of damage to the piping owing to their potential contact with the civil engineering structures of the emergency diesel generator sets in the event of an earthquake. This damage could lead to rupture of these pipes and failure of the emergency diesel generating sets.

EDF initially detected this deviation at the end of October 2018 on one of the two emergency diesel generating sets for reactors 2 and 3 of the Tricastin NPP. On 6 May 2019, EDF informed ASN that, following characterisation, it also concerned the two emergency diesel generating sets for the reactors of the Civaux, Gravelines and Paluel NPPs as well as one of the two emergency diesel generating sets for the reactors of the Fessenheim, Cruas, Saint-Laurent-des-eaux and Nogent NPPs, reactor 3 of the Dampierre NPP, reactors 2 and 3 of the Tricastin NPP and reactor 1 of the Le Blayais NPP.

Repairs were made to the reactors concerned, except for one emergency diesel generating set for reactor 4 of the Paluel NPP, which is currently shut down. This anomaly will be corrected before the reactor is restarted. More particularly during the course of its inspections, ASN checks that these repairs are carried out satisfactorily."

Non-compliance with the technical operating specifications of reactor 2 at Nogent-sur-Seine[8]

On 7 September 2020, the operator of the Nogent-sur-Seine nuclear power plant reported to ASN a safety-significant event relating to the failure to comply with the reactor 2 fall time of the cluster.

[6] ICS (London), Rebecca Gualandi. 2019/09/11

[7] ASN Information notice, Published on 14/05/2019

[8] ASN, Published on 14/09/2020

The control clusters are located in the reactor core and are made of materials that can interrupt the neutron chain reaction within seconds. The proper functioning of the clusters and the automations that control their fall are regularly tested.

On 28 August 2020, during a test to check the availability of the control clusters at the fall, the operator noticed the appearance of an unexpected alarm.

On August 31, 2020, he identified that a parameter was incorrect in the control automations of these clusters. In such a situation, the technical specifications for the operation of the reactor require that the equipment concerned be repaired within eight hours or, failing that, that the reactor be withdrawn. As the incorrect implementation of the parameter occurred during the ten-year inspection of the reactor, which ended on August 6, 2020, this deadline was not respected.

This event had no impact on people or the environment. However, it has degraded the safety function related to the control of reactivity. In view of its late detection, which led to non-compliance with the technical operating specifications of the reactor, this event was classified as level 1 of the INES scale.

The equipment was restored to satisfactory operation on 1er September, after the correct settings have been implemented.

Late detection of the unavailability of the emergency turbo-generator of reactor 2 at the Nogent-sur-Seine power plant[9]

On 9 September 2020, the operator of the Nogent-sur-Seine nuclear power plant reported to ASN a safety-significant event relating to the late detection of the unavailability of the emergency turbo-generator of reactor 2.

The reactors are equipped with two external power supply lines from the national grid and two diesel-powered emergency generators. In the event of a total loss of power supplies, including emergency generators, the emergency turbine generator (LLS system), powered by steam from the steam generators, provides power to the minimum operating equipment, the emergency lighting and the injection backup pump to the joints of the primary pump sets.

On 31 August 2020, the operator discovered a defect in the valve control interlock mechanism at the steam supply to the LLS system. This defect led to a risk of inadvertent valve tripping and made the LLS system unavailable. The operator's analysis of the events led him to consider that this situation had lasted at least since 30 July 2020. However, during this period, operations were carried out that required the availability of the LLS system.

This event had no impact on people or the environment. However, it affected the safety function related to the power supply to the reactor. In view of its late detection, this event was classified as level 1 of the INES scale.

[9] ASN, Published on 14/09/2020

As soon as the fault was discovered, the valve was properly reset, which made it possible to regain the availability of the emergency turbine generator.

Failure to comply with the general operating rules for reactor 3, Cattenom NPP[10]

In September 2020, the operator of the Cattenom nuclear power plant notified the ASN of a safety-related incident in connection with non-compliance with the behaviour prescribed in the general operating rules (RGE) of reactor 3 with regard to the repair time of a I&C system.

The RGEs are a set of regulations approved by the ASN that define the authorised operating area of the plant and the associated operating requirements. They also stipulate maximum repair times in the event of a malfunction of certain devices.

From 26 August 2020, EDF detected malfunctions in an instrument cabinet with several electronic cards. These cards provide information to monitor the operation of the reactor and, if necessary, automatically initiate the start-up of equipment and safety alarms. On 28 August 2020, in the late afternoon, one of the electronic cards was affected by a malfunction. Maintenance work was carried out to bring the plant back into operation. During this work, several defects were identified that required the replacement of various components. The work took a total of 50 hours.

In this situation, the RGE stipulate that the reactor must be shut down within 8 hours and that the repair time must not exceed 8 hours. This last deadline was not met by the operator. On the other hand, the reactor was shut down within the prescribed time on the night of 28 to 29 August 2020.

Late detection of unavailability of an emergency motor pump, FLAMANVILLE NUCLEAR POWER PLANT[11]

On 24 September 2020, EDF declared to ASN a safety-significant event relating to the late detection of the unavailability of an emergency motor pump allowing, in certain feared situations, the supply of water to one of the two reactors.

By design, each reactor at the Flamanville generating station has two external power sources (main transformer and auxiliary transformer), as well as two internal power sources (two diesel-powered emergency generators). Finally, the Flamanville site has a combustion turbine that can be connected to one of the reactors to ensure its power supply.

When the primary circuit is in a particular state (full circuit but with an open vent), a mobile emergency pump must be installed in order to ensure, in the

[10] ASN, Published on 08/09/2020

[11] ASN, Published on 29/10/2020

event of loss of the various sources of electrical power, the injection of water and the cooling of the reactor, until they are restored.

In December 1999, this mobile emergency pump was modified to improve the management of the risk of contamination in use. This modification consisted of replacing the combustion engine with an electric motor, coupled with a dedicated thermal generator. Since then, this emergency pump has been subject to periodic annual tests to ensure that it is working properly.

During the last annual test on June 25, 2020, the pump stopped working after 10 minutes of use. As a result, the test was declared unsatisfactory and the operator declared the emergency pump unavailable. The analysis conducted following this test identified an undersizing of the thermal relay in relation to the rated operating current of the motor. This anomaly had existed since the 1999 amendment.

Non-compliance with operating rules at the end of an incident and accidental operation phase of reactor 2, FLAMANVILLE NUCLEAR POWER PLANT[12]

On 11 September 2020, EDF notified ASN of a safety-significant event relating to non-compliance with the conduct to be followed by the general operating rules for reactor 2.

The general operating rules are a set of rules approved by ASN, which define the rules to be complied with depending on the state of the installation. They distinguish between normal conduct, which allows the operator to operate its facility within safely guaranteed limits, and incidental and accidental conduct, which aims to stabilize the reactor when it is affected by an event. Once stabilization is achieved, a return to normal driving is permitted provided that the installation complies with the requirements of a standard state of the general operating rules.

On September 2, 2020, reactor 2 at the Flamanville generating station was shut down for maintenance and the fuel was loaded into the vessel. An event that occurred during the night led the operator to apply the rules of incidental and accidental driving. After stabilization of the reactor, the return to normal operation was authorized by the operator, who considered the facility to be in compliance with the "open primary circuit" state.

After analysis, EDF detected that this state was not suitable, in particular because of the fact that this circuit had not been opened. In this configuration, the operating procedures applied by the operator were not adequate.

[12] ASN, Published on 04/10/2020

Non-compliance with the technical operating specifications of Unit 1, NOGENT-SUR-SEINE NUCLEAR POWER PLANT[13]

On 16 December 2020, the operator of the Nogent-sur-Seine nuclear power plant declared to ASN a safety-significant event relating to non-compliance with the technical operating specifications for reactor 1. This occurrence occurred during the processing of a fault on a recorder used to monitor the pressure of the steam generators and the primary circuit from the control room.

The recorder in question, which is redundant with another of the same type, makes it possible, in a post-accident situation, to obtain information concerning the state of the reactor and to monitor the installation. In particular, it makes it possible to visualize the pressure measurement in each of the four steam generators as well as that of the primary circuit.

On December 11 at 1:56 a.m., a control room operator detected a malfunction in this recorder, making it unavailable. The operator identified that the unavailability of this recorder, if it were to last more than 24 hours, meant that the reactor would have to be shut down, in accordance with the technical operating specifications. The replacement and requalification of the recorder was therefore promptly ordered. At 7:53 a.m., at the end of the intervention, the operator considered that the recorder was available again.

However, on 12 December at 9:00 a.m., the operator noticed anomalies concerning this recorder, and in particular a reversal of the values reported on it. As a result, a new replacement was ordered.

A posteriori and after analysis, it appears that the intervention of 11 December did not make it possible to find the availability of the recorder concerned. As a result, the unavailability of the reactor lasted more than 24 hours, which should have led to the reactor being withdrawn in accordance with the technical operating specifications.

Non-compliance with the technical operating specifications of reactor 1 at the Belleville-sur-Loire nuclear power plant[14]

On 11 December 2020, the operator of the Belleville-sur-Loire nuclear power plant notified ASN of a safety-significant event relating to the late discovery of the unavailability of a system contributing to the containment of radioactive substances in reactor 1.

The reactor building has a ventilation system that keeps it in a vacuum compared to the surrounding buildings. This system thus contributes to the containment of the reactor building, to prevent the dissemination of radioactive substances that could be released in the event of an accident, particularly during fuel handling.

[13] ASN, Published on 21/12/2020

[14] ASN, Published on 15/12/2020

As of December 11, 2020, refueling operations were underway. As part of the preparation of an independent test of this activity, an air extraction damper involved in the depressivity of the reactor building was closed. This situation caused the reactor building to be overpressurized in relation to the nuclear auxiliaries building during fuel handling operations. As soon as the discrepancy was discovered, three hours after the log closed, fuel handling operations were stopped.

The technical operating specifications require that the reactor building be kept in a vacuum relative to the nuclear auxiliary building during fuel handling. They also require the shutdown of these operations within one hour in the event of non-compliant containment of the reactor building. Due to the late discovery of the overpressurization of the reactor building during fuel handling operations, the technical operating specifications were not met.

Failure to comply with the general operating rules for reactor 3, CATTENOM NUCLEAR POWER PLANT[15]

On 3 February 2021, the operator of the Cattenom nuclear power plant reported to ASN a safety-significant event relating to non-compliance with the conduct to be followed by the general operating rules (RGE) of reactor 3 concerning an exceedance of the fallback period of this reactor required in the event of a cumulative number of events.

The RGEs are a set of rules approved by ASN that define the authorised operating area of the installation and the associated driving requirements. In particular, they prescribe deadlines for the shutdown of reactors in the event of a failure of certain equipment. These delays are reduced when multiple downtimes occur at the same time.

On 29 January 2021, EDF carried out a test of the proper functioning of valves located on one of the two safety injection circuits (RIS) as well as on one of the two emergency sprinkler circuits (EAS) of reactor 3; This test was unsatisfactory, as the valves did not operate during the test. In this situation, where there are two unavailability of equipment, the RGEs require the shutdown of the reactor if it is not repaired within eight hours.

An initial diagnosis involved an electronic board of the reactor protection system. The intervention on this card, which itself leads to unavailability of this system, is also subject to an eight-hour delay.

As a result of this intervention, a poor analysis by the maintenance team led to the incomplete performance of tests to ensure the availability of the equipment. That omission led, when the valve operation tests were resumed, to a cumulative of three simultaneous unavailability over a total duration of just over two hours, whereas this accumulation is subject to a delay reduced to one hour,

[15] ASN, Published on 11/02/2021

instead of the eight hours provided for the events taken separately. In the end, the reactor was withdrawn outside the time frame set out in the RGE.

Failure to comply with the conduct required by the general operating rules, PALUEL NUCLEAR POWER PLANT[16]

On 17 June 2021, EDF reported to ASN a significant event relating to non-compliance with the conduct to be followed by the general operating rules for reactor 1 concerning the duration of unavailability of emergency power sources.

The general operating rules are a set of rules approved by ASN that define the authorised operating area of the installation and the operating requirements for the associated reactors. In particular, they prescribe maximum repair times in the event of unavailability of the systems required to ensure the safety of the reactors.

Each pressurized water reactor is equipped with two diesel-powered emergency generators that can redundantly provide power to certain safety systems in the event of a failure of the site's external power supplies. The Paluel nuclear power plant also has a combustion turbine to compensate for the unavailability of an emergency generator.

During the night of 14 to 15 June, while the Paluel reactor 1 was shut down for maintenance, the operator noticed a coolant leak on one of the two diesel-powered emergency generators. EDF then considered that this leak could call into question the ability of this equipment to perform its function. In addition, the second redundant standby generator was unavailable due to scheduled maintenance. In this situation, the general operating rules require that one of the two generators be restarted within 24 hours.

Repair operations were unable to meet this deadline, as both generators were unavailable for 54 hours. As a compensatory measure, EDF had nevertheless connected the site's combustion turbine as a substitute for an emergency generator.

Late detection of pump unavailability in the emergency steam generator supply system, CATTENOM NUCLEAR POWER PLANT[17]

On 9 July 2021, the operator of the Cattenom nuclear power plant reported to ASN a safety-significant event relating to the late detection of the unavailability of a pump in the emergency steam generator (ASG) supply circuit of reactor 1.

One of the functions of the ASG circuit is to supply water to the steam generators in the event of a failure of their normal supply. It is made up of two redundant channels. Steam generators are heat exchangers that allow fuel to be cooled while the reactor is in operation. In the event of a failure of a supply

[16] ASN, Published on 28/06/2021

[17] ASN, Published on 20/07/2021

pump to the ASG circuit, the general operating rules require that it be repaired within 24 hours.

On May 21, 2021, reactor 1 of the Cattenom nuclear power plant was in the re-start phase following its shutdown for scheduled maintenance and refueling.

During a periodic test to test the proper functioning of a pump in the supply circuit of the ASG circuit, the operator identified a malfunction affecting the pump: its shaft jammed.

However, the second channel of this circuit was available and could have performed this function in the event of an accident. Following the discovery of the malfunction, and in view of the foreseeable time for repairing the pump, the operator decided to fold the reactor in accordance with the Technical Operating Specifications (STE).

While carrying out an expert assessment of the pump, the operator identified a mechanical blockage located at one of the impellers. In addition, after a thorough analysis, it was not possible to precisely date the onset of the unavailability of the equipment; It was therefore conservatively considered that it could have started immediately after its last commissioning, i.e. on 23 March 2021. As a result, the 24-hour compliance period allowed by the general operating rules was not respected.

Exit from the authorized operating range of Paluel reactor 1, PALUEL NUCLEAR POWER PLANT[18]

On 20 August 2021, EDF declared to ASN a safety-significant event relating to the departure from the operating envelope authorised by the general operating rules for reactor 1 following the opening of two safety valves.

The general operating rules are a set of rules approved by ASN that define the authorised operating area of the installation and the operating requirements for the associated reactors.

The pressurizer is a tank whose function is to control the pressure of the primary circuit by means of heaters and a sprinkler system. Overpressure protection of the main primary circuit is provided at the pressurizer by three lines, each with two pilot-operated safety valves, the first being called the protective valve and the second isolation valve. During normal operation, the second valve, which isolates the line if the protective valve does not close after loading, is in the open position.

On 14 August 2021, while the reactor was in the normal shutdown operating range powered by the shutdown cooling system (AN/RRA), the operator detected a leak on the control system of two protective valves.

On 18 August 2021, in order to replace the control system of the two leaking valves, the operator isolated the affected lines without closing the associated

[18] ASN, Published on 23/08/2021

isolation valves. The purging of the pilot system resulted in a loss of water from the primary system through the isolation valves. This loss of primary water, collected by the pressure relief tank of the pressurizer, led to a drop in the pressure of the primary circuit of up to 6 bar, whereas the minimum pressure allowed by the general operating rules in the AN/RRA domain is 25 bar.

Non-compliance with the technical operating specifications of Unit 2, NOGENT-SUR-SEINE NUCLEAR POWER PLANT[19]

On 4 November 2021, the operator of the Nogent-sur-Seine nuclear power plant declared to ASN a safety-significant event relating to non-compliance with the technical operating specifications concerning the control of the reactivity of reactor 2.

Boron is a chemical element with the property of absorbing neutrons produced by the nuclear reaction. It is mixed with the water in the primary circuit and thus makes it possible to control and, if necessary, stop the nuclear reaction. As soon as nuclear fuel is present in the reactor vessel, the boron concentration in the primary circuit is therefore monitored to ensure compliance with the criteria set out in the technical operating specifications. The same specifications also stipulate that water top-ups to the primary circuit must only be made with sufficiently bored water, in order to prevent the risk of dilution of boron in the primary circuit.

On October 29, 2021, during the preparation of the addition of reagents in the primary circuit of reactor 2, a poor configuration of the circuits led to the injection of insufficiently borated water for 2 hours and 15 minutes. This action resulted in a decrease in the boron concentration of the primary circuit, which nevertheless remained within the required specifications.

Late Crack Detection on a Cluster Control Rod, PALUEL NUCLEAR POWER PLANT[20]

On 22 July 2022, EDF reported to ASN a safety-significant event relating to the late detection of a crack on a bundle control rod during the shutdown of reactor 4. The control clusters, operated via the control rods, are used to control the nuclear reaction.

On 15 June 2022, as part of televisual inspection (video camera) control operations on the cluster control rods, EDF identified a circular crack on one of them. In order to analyze and characterize the defect, the operator re-examined the video recordings of the previous inspections and realized that the cracking had been present for several stops. The operator replaced the cracked cluster control rod before continuing operations.

[19] ASN, Published on 18/11/2021

[20] ASN, Published on 26/07/2022

The analysis of this event should focus on understanding the reasons why the defect was not correctly identified during previous checks.

Late detection of the unavailability of cooling water filtration for reactor 2 at the Cattenom nuclear power plant.[21]

On 16 September 2022, the operator of the Cattenom nuclear power plant notified ASN of a safety-significant event relating to the late detection of the unavailability of one of the two channels of the water filtration system intended for cooling reactor 2.

Reactors 1 and 2 have a water filtration system located inside a pumping station common to both reactors. Each filtration system, which has two redundant channels, requires intermittent washing of its filter for its proper functioning.

On the night of September 14, 2022, while trying to carry out an intervention on reactor 1, the operator mistakenly closed a valve of the filter washing system on reactor 2, rendering its washing inoperative.

The valve was closed in the morning during a surveillance round. The operator then immediately began to restore the equipment to its proper configuration. However, the time to return the valve to the correct position exceeded the maximum time allowed by the technical operating specifications, which is eight hours, by one hour.

The operator has initiated an in-depth analysis of this occurrence. ASN will ensure the quality of this analysis, particularly with regard to the organisational and human factors that led to intervention on the wrong reactor.

Late detection of the incorrect setting of a level sensor in the fuel storage pool of reactor 2 at the Nogent-sur-Seine power plant[22]

On 20 December 2022, the operator of the Nogent-sur-Seine nuclear power plant reported to ASN a safety-significant event relating to the late detection of the incorrect adjustment of a level sensor in the fuel storage pool of reactor 2.

The fuel bay receives all reactor core fuel assemblies during refuelling shutdowns and is used to store spent assemblies while awaiting shipment to a processing plant.

The technical operating specifications of the reactor require that the water level of its fuel bay be equal to or greater than 22.15 m.

On 9 December 2022, during a periodic test, the operator noticed the incorrect adjustment of a level sensor in the pool of reactor 2, the function of which ensures the appearance of an alarm in the event of a low level of this pool. The consequence of this incorrect setting was that such an alarm would only have

[21] ASN, Published on 21/09/2022

[22] ASN, Published on 23/12/2022

appeared from a level 39 mm lower than the minimum level required by the technical operating specifications. Nevertheless, the existence of a second sensor, correctly adjusted, would have allowed a redundant alarm to appear.

A November 2021 modification to the fuel bay instrumentation is the cause of this adjustment error. The sensor in question had therefore been unavailable since that date, without having been identified as such.

Error in Determination of Expected Primary Flow of Reactor 1, CATTENOM NUCLEAR POWER PLANT[23]

On 16 February 2023, the operator of the Cattenom nuclear power plant reported to the French Nuclear Safety Authority a safety-significant event relating to an error in the determination of the flow rate in the primary circuit, a parameter used by the reactor protection system.

The primary circuit is a closed circuit, containing pressurized water. This water heats up in the reactor vessel when it comes into contact with the fuel assemblies. The water in the primary circuit is set in motion by four pumps known as "primary pumps".

On February 12, 2023, tests were carried out on reactor 1, in particular to determine the flow rate in the primary circuit. The measured values were used to update the parameters of the reactor protection system, which manages the automatic shutdown of the reactor and the commissioning of the backup systems.

On 13 February 2023, the operator detected an error in the uncertainty taken into account in the determination of the primary water flow. This error could, in the event of an uncontrolled withdrawal or ejection of a control cluster, have led to a slight delay in the detection of the situation and the implementation of automatic reactor shutdown protection.

This event had no impact on facilities, people or the environment. However, the occurrence affected the safety function related to cooling control by slightly increasing the thresholds of the reactor protection systems.

Anomaly in the adjustment of the automatic reactor shutdown threshold on reactor 1 neutron flux measurement chains, SAINT-ALBAN NUCLEAR POWER PLANT[24]

On 15 September 2023, EDF declared to the French Nuclear Safety Authority (ASN) a safety-significant event concerning a failure to set the automatic shutdown threshold of the reactor by detecting a high neutron flux by the source-level neutron chains of reactor 1 of the Saint-Alban nuclear power plant.

[23] ASN, Published on 26/02/2023

[24] ASN, Published on 20/09/2023

The nuclear power measurement system provides continuous monitoring of the reactor power. This monitoring, which consists of measuring the neutron flux, is carried out via measurement chains arranged outside the vessel:

- Power Chains (CNP), used in normal operation;
- intermediate-level chains (CNI), used during the start-up or shutdown of the reactor;
- Source Level Chains (CNS), capable of measuring very low fluxes when the reactor is shut down.

These chains trigger alarms and automatic actions to protect the reactor, including its automatic shutdown, in the event of an abnormal rise in neutron flux.

On July 26, 2023, while Unit 1 was shut down, one of the CNS/CNI detectors was replaced. In order to carry out the requalification tests following this replacement, the general operating rules allowed the setting of the threshold triggering the automatic shutdown of the reactor to be increased by a decade.

On 22 August 2023, EDF noted that the return to the usual setting of the threshold triggering the automatic shutdown of the reactor had not been achieved, whereas between 26 July 2023 and 22 August 2023, reactor 1 had entered a normal shutdown state, cooled by the shutdown reactor cooling system (RRA). In this state of the reactor, the temporary increase in the threshold setting triggering the automatic shutdown of the reactor is not in accordance with the general operating rules. In the event of an increase in neutron flux, the automatic shutdown signal could have occurred later than expected.

Departure from the operating range authorised by the general operating rules (RGE) of reactor 1 of the Belleville-sur-Loire nuclear power plant25

On 2 April 2024, the operator of the Belleville-sur-Loire nuclear power plant declared to the French Nuclear Safety Authority (ASN) a significant safety event relating to the exit from the operating envelope authorised by the RGE, due to an excessively high temperature of the water in the main primary circuit (MPC) of reactor 1.

The General Operating Rules (RGE) are a set of rules approved by ASN that define the authorised operating area of the installation and the operating requirements for the associated reactors. In particular, they specify the minimum and maximum permissible limits for the pressure and temperature of the water in the primary circuit. These limits define the authorized operating range.

On 21 March 2024, reactor 1 was in production and was expected to keep up with changes in demand from the national electricity grid. At 3:43 p.m., in response to the appearance of a "very high temperature" pre-alarm, the operator decided to manually control the control of the CPP temperature control cluster, known as "R group", and to insert it into the reactor core in order to reduce its

[25] ASN, Published on 08/04/2024

power and thus reduce the average temperature of the CPP. However, the operator then forgot to switch the "R group" control to autopilot.

Due to the maintenance of the "R group" control in manual control, the automation systems were unable to adapt the reactor power to the variations in the demand of the national electricity grid and the average temperature of the CPP drifted to exceed the maximum temperature threshold of 307.3 °C allowed by the RGE. As soon as this exceedance was detected, at 4:06 p.m., the operator manually inserted the R group in order to bring the average temperature of the COPC back within the authorized range.

Failure to monitor the R group for 23 minutes resulted in an output from the operating envelope of approximately 6 minutes with a maximum temperature reached of 307.6 °C.

The analysis of the operator's initial declaration of this event was the subject of several exchanges with ASN, which led to an update of the initial report. ASN will be vigilant in analysing the human and organisational causes that led to this exit from the domain and the actions taken to avoid its recurrence.

2.2.2 Results of OSART Missions

Since 1982, the IAEA has offered internationally staffed review teams (OSART missions) to assess the status of the safety-oriented interaction of personnel, technical and organisational factors in nuclear power plants. In the respective reports on the results of the OSART missions, reference was made, among other things, to deficiencies identified in the area of operational management:

Fessenheim[26]

A number of proposals for improvements in operational safety were offered by the team. The most significant proposals include the following:

- Corrective actions for safety-significant events are not prioritized and some of these actions are rescheduled;
- Not all opportunities have been taken to eliminate industrial safety risks in the plant related to unprotected hot pipes and equipment, inadequate installed guards on rotating equipment and tripping hazards particularly due to uncontrolled extension cords;
- Leaks of water and oil on the equipment within the industrial buildings are not systematically identified and corrective actions are not always initiated.

[26] http://www-ns.iaea.org/downloads/actionplan/OSART%20Mission%20to%20Fessenheim_March_2009_152.pdf

Bugey[27][28]

The most significant issues identified were:

- The plant should improve the rigor and supervision of its conduct of operations;
- The plant should consistently ensure proper preparation and high quality of its maintenance work;
- The plant should ensure adequate training is implemented for all the personnel responsible for the implementation of the severe accident management guidelines at the plant.

Long Term Operation:

The team noted the following:

- By using the criterion 'Non-safety SSCs, whose failure due to an ageing mechanism could represent a hazard for safety SSCs' for the scoping of non-safety SSCs for LTE, non-safety SSCs whose failure due to other reasons could represent a hazard for safety SSCs are neglected.
- The current guidelines for SSC scoping do not yet cover all relevant hazards which need to be considered. There is not yet a specific guidance on how to perform scoping of non-safety SSCs due to potential internal flooding of safety SSCs at the plant.
- The results of scoping are currently spread across different documents such as EIPs (safety related) list, EIPr (ultimate release containments – usually civil works like core retention) and EIPi (negative impact for population like noise, smell, releases) lists and multiple unit DAPE (Ageing Analysis Report) documents.
- There is no unique list or database of SSCs which differentiates between SSCs in the scope and out-of-the scope SSCs for LTE.
- SYGMA database contains the plant equipment master list of plant SSCs but there is no identification of in-scope and out-of-scope SSCs.
- All databases/lists and documents with SSCs for ageing management and LTE are kept separately from the SYGMA database equipment master list.
- Review of consistency of scoping databases/lists against changes in the SYGMA database is performed only once in 10 years prior to VD (ten-yearly outage) and after VD.
- For non-safety SSCs, which can cause internal flooding of safety SSCs, only non-safety auxiliary piping is in the process of analysis. Other components, which can cause internal flooding such as valves, pumps, tanks, are currently not yet identified from this perspective and their FAVs (Ageing Analysis Sheets) are not created yet.

[27] REPORT OF THE OPERATIONAL SAFETY REVIEW TEAM (OSART) MISSION TO BUGEY NUCLEAR POWER PLANT FRANCE 2 – 19 October 2017

[28] REPORT OF THE OPERATIONAL SAFETY REVIEW TEAM (OSART) MISSION TO BUGEY NUCLEAR POWER PLANT FRANCE 2 to 19 October 2017 And FOLLOW-UP MISSION 30 September to 4 October 2019

- There is currently no specific guidance how to perform scoping of non-safety SSCs due to potential internal flooding of safety SSCs (for example walk-downs).
- For all non-safety SSCs with a potential impact on safety SSCs in case of earthquake, walk-downs and visual inspections were performed by sampling during VD3 to confirm that these components are resistant in case of seismic event. Not all rooms and all components were reviewed.

Without a complete scope of SSCs for LTE evaluations, the operating organization cannot demonstrate that all ageing effects of SSCs important to safety are properly managed for LTE.

Flamanville 1 und 2[29]

A number of proposals for improvements in operational safety were offered by the team. The most significant proposals include the following:

- ensure adequate preparedness for the evacuation of the Flamanville and reinforce the preparation for protection of emergency workers;
- improve the management process for the preparation and revision of plant procedure and for control of staff adherence to plant procedures to ensure that the plant is always operated within established limits;
- enhance the rigor and supervision in the main control room during operator's actions that impact important primary parameters;
- enhance maintenance work processes and practices to ensure high quality of plant maintenance;

Flamanville 3 (EPR)[30]

The most significant issues identified were:

- The plant should fully implement its Foreign Material Exclusion programme throughout all departments and areas to attain a high standard level of implementation;
- The plant should consider implementing procedures and practices to ensure that the potential impact of unsecured items on safety related equipment in seismically qualified areas is minimised;
- The plant should improve the arrangements and practices targeting the integrity of fire barriers and prompt fire suppression to ensure that fire risk is always minimized.

[29] REPORT OF THE OPERATIONAL SAFETY REVIEW TEAM (OSART) MISSION TO THE FLAMANVILLE 1&2 NUCLEAR POWER PLANT FRANCE 6 – 23 OCTOBER 2014 AND FOLLOW UP MISSION 28 NOV– 2 DEC 2016

[30] REPORT of the PRE-OPERATIONAL SAFETY REVIEW TEAM (PRE-OSART) MISSION TO FLAMANVILLE UNIT 3 NUCLEAR POWER PLANT 17 JUNE TO 4 JULY 2019

Dampierre[31]

A number of proposals for improvements in operational safety were offered by the team. The most significant proposals include the following:

- improve operational practices to ensure that deficiencies are systematically identified in the field;
- enhance the rigor in human performance and supervision in the main control room during operator's actions that impact important primary parameters;
- improve the quality of operational event analyses to ensure root causes and corrective actions are systematically identified;
- consider improvement in the management of emergency drills and exercise to ensure they are adequately implemented and their effectiveness is timely evaluated;
- consider increasing the scope of the guidance provided to the plant staff to mitigate severe accidents, including accidents at multiple units, accidents occurring in reactor shutdown states and spent fuel pool accidents.
- enhance the process of root cause analysis and perform analysis of operational events in sufficient depth;
- improve operational practices to ensure plant deficiencies are systematically identified and tagged adequately.

Gravelines[32]

The IAEA mission in 2012 made a number of recommendations and suggestions for consideration by the Gravelines NPP operators. The station thoroughly analyzed the OSART recommendations and suggestions and developed corrective action plans.
The team identified some issues which have achieved satisfactory progress toward resolution, but need further work, including:

- Further improvement of measures to preventing the ingress of items or chemicals into circuits and equipment;
- Comprehensive application of the corrective actions programme;
- Reinforcement of the containment protection system in the event of an extremely adverse situation.

The team identified the following issue as one which has made insufficient progress toward resolution and needs further work:

- Emergency response arrangements do not follow current IAEA safety standards recommending that the plant should have a person on the site

[31] REPORT OF THE OPERATIONAL SAFETY REVIEW TEAM (OSART) MISSION TO THE DAMPIERRE NUCLEAR POWER PLANT FRANCE 31 August to 17 September 2015 AND FOLLOW-UP VISIT 20 to 24 February 2017

[32] Press Release 2014/12, IAEA Team Reviews Safety Progress at French Nuclear Power Plant 19-23 May 2014

at all times with the authority and responsibility to initiate appropriate emergency response measures.

Civaux NPP ('N4' design, 1450 MWe)[33]

Several proposals for improvements in operational safety were offered by the team. The most significant proposals include the following:

- The plant should establish and implement a system to ensure that operator aids used by plant personnel are authorized and controlled.
- The plant should enhance the processes and practices to manage modifications.
- The plant should enhance the effectiveness and timeliness of corrective actions implementation and use of operating experience.

Tricastin[34] (CP(Y))

The most significant issues identified were:

- The plant should consider ensuring that the management expectations are systematically set and consistently reinforced to ensure that observed performance deficiencies are addressed in an effective and timely manner.
- The plant should enhance the rigor with which operators carry out field walkdowns in line with plant expectations.
- The plant should enhance its work management system to ensure that work is completed to schedule and maintenance backlogs are minimized.

Long Term Operation

- The plant practices for the identification of structures, systems and components (SSCs) to be included in the scope of ageing management (AM) were in some cases incomplete. Some areas lacked detailed guidance and some SSCs results were not fully documented.
- The plant conducted a set of walkdowns to confirm the equipment operability in case of seismic events, floodings, explosions and High Energy Line Breaks. However the analysis and documentation of the walkdown results for the purpose of AM scoping were not finalised.

[33] REPORT OF THE OPERATIONAL SAFETY REVIEW TEAM (OSART) MISSION TO THE CIVAUX NUCLEAR POWER PLANT FRANCE 30 SEPTEMBER TO 17 OCTOBER 2019 AND FOLLOW UP MISSION 9 to 13 MAY 2022

[34] REPORT OF THE OPERATIONAL SAFETY REVIEW TEAM (OSART) TO THE TRICASTIN NUCLEAR POWER PLANT FRANCE 28 NOVEMBER – 15 DECEMBER 2022

Penly[35]

The most significant issues identified were:

- The plant should improve the sensitivity of their managers and supervisors to recognize, challenge and correct inappropriate behaviours on site and establish an intolerance for rationalizing deviations to maintain personnel safety and high levels of standards.
- The plant should improve implementation of the processes related to plant configuration and status control to ensure plant safety.
- The plant should improve its preparation, control, and implementation of maintenance activities to ensure equipment reliability and personnel safety.

Paluel[36]

The most significant issues identified were:

- The plant leaders have not systematically ensured that plant staff are complying with requirements and standards for industrial safety and human performance in a rigorous and consistent manner.
- The plant work control process does not support the timely completion of preventive maintenance to ensure its safe and reliable operation.
- The plant operating experience programme does not always ensure that safety related events are adequately categorized, analysed, and have effective corrective actions to prevent recurrence.

Long Term Operation

The team noted the following:

- There is a corporate document which defines how to assess the lifetime of equipment when ageing effects (AE) cannot be measured. This document establishes rules for the collection of cycle records since the start of operation as the basis for TLAA (Time limited ageing analyses). However, this is done only for primary and secondary circuits, containment and some crane structures.
- The plant does not have a list of equipment, the life of which is to be extended based on ageing limited analyses.
- TLAAs have only been identified for the 900 MWe series and not yet for the 1300 MWe series.
- The corporate tested cables from various plants as part of project 'Extension of lifetime to 60 years'. The results are summarized in report, dated 15 December 2020. One sample of cable was taken from Paluel NPP and another one from Nogent NPP, however:

[35] REPORT OF THE OPERATIONAL SAFETY REVIEW TEAM (OSART) MISSION TO THE PENLY NUCLEAR POWER PLANT FRANCE 4-21 SEPTEMBER 2023

[36] REPORT OF THE OPERATIONAL SAFETY REVIEW TEAM (OSART) MISSION TO THE PALUEL NUCLEAR POWER PLANT FRANCE 20 SEPTEMBER – 7 OCTOBER 2021

  - the test was limited to physical/chemical properties, electrical properties were to be tested later.
  - the report does not include information as to whether or not the samples were selected on a conservative basis – from 'hot spots.
  - the report states that the cables are in good conditions but does not specify the expected lifetime.
- In 2014 the plant recorded its highest temperatures in rooms where cables were present. These records were used as the basis for assessing the lifetime and qualification of the cables. However, the records have not been updated since and include only average room temperatures and no information about 'hot spots' affecting SSCs to be qualified.
- There are no records about the decision-making process regarding the selection of sampling points and representativity of the results for the specific plant.
- For representative samples of SSCs (e.g. temperature sensors, connectors) selection criteria were not conservative as they did not mention the influence of ageing factors, only the operational time.

Without a complete identification of SSCs, the life of which is to be extended based on time limited ageing analyses and the revalidation of the analyses for the planned period of LTE, the operating organization cannot demonstrate readiness of the SSCs for safe long-term operation.

Civeau[37]

The most significant areas of improvement were:

- The plant should establish and implement a system to ensure that operator aids used by plant personnel are authorized and controlled,
- The plant should enhance the processes and practices to manage modifications,
- The plant should enhance the effectiveness and timeliness of corrective actions implementation and use of operating experience.

Golfech-nuclear-power-plant[38]

However, further work is needed to fully implement some action plans drawn up by the plant after the 2016 mission, including:

- The plant management should better track corrective actions to support more effective resolutions of issues on site.

[37] REPORT OF THE OPERATIONAL SAFETY REVIEW TEAM (OSART) MISSION TO THE CIVAUX NUCLEAR POWER PLANT FRANCE 30 SEPTEMBER TO 17 OCTOBER 2019 AND FOLLOW UP MISSION 9 to 13 MAY 2022

[38] https://www.iaea.org/newscenter/pressreleases/iaea-safety-mission-sees-significant-progress-at-frances-golfech-nuclear-power-plant-encourages-continued-improvement, 21.05.2019

- The plant should continue to improve the quality of maintenance work.
- The plant personnel should systematically use human-performance tools to prevent errors.
- The plant should more efficiently manage design modifications.

Belleville-nuclear-power-plant[39]

The mission made proposals to improve operational safety, including:

- The plant should further improve operator crew performance such as using pre-job briefings more effectively.
- The plant should minimize delays in completing corrective actions to prevent the recurrence of events.
- The plant should improve its work management process to maximise equipment availability.

2.2.3 Conclusions and recommendation

The safety status of a nuclear power plant is essentially determined by the interaction between man, technology and organisation (MTO concept).

This analysis shows that the organisational and human factors play an important role due to their significance for the quality of maintenance and operation and have a significant impact on the probability of an accident.

There are a wide variety of incidents: design errors; defective equipment either due to its manufacture, ageing or lack of maintenance; incorrect operation during operation risk of failure due to external factors, etc.

The existing shortcomings of the plants in France compared to today's requirements are aggravated by shortcomings in safety management, as also identified by the OSART missions and revealed by the incidents listed. The incidents related to irregularities and falsifications have a very negative impact on the assessment of the safety status of the nuclear power plants in France.

The fact that a number of incidents have their origin in the design and construction phase also indicates shortcomings in the necessary continuous safety review.

In the OSART missions, in which the preparation and implementation of LTE activities were part of the missions, deficits were recognised and proposals made to eliminate them.

[39] https://www.iaea.org/newscenter/pressreleases/iaea-mission-observed-safety-commitment-by-frances-belleville-nuclear-power-plant-encourages-continued-improvement, 02.12.2021

2.2.3.1 Recommendation (2): Reduce number of reportable incidents related to "safety culture"

Motivation/Observation:

In chapter 1.2.1 of /ASN 2020/ the "Safety culture" is discussed: "Safety culture reflects the way in which the organisation and individuals fulfil their roles and responsibilities with regard to safety. It is one of the essential foundations to maintaining and improving safety. It commits organisations and individuals to pay special and appropriate attention to safety. It must be expressed at individual level through a rigorous and prudent approach and a questioning attitude that allows both sharing and initiative. It is reflected in day-to-day decisions and actions related to activities."

A considerable number of reportable incidents are related to the "safety culture". [40]

Recommendation:

ASN should ensure that EDF acts in compliance with the "culture for safety" in order to reduce the number of such incidents in French nuclear power plants.

2.3 Operational experience in primary circuit components and systems, including steam generators and spent fuel pools and safety systems, including secondary back-up systems (Examples from the operating practice of 1300 MWe reactors)

Operational experiences regarding reactor pressure vessels

With regard to the reactor pressure vessels, EDF is confident that it can prove that the service life can be extended beyond 40 years. In any case, however, increasing the safety feed temperature remains an option in order to ensure the necessary margins[41]. Further measures to limit embrittlement are being discussed and proposed by IRSN in order to ensure operation beyond 40 years[42].

[40] Rapport de l'ASN sur l'état de la sûreté nucléaire et de la radioprotection en France en 2019, ASN REPORT on the state of nuclear safety and radiation protection in France in 2021

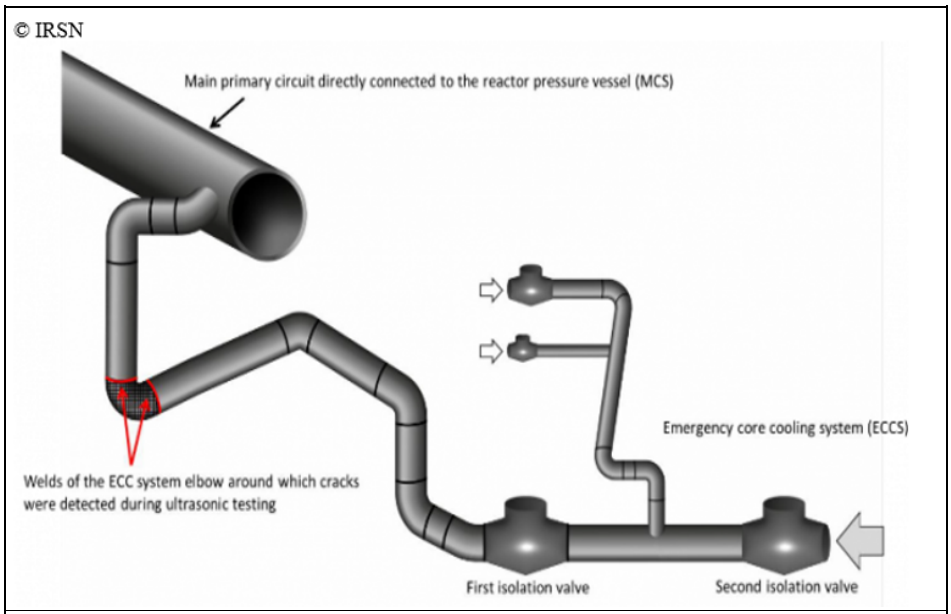
[41] Long Term Operation For EDF Nuclear Power Plants : Towards 60 years, Françoise Ternon-Morin, Claude Degrave, IAEA –CN-194-036, 14-18 May Salt Lake City, 2012

[42] DIALOGUE TECHNIQUE SUR LE 4E RÉEXAMEN PÉRIODIQUE DES RÉACTEURS DE 1300 MWE JOURNÉE DU 30 JUIN 2023 - Cuve des réacteurs

Safety-relevant damage in the safety feed-in system of French nuclear power plants

In numerous French reactor units, cracks have been found on weld seams in the safety feed systems (Figure 1).

Figure 1
Location of the pipe sections affected by the findings



Source: © IRSN

umweltbundesamt

The damage was first detected during the safety inspections of the pressurised water reactor at Civaux-1, which take place every ten years.

According to EDF (as of August 2022), the following are particularly susceptible to the corrosion phenomenon

- the lines of the safety injection system located in the cold leg and the suction lines of the residual heat removal system of the N4 reactors (two 1,450 MWe units each in Chooz B and Civaux);
- the lines of the safety feed-in system located in the cold leg of the P'4 reactors (a total of twelve 1300 MWe units at the Belleville, Cattenom, Golfech, Nogent-sur-Seine and Penly sites).

According to current knowledge, the corresponding systems of the P4 reactors (1300 MWe) and the 900 MWe reactors are hardly susceptible to this form of stress corrosion cracking. The control strategy therefore envisages prioritising the N4 and P'4 reactors.

On 7 March 2023, the supervisory authority ASN provided information on an updated report from the operator EDF on new findings of stress corrosion cracking in Unit 3 of the Cattenom NPP and in the Civaux, Chooz B and Penly NPPs. As part of the ongoing investigations, a crack was discovered in Unit 1 of the Penly NPP, which - as in the other affected reactors - is located near a weld seam of a pipeline of the safety feed-in system. Unlike previous cracks, this one

is located in one of the reactor's hot trains. Up to now, EDF has considered pipes in cold strings to be particularly susceptible to the corrosion phenomenon.

In addition, the crack discovered in Unit 1 of the Penly NPP is significantly deeper than all cracks found to date: It extends over 155 mm, which corresponds to about a quarter of the pipe circumference; its maximum depth is 23 mm with a wall thickness of 27 mm.

According to the ASN, the presence of a crack of these dimensions means that the strength of the pipeline can no longer be verified. However, the safety case for the reactor takes into account the rupture of this pipe. This means that the system is designed to ensure the cooling of the reactor core even in the event of such a pipe rupture.

The supervisory authority categorises the finding in Penly-1 as an INES-2 event due to the increased probability of a pipe rupture and the possible safety-relevant consequences. The cracks in the other reactors mentioned above were categorised as INES-1 events.

The supervisory authority ASN announced on 16 March 2023[43] that EDF had submitted a revision of the inspection and repair strategy, which the operator had submitted in December. The revision is to be seen against the background of the latest crack findings on weld seams, in particular the one in Penly-1, where a particularly long and deep crack was discovered in a pipe that was previously not considered susceptible to stress corrosion cracking; however, the affected weld seam had been repaired twice during reactor construction[44]. In addition, two cracks were also found during the examination of pipe sections that had already been cut out, the structure of which suggests thermal fatigue cracks as the cause.

Relevance of the damage for safety

If the cracks reach a certain size during ongoing operation, a leak or rupture of one of the affected pipes may occur, especially if there is additional mechanical stress. As there is a direct connection between the location of the cracks and the primary circuit, this would result in a loss-of-coolant accident.

Scenarios are conceivable in which mechanical loads act simultaneously on all affected lines of the safety feed-in system, e.g. in the event of a severe earthquake. If several of these lines were to be ruptured simultaneously in such a case, core damage or even a meltdown could only be prevented if further emergency measures for reactor cooling could be successfully implemented.

The crack discovered in Unit 1 of the Penly NPP is significantly deeper than all cracks found to date: It extends over 155 mm, which corresponds to about a

[43] L'ASN précise ses attentes sur la stratégie de contrôle d'EDF face au phénomène de corrosion sous contrainte (CSC), Publié le 16/03/2023

[44] https://www.powerinfotoday.com/europe/civaux-1-2-france/

quarter of the pipe circumference; its maximum depth is 23 mm with a wall thickness of 27 mm. This crack was discovered in a pipe that was not previously considered susceptible to stress corrosion cracking. According to the ASN, the strength of the pipeline can no longer be proven with this crack configuration.

Possible causes of the cracks include thermal fatigue, stress corrosion cracking and impeded vibrations. Damage caused by mechanical vibrations and pulsations should be avoided as far as possible during the planning and installation phase by taking preventive measures. The existing findings require proper repair.

Vibrations have also been detected in the EPR, specifically in the surge line[45].

Replacing steam generators in French nuclear power plants is an essential process for ensuring the safety and performance of the facilities. Here is some information on the subject:

ASN reports damage to the steam generator tubes of the 1300 MWe reactors.[46]

Steam generators are essential components of nuclear power plants. They exchange heat between the primary circuit heated by the reactor and the secondary circuit that produces the steam that drives the steam turbine. These generators are made up of thousands of thin tubes, in which the hot fluid circulates, and around which the fluid to be heated circulates.

The rupture of one of the steam generator tubes must be reliably controlled by the existing safety system. In the event of other faults that can be assumed in the accident sequence, there is a fundamental risk of an accident situation developing, including a core meltdown. Accordingly, preventive measures should be taken to avoid major corrosive damage to the tubes during operation. With this in mind, preventive measures should be taken to avoid operating methods that could lead to corrosion of the tubes. However, corrosive conditions or impurities in the steam generators that cause corrosion are inherent to the system and therefore cannot be practically ruled out.

For this reason, strategies to avoid corrosion conditions must be implemented for the "new" steam generators in the 1300 MWe reactors and the exclusion of stress-induced cracks on the steam generator tubes must be verified over the intended operating period.

EDF's steam generator replacement programme:

- EDF began replacing steam generators in the 1990s. To date, this programme covers all 900 MWe units.

[45] Surge Line: The pressurizer connects to the RCS through a surge line to the hot leg of RCS loop 3. The surge line allows continuous coolant volume and pressure adjustments between the pressurizer and the RCS.

[46] Anomalie générique concernant le taux de colmatage élevé des générateurs de vapeur de certains réacteurs des centrales EDF, Publié le 18/07/2007

- It is planned that new steam generators will be installed in all 1300 MWe reactors[47].

Faulty tightening of core instrumentation system cable connection adapters

On 26 March 2024, EDF declared a significant safety event to the ASN concerning defects in the tightening of adapters used to connect thermocouple cables in the core instrumentation system. The faults concerned reactor 1 at the Saint-Alban nuclear power plant, reactor 2 at the Nogent-sur-Seine nuclear power plant and reactor 3 at the Cattenom nuclear power plant.

Reactor building inter-enclosure vacuum system unavailable[48], NOGENT-SUR-SEINE NUCLEAR POWER PLANT

On 5 October 2023, EDF declared to the French Nuclear Safety Authority (ASN) a significant safety event relating to the unavailability of the system used to maintain a vacuum inside the "inter-bay" space of Reactor 1 at the Nogent-sur-Seine power plant.

The reactor containment, known as the "reactor building", is a concrete building containing the reactor core and the primary circuit. In the event of an accident, its purpose is to contain the radioactive substances that would be released if the primary circuit broke.

On the reactors at Nogent-sur-Seine, this enclosure is made up of a double wall. The space between the two walls, known as the inter-enclosure space, is depressurised by a ventilation system, which filters and limits any radioactive aerosols released in the event of an accident. This system consists of two redundant channels (main operating line and emergency line). The reactor's general operating rules set the level of availability of this system according to the operating and shutdown phases of the reactor.

On 28 September 2023, during the shutdown of Reactor 1, the two channels of the inter-enclosure vacuum system were made unavailable one hour too early, in a phase where this was not yet authorised by the general operating rules.

This event had no impact on the installations, people or the environment. However, it did affect the safety function related to the containment of radioactive materials. Given the failure to comply with the reactor's general operating rules, this event was classified as level 1 on the INES scale.

[47] FRENCH NUCLEAR PLANT LIFE MANAGEMENT STRATEGY APPLICATION ON REACTOR PRESSURE VESSELS AND STEAM GENERATORS LIFE MANAGEMENT, 18th International Conference on Structural Mechanics in Reactor Technology (SMiRT 18) Beijing, China, August 7-12, 2005 SMiRT18-D01-6

[48] ASN, Published on 16/10/2023

Late detection of partial unavailability of the intermediate cooling circuit[49], GOLFECH NUCLEAR POWER PLANT

On 21 September 2023, the operator of the Golfech nuclear power plant declared to the French Nuclear Safety Authority (ASN) a significant safety event relating to the late detection of the partial unavailability of the intermediate cooling system (ICS) in Reactor 1.

The intermediate cooling system (ICS) is used to cool all the reactor's auxiliary and backup system equipment, both in normal operation and in an accident situation. It is made up of two redundant circuits (channels A and B), each with two heat exchangers, cooled by river water through the raw backed-up water circuit (SEC). This means that even in the event of the loss of one channel of this circuit, the other channel alone is capable of cooling the reactor's auxiliary and back-up systems.

On 19 September at 1.35 am, following a cleaning operation on one of the exchangers in channel B of the intermediate cooling circuit, the operator took steps to make this exchanger available again. Initially, an operator half-opened the isolating valve on this exchanger in order to homogenise the temperature of the circuit, without any jerking. The operator should then have opened the valve fully, but mistakenly closed it again.

At 1.40 am, the operator began cleaning the second exchanger on channel B of the intermediate cooling circuit. During this cleaning, which lasted 15 hours, the two exchangers on channel B of the intermediate cooling circuit were unavailable. The operator therefore failed to comply with the reactor's general operating rules, which require the reactor to be shut down within one hour if two exchangers on the same channel are unavailable.

At the end of the cleaning operation on the second heat exchanger, the operator restarted the pumps for the intermediate cooling system (ICS) and the raw backed-up water system (RSW), then reopened the isolation valve on this heat exchanger. The operator then noticed that there was no flow in channel B of the intermediate cooling circuit (RRI).

Auxiliary and backup equipment continued to be cooled by channel A of the intermediate cooling circuit. This event had no impact on the installations, people or the environment, but it did affect the cooling-related safety function. Due to its late detection and failure to comply with general operating rules, this event was classified as level 1 on the INES scale.

On 19 September at 4.40pm, the operator brought the plant back into compliance by reopening the isolation valves on the two exchangers on channel B of the intermediate cooling circuit (ICR).

[49] ASN, Published on 10/10/2023

Delayed detection of the unavailability of a turbopump in the emergency steam generator supply system at Reactor 1 of the Flamanville nuclear power plant[50]

On 12 September 2023, EDF declared to the French Nuclear Safety Authority (ASN) a significant event relating to the late detection of the unavailability of a turbopump in the emergency steam generator supply circuit in Reactor 1 of the Flamanville nuclear power plant.

The steam generator emergency supply system (ASG) is used to cool the reactor in the event of failure of the normal water supply to the steam generators. It is also used during the reactor shutdown and start-up phases. The ASG circuit comprises two redundant paths. Each of these channels is equipped with a motor pump driven by an electric motor and, in redundancy, a turbopump driven by a steam turbine.

On 9 September 2023, Reactor 1 was being restarted following a shutdown for maintenance and refuelling. As part of a periodic test, EDF detected that a valve in the ASG circuit was incorrectly positioned. This incorrect configuration has rendered a turbopump unavailable since 2 September 2023, when the valve was last operated. However, as part of the restart of Reactor 1, the turbopump had been required by the technical operating specifications (TOS) since 6 September 2023. The operator therefore failed to comply with the STEs, which require the reactor to be shut down within 8 hours in the event of unavailability.

This event had no impact on people or the environment. However, given the late detection of the unavailability of the turbopump in the emergency steam generator supply circuit, as required by the technical operating specifications, this event was classified as level 1 on the INES scale.

As soon as the event was detected on 9 September 2023, the operator brought the ASG system channel back into compliance by repositioning the valve correctly.

Failure to comply with the procedure laid down in the general operating rules following late detection of the unavailability of an emergency generator set at Reactor 1[51], CATTENOM NUCLEAR POWER PLANT

On 24 August 2023, the operator of the Cattenom nuclear power plant declared to the ASN a significant event relating to non-compliance with the general operating rules for Reactor 1 following the unavailability of a diesel-powered emergency generator.

Each reactor is equipped with two external power supply lines from the national grid, an emergency diesel generator installed following the Fukushima accident and two diesel-powered emergency generators to compensate for the failure of

[50] ASN, Published on 18/09/2023

[51] ASN, Published on 08/09/2023

the power grid. Individually, these two generators can supply power to all the equipment needed to maintain the reactor in a safe state.

On 17 August 2023, during a periodic test on a standby diesel as part of the re-start of Reactor 1, a switch failed to close, preventing the tested standby diesel from resuming power supply to the reactor. The diagnosis carried out did not reveal any fault and only led to the tightening of a plug on an electrical cabinet. After several tests, the diesel was declared available on 19 August.

On 21 August 2023, when another periodic test was carried out on the same emergency diesel, the phenomenon reappeared. The additional diagnostics then identified a fault on an electronic board, a fault that had not been identified during the initial diagnostics.

As a result of the late identification of the fault, the operator wrongly considered this emergency generator set to be available from 19 August 2023, a period during which other equipment was unavailable. The accumulation of these unavailabilities led the operator to fail to comply with the general operating rules.

In the absence of any loss of external power supplies and the availability of other emergency power sources, this event had no consequences. However, because of the failure to comply with the operating conditions, this event was classified as level 1 on the INES scale.

As soon as the fault was identified on 21 August, the operator began repair work.

Late detection of the unavailability of a turbopump in the emergency steam generator supply system at Reactor 2[52], CATTENOM NUCLEAR POWER PLANT

On 13 July 2023, the operator of the Cattenom nuclear power plant declared to the ASN a significant event relating to the late detection of the unavailability of a turbopump in the emergency steam generator supply circuit for Reactor 2.

The emergency steam generator (ESG) circuit is used to cool the reactor in the event of failure of the normal water supply to the steam generators. It is also used during the reactor shutdown and start-up phases. The ASG circuit comprises two redundant channels (channels A and B), each equipped with a motor pump driven by an electric motor and, in redundancy, a turbopump driven by a steam turbine.

On 9 July 2023, during a periodic test on channel A of the ASG system as part of the restart of Reactor 2, an alarm occurred and the ASG turbopump failed to

[52] ASN, Published on 20/07/2023

start. This led EDF to declare the turbopump unavailable, and to initiate investigations which revealed that an isolation valve on a pressure sensor in the turbopump's pre-greasing circuit had been closed.

The valve was reopened and a new test of channel A of the ASG system was carried out. The ASG turbopump was available again on 9 July 2023. However, the General Operating Rules (RGE) require channel A and channel B to have been available since 5 July, with a maximum unavailability period of 3 days, which was not met since the pump had been unavailable since the start of the reactor restart operations.

This event had no impact on people or the environment. However, because of the late detection of the unavailability of the ASG turbopump and the failure to comply with operating conditions, this event was classified as level 1 on the INES scale.

As soon as the event was detected, the operator brought channel A of the ASG system back into compliance by opening the valve. In addition, there was no incident or accident that could have led to the use of this turbopump during the time it was unavailable.

Incomplete maintenance of main secondary circuit valves on the four reactors at the Paluel nuclear power plant[53], PALUEL NUCLEAR POWER PLANT

On 20 April 2023, EDF declared to the French Nuclear Safety Authority (ASN) a significant event relating to the failure to perform all the required maintenance on the main live steam circuit (VVP) valves in the four reactors at the Paluel nuclear power plant.

The main steam vent lines (VVP) are pipes in the main secondary circuit that transport pressurised steam produced in the steam generators to the turbine. They thus contribute to the cooling of the reactor. These lines, of which there are four on the Paluel power plant reactors, are equipped with seven safety valves to protect the installations from any excess pressure. These valves are subject to a preventive maintenance programme, the latest version of which has been applicable since January 2017.

On 20 April 2023, the operator of the Paluel nuclear power plant noted that the procedure used by the company working on Reactor 1 dated back to December 2014, and that the maintenance operations were therefore incomplete. Analyses carried out by EDF revealed that this discrepancy also affected the other three reactors.

As the periodic tests carried out on the valves when the reactors were operating did not reveal any anomalies, this event had no impact on the safety of the facilities. However, because of the operator's late detection of this deviation relating

[53] ASN, Published on 01/06/2023

to non-compliance with the performance of all maintenance operations, this event was classified as level 1 on the INES scale.

The operator corrected the document discrepancy and carried out all the maintenance operations on the VVP valves inspected during the shutdown of Reactor 1. It also took these elements into account during the shutdown of Reactor 3, which has just begun. As regards Reactors 2 and 4, the operator is going to ensure that the valves are working properly through tests, and will undertake the appropriate maintenance operations during the next shutdown of these reactors.

The analysis of this event should focus on understanding the reasons why this discrepancy was not identified during previous operations.

On 23 February 2023, EDF notified the French nuclear safety authority (ASN) of a significant event relating to defects in the fire compartmentation of the four reactors at the Paluel nuclear power plant.[54]

Fire compartmentalisation consists of physically separating premises using fire-resistant structural elements, in order to prevent the spread of a fire. In particular, it ensures that the same fire cannot simultaneously affect equipment performing the same function. To guarantee the integrity of this sectorisation, PVC pipes running through walls on the edge of a fire zone are fitted with intumescent fire-stop collars, and floor drains likely to open into other premises must always be filled with water.

On 30 January 2023, checks carried out by EDF on the fire compartmentation of the buildings of reactor 4 at the Paluel power plant revealed that some floor drains were not watertight proof, resulting in four breaches of compartmentation.

On 10 February 2023, a maintenance programme revealed the absence of intumescent fire-stop collars on PVC floor drains, resulting in four new fire separation breaks. Following these findings, an examination of the results of previous maintenance operations carried out in 2017 on reactors 1, 2 and 3 showed the presence of identical anomalies that had not been corrected.

EDF therefore failed to comply with the fire sectorisation management rule, which limits the cumulative number of fire sectorisation integrity losses to five.

As no fire affected the premises concerned, this event had no real impact on personnel, the environment or the safety of the installation. Nevertheless, because of the number of faults in the fire segregation system, the risk of fire spreading that could have resulted, and the fact that feedback of a similar nature was not taken into account, this event was classified as level 1 on the INES scale.

[54] ASN, Published on 17/03/2023

The restoration of integrity losses in the fire sectorisation of Reactor 4 was completed on 15 February 2023, and the processing of all deviations in the other reactors was finalised on 6 March 2023.

The analysis of this event should focus in particular on understanding the reasons for the failure to identify discrepancies during previous inspections, and determining why similar feedback was not properly taken into account by the operator.

Stress corrosion: presence of a deep crack in the safety injection circuit of Reactor 1 at the Penly power plant [Update] [55]

On 6 March 2023, EDF sent the French Nuclear Safety Authority an update on its declaration of a significant safety event relating to the presence of stress corrosion cracking on several of its reactors. This update concerns reactor 3 at the Cattenom nuclear power plant and reactors at the Civaux, Chooz B and Penly nuclear power plants.

In particular, this update includes the detection of a crack located near a weld on a line located in the hot branch of the safety injection system (RIS BC) of reactor 1 at the Penly power plant. The crack extends over 155 mm, i.e. about a quarter of the circumference of the pipe, and its maximum depth is 23 mm, for a pipe thickness of 27 mm.

This line was considered by EDF not to be susceptible to stress corrosion cracking, mainly because of its geometry. However, this weld was repaired twice during the construction of the reactor, which is likely to alter its mechanical properties and the internal stresses of the metal in this area.

The presence of this crack means that the strength of the piping can no longer be demonstrated. However, the reactor safety demonstration takes into account the rupture of one of these lines.

In this update, EDF states that the checks also revealed the presence of thermal fatigue cracks on lines considered to be sensitive to stress corrosion in the safety injection circuit (RIS) at Reactor 2 of the Penly nuclear power plant and Reactor 3 of the Cattenom nuclear power plant. The pipes concerned were replaced as part of the programme undertaken by EDF on the RIS system lines of P'4 reactors.

This event had no impact on personnel or the environment. Nevertheless, it affected the safety function linked to reactor cooling. Because of its potential consequences and the increased probability of a rupture, ASN has classified it as level 2 on the INES scale for reactor 1 at Penly nuclear power plant and as level 1 for the other reactors concerned.

[55] ASN, Published on 08/03/2023

EDF is implementing a programme to inspect repaired welds on the RIS and RRA systems. More than 150 welds have been examined in the laboratory and inspections are continuing, with a programme to inspect all reactors from 2023.

ASN has asked EDF to revise its strategy to take account of this new information. It will shortly take a position on this revised strategy.

Error in determining the expected primary flow rate for Reactor 1[56], CATTENOM NUCLEAR POWER PLANT

On 16 February 2023, the operator of the Cattenom nuclear power plant declared to the Nuclear Safety Authority a significant safety event relating to an error in determining the flow rate in the primary circuit, a parameter used by the reactor protection system.

The primary circuit is a closed circuit containing pressurised water. This water heats up in the reactor vessel when it comes into contact with the fuel assemblies. The water in the primary circuit is set in motion by four pumps known as "primary pumps".

On 12 February 2023, tests were carried out on Reactor 1 to determine the flow rate in the primary circuit. The values measured were used to update the parameters of the reactor protection system, which manages the automatic shutdown of the reactor and the activation of the backup systems.

On 13 February 2023, the operator detected an error in the uncertainty taken into account in determining the primary water flow rate. In the event of the uncontrolled withdrawal or ejection of a control rod, this error could have led to a slight delay in detecting the situation and implementing protection by automatically shutting down the reactor.

This event had no impact on the facilities, people or the environment. However, the event affected the safety function related to cooling control by slightly increasing the thresholds of the reactor protection systems.

Because of its late detection, this event was classified as level 1 on the INES scale.

As soon as the event was detected, the operator reduced the power of the reactor in accordance with its technical operating specifications, then corrected the setting of the primary water flow parameters, before restoring the reactor to its nominal production regime.

[56] ASN, Published on 26/02/2023

Adapter tightening defects in the wiring of thermocouples in the core instrumentation system of EDF's 1300 MWe reactors[57], CATTENOM NUCLEAR POWER PLANT

On 21 October 2022, EDF declared a significant safety event to the ASN concerning the incorrect tightening of adapters used to connect thermocouple cables (temperature probes) in the core instrumentation system of six 1300 MWe nuclear reactors.

This event concerns :

- Reactor 1 at Belleville nuclear power plant ;
- Reactor 2 at Cattenom nuclear power plant;
- Reactors 1 and 2 at Flamanville nuclear power plant;
- Reactor 1 at Nogent-sur-Seine nuclear power plant;
- Reactor 1 at Paluel nuclear power plant.

EDF detected these tightening defects during the disconnection of these thermocouples, which is carried out each time the reactor is shut down for refuelling. The adapters with the faulty tightening had been fitted as part of a modification to the wiring of these thermocouples.

In an accident situation, a tightening fault could cause the adapters to leak and jeopardise the availability or validity of the measurements made by the thermocouples concerned.

These measurements contribute to the operation of the "ebulliometers", two computers which, in an accident situation, inform the operators in the control room of the maximum temperature of the primary fluid leaving the reactor core and the margin between this temperature and the boiling temperature of the primary fluid. However, given the method used to establish the temperature, EDF considers that the ebulliometers would have fulfilled their function. The ASN is currently investigating these technical elements.

This event had no consequences for people or the environment. However, in view of its potential impact on safety, this event has been classified as level 1 on the INES scale.

EDF has corrected the faults observed in the six reactors concerned and has planned to modify the wiring of the core instrumentation system thermocouples for those reactors that have not yet done so. For reactors currently in operation that may also be affected by this discrepancy, EDF plans to carry out checks and bring them back into compliance during the next outage.

[57] ASN, Published on 22/11/2022

Loss of external power supplies to reactor 3 at Cattenom nuclear power plant[58], CATTENOM NUCLEAR POWER PLANT

On 11 June 2021, the operator of the Cattenom nuclear power plant declared to the ASN a significant event relating to non-compliance with the general operating rules (RGE) for reactor 3 following the unavailability of external power supplies to this reactor.

At 10.56 am, work on a control cabinet caused the circuit breaker on the auxiliary transformer to open, thereby shutting down the external power supply to Reactor 3. This situation led to the shutdown of ventilation in the nuclear zone premises and a halt to fuel handling, which was in progress in the fuel building pool.

The EMOs stipulate a time limit of one hour for restoring ventilation. After investigation and intervention, power from the auxiliary transformer was restored after 1 hour and 12 minutes and ventilation was restored after 1 hour and 19 minutes. Cutting off the auxiliary transformer and exceeding the one-hour time limit for restoring ventilation constitutes a failure to comply with the general operating rules for installations.

This event had no real impact on personnel or the environment. However, insofar as several provisions of the general operating rules were not complied with, this event was classified as level 1 on the INES scale.

Immediately after the loss of the main transformer, the two emergency power supplies (generators) took over from the main power supply and ensured cooling of the fuel storage pool. EDF has undertaken an in-depth analysis of this event. The ASN will ensure the quality of the analysis of the event and its conclusions.

Late detection of the unavailability of a back-up motor-driven pump[59], CENTRALE NUCLÉAIRE DE FLAMANVILLE

On 24 September 2020, EDF declared a significant safety event to the ASN concerning the late detection of the unavailability of an emergency motor-driven pump which, in certain critical situations, supplies water to one of the two reactors.

By design, each reactor at the Flamanville power plant has two external power sources (withdrawal transformer and auxiliary transformer), as well as two internal power sources (two diesel-powered emergency generators). Lastly, the Flamanville site has a combustion turbine that can be connected to one of the reactors to provide power.

[58] ASN, Published on 29/06/2021

[59] ASN, Published on 29/10/2020

When the primary circuit is in a particular state (full circuit but with an open vent), a mobile emergency pump must be installed to ensure that water is injected and the reactor cooled, in the event of loss of the various electrical power sources, until these are restored.

In December 1999, this mobile emergency pump was modified to improve management of the risk of contamination in the event of its use. The modification involved replacing the diesel engine with an electric motor, coupled to a dedicated diesel generator. Since then, this emergency pump has undergone periodic annual tests to check that it is working properly.

During the last annual test, on 25 June 2020, the pump stopped working after 10 minutes of use. The test was therefore declared unsatisfactory and led the operator to declare the emergency pump unavailable. The analysis carried out following this test identified that the thermal relay was undersized in relation to the motor's rated operating current. This anomaly had existed since the 1999 modification.

This discrepancy had no impact on personnel or the environment. However, given its late detection, this event was classified as level 1 on the INES scale.

Prior to the restart of Reactor 2, which resulted in the primary circuit being in the specific state described above, EDF installed another functional emergency motor pump to replace the faulty pump. Since 9 September 2020, EDF has brought the pump's thermal protection back into compliance and then requalified it.

Degradation of the seal on the door of the reactor 2 fuel storage building[60], CENTRALE NUCLÉAIRE DE FLAMANVILLE

On 7 August 2020, EDF declared a significant safety event to the ASN, relating to the handling of nuclear fuel, when the tightness of the fuel storage building of reactor 2 at the Flamanville power plant was not perfectly guaranteed.

On 20 May 2020, while carrying out a periodic test, EDF noted the degradation of the seal on the door of the fuel storage building at Reactor 2. No repair action was taken. On 24 July, the degraded state of the seal was noted again and the impact of this situation on the ventilation of the fuel storage building was assessed. On 29 July 2020, it became apparent that the condition of the seal was such that the radioactive iodine extraction and trapping system could not function properly in an incident or accident situation, and had not done so since at least 20 May 2020.

When the fuel for a nuclear reactor has been completely unloaded from the reactor core and transferred to the fuel storage building, the general operating rules require that if the iodine extraction and trapping function is unavailable,

[60] ASN, Published on 13/08/2020

fuel handling must be stopped within one hour and the system repaired within three days.

After analysis, the operator found that, during this period, fuel handling had taken place on 21 and 22 July 2020, which constituted non-compliance with the general operating rules. However, no incidents occurred during these fuel handling operations.

This event had no impact on the facilities, people or the environment. Nevertheless, due to its late detection, this event was classified as level 1 on the INES scale.

EDF had the seal replaced on 31 July 2020.

Incorrect installation of thermal fuses in fire dampers and flame dampers[61], CATTENOM NUCLEAR POWER PLANT

On 22 May 2020, EDF declared a significant event to the ASN following the discovery of incorrectly rated thermal fuses installed in fire dampers and flame arresters in Reactor 3 of the Cattenom nuclear power plant, Reactors 1 and 2 of the Golfech nuclear power plant, Reactors 1 and 2 of the Chooz B nuclear power plant and Reactor 1 of the Civaux nuclear power plant.

Fire dampers and flame arresters help to contain the effects of a fire in a given group of premises by preventing smoke from spreading through ventilation systems to adjacent premises. In the event of a fire, they protect equipment and prevent breakdowns. When a given temperature is reached, a thermal fuse installed in each damper melts and closes the damper.

The faults detected by EDF were of two types:

- The damper was fitted with a fuse of a higher rating than that required, causing it to close late in the event of a rise in temperature. This case concerned 32 fire dampers spread across all the reactors affected by these faults. EDF's analysis concluded that the late closure of these dampers in the event of a fire was not likely to cause the fire to spread and had no impact on the safety of the installations;
- the valve was fitted with a fuse of lower calibre than that required, causing it to close early in the event of a rise in temperature. This case involved 16 flame dampers on reactors 1 and 2 at the Chooz B nuclear power plant. These valves protect the iodine filters, which filter out radioactive emissions in the event of an accident. Early closure of these valves in an accident situation would have rendered the filters unavailable, leading to radiological consequences greater than those envisaged for such situations.

This event had no consequences for the facilities, people or the environment. However, the event did affect the safety of the facilities. The ASN classifies it as level 1 on the INES scale for reactors 1 and 2 at the Chooz B nuclear power plant

[61] ASN, Published on 23/07/2020

and as level 0 for reactor 3 at the Cattenom nuclear power plant, reactors 1 and 2 at the Golfech nuclear power plant and reactor 1 at the Civaux nuclear power plant.

EDF has carried out the necessary compliance work on the six reactors concerned. EDF has also launched an inspection campaign to check that the fuses on its other reactors are correctly calibrated.

Lack of braking device on pump fixing screws on EDF 1300 MWe reactors[62], CENTRALE NUCLÉAIRE DE BELLEVILLE-SUR-LOIRE

On 27 January 2020, EDF declared to the ASN a significant safety event concerning the absence of a braking device on certain connecting screws of the thermostatic valves of the medium-pressure safety injection (RIS) and chemical and volumetric control (RCV) pumps of certain 1300 MWe nuclear reactors.

This event concerns :

- Reactor 2 at the Belleville nuclear power plant ;
- Reactors 1, 2 and 3 at Cattenom nuclear power plant;
- Reactors 1 and 2 at Flamanville nuclear power plant;
- Reactors 1 and 2 at Golfech nuclear power plant;
- Reactors 1 and 2 at Nogent-sur-Seine nuclear power plant;
- Reactors 1 and 2 at Penly nuclear power plant;
- Reactors 1 to 4 at Paluel nuclear power plant;
- Reactor 1 at Saint-Alban nuclear power plant.

In 2013, EDF noted that screws had come loose on this type of valve. It retightened them and installed braking devices. These events were the subject of significant event declarations.

EDF has recently discovered that, since this event, thermostatic valves have been replaced on 1300 MWe reactors as part of maintenance operations, without the installation of a braking device for the fixing screws. However, no loosening of these screws was observed.

In the event of an accident causing a major breach in the reactor's primary circuit, the safety injection system (RIS) is used to introduce pressurised boron water into the reactor to quell the nuclear reaction and cool the core.

The main function of the volumetric and chemical control system (RCV) is to maintain the quantity of water needed to cool the core in normal operation or in the event of a very small breach.

Prolonged operation of these pumps, estimated by EDF at more than three days, could have loosened these screws and damaged the pumps concerned. EDF considers that the safety implications of these pumps malfunctioning for more than three days would have been limited, given that their operation in an

[62] ASN, Published on 17/03/2020

accident situation is required for no more than ten hours. ASN is currently investigating these technical elements.

EDF plans to rectify this discrepancy as soon as possible and within a timeframe that complies with the recommendations of ASN guide no. 21.

This event had no consequences for people or the environment. However, given that this event affected both channels of the RIS and RCV systems and that it was repeated, it is classified as level 1 on the INES scale for the 1300 MWe reactors concerned.

As part of its inspections, the ASN is making sure that these deviations are properly corrected.

Flamanville, Paluel, Belleville, Nogent and Penly nuclear power plants: ASN classifies a significant safety event involving the emergency generators at level 2 on the INES scale[63], CENTRALE NUCLÉAIRE DE FLAMANVILLE

On 31 January 2020, EDF declared a significant safety event concerning defects in the seismic resistance of certain equipment contributing to the operation of the diesel-powered emergency power generators (emergency diesels) of several of its 1300 MWe reactors. The emergency diesels provide a redundant power supply for certain safety systems in the event of failure of the external power supplies. In the event of an earthquake leading to a loss of external power supplies, the operation of the standby diesels could no longer be ensured, due to these faults. These faults, identified during inspections prescribed by the ASN in decision no. 2019-DC-0662 of 19 February 2019, are of three types:

- incorrect assembly of elastomer pipe fittings,
- corrosion of certain sections of piping or their supports,
- connection faults in certain electrical cabinets.

This event had no impact on people or the environment. However, in view of the potential consequences of the malfunction of the two emergency diesels of the same reactor in the event of an earthquake, this event is classified as level 2 on the INES scale for the following eight reactors:

- Reactors 1 and 2 at the Flamanville nuclear power plant,
- Reactors 1, 3 and 4 at Paluel nuclear power plant,
- Reactor 1 at Belleville-sur-Loire nuclear power plant,
- Reactor 1 at Nogent nuclear power plant,
- Reactor 2 at Penly nuclear power plant.

The event is classified as level 1 on the INES scale for eight other reactors, where the extent of the faults was less severe and would not have led to the loss of the two emergency diesels in the event of an earthquake. These reactors are

[63] ASN, Published on 05/02/2020

- Reactor 2 at Paluel nuclear power plant,
- Reactor 2 at Saint-Alban nuclear power plant,
- Reactor 2 at Belleville-sur-Loire nuclear power plant,
- Reactors 1 and 3 at Cattenom nuclear power plant,
- Reactor 1 at Penly nuclear power plant,
- Reactor 2 at Chooz nuclear power plant,
- Reactor 1 at Civaux nuclear power plant.

All the defects found have been repaired by EDF for the reactors concerned, or, in the case of the incorrect assembly of certain elastomer fittings, subject to reinforced monitoring until the next reactor shutdown, when they will be replaced.

As part of its inspections, ASN is making sure that these faults are being properly rectified.

ASN decision no. 2019-DC-0662 of 19 February 2019 also prescribes other inspections of electrical sources in nuclear power plants. Similar faults were found by EDF on the emergency diesels of some of its 900 MWe reactors and were the subject of a significant event classified at level 1 on the INES scale in October 2019.

Reactor 2 at Penly nuclear power plant: a significant safety event relating to faulty electrical components is classified at level 2 on the INES scale[64], PENLY NUCLEAR POWER PLANT

On 18 December 2019, EDF declared a significant safety event relating to faulty electrical components that rendered emergency systems unavailable in Reactor 2 at the Penly nuclear power plant.

In nuclear power plants, the safety equipment in each reactor is supplied with electricity via two redundant switchboards (channels A and B). In particular, these switchboards supply power to the motors operating the valves and pumps of the backup systems and to the reactor control panels.

As part of the shutdown for scheduled maintenance and refuelling of Reactor 2 at the Penly nuclear power plant, which began on 27 July 2019, EDF replaced moving parts of these switchboards. The work was carried out simultaneously on tracks A and B, as it had not been possible to carry out the work on track A alone during a previous shutdown.

During the restart, for requalification after work, of the reactor's backup and cooling pumps, while the reactor was still shut down, anomalies led EDF to detect, from 12 October 2019, a malfunction in four electrical components.

On 10 December, while the reactor was still shut down but recharged, EDF conducted investigations and analysed the origin of these successive faults. These

[64] Published on 23/12/2019

investigations revealed that 28 components replaced on electrical switchboards were potentially faulty. EDF then considered that the pumps in the reactor's backup and cooling systems affected by the fault were unavailable.

The unavailability of several safety-critical items of equipment had no impact on people or the environment.

Because of the degradation of safety functions, linked to the installation of faulty components on electrical switchboards important to safety, and to the operator's poor organisation, both in the preparation of maintenance activities and in the late analysis of successive faults, the event is classified as level 2 on the INES scale.

EDF is currently completing the replacement of the 28 potentially faulty electrical components. Examination of the first eighteen insertion contacts has revealed a manufacturing defect in eight of them, all belonging to the same batch. In addition, EDF is currently checking which other reactors could be affected by the faulty parts and will be replacing them.

2.3.1 Conclusions and recommendations

EDF reported technical anomalies on various installations, e.g. on

- Auxiliary systems of the diesel generators
- Fire extinguishing pipes.

Most of these anomalies are related to a lack of resistance to earthquake and exist since the construction of the plants

In 2020, the ASN ensured continuous improvement in the management of deviations affecting the facilities.[65]

However, as in previous years, the ASN is of the opinion that the actual level of compliance with the rules and regulations applicable to the installations must be significantly improved. The year 2020 was again characterised by the identification of deviations that affect the ability of installations to control accidents. Some of these deviations originated during construction, others arose when changes were made to the installations, including changes to the installations, including recent ones, or they are the result of ageing of the equipment or inadequate maintenance.

2.3.1.1 Recommendation (3): Perform root cause analysis for feed-in system damage events before LTE

Motivation/Observation:

[65] Rapport de l'ASN sur l'état de la sûreté nucléaire et de la radioprotection en France en 2020

The causes of the safety-relevant damage in the safety feed-in system of French nuclear power plants have not yet been conclusively clarified.[66]

Scenarios are conceivable in which mechanical loads act simultaneously on all affected lines of the safety feed-in system, e.g. in the event of a severe earthquake. If, in such a case, several of these lines were to be torn down at the same time, core damage or even a meltdown could only be prevented if further emergency measures for reactor cooling could be successfully implemented.

Recommendation:

The root cause of safety-related damage in the safety feed-in system of French nuclear power plants would have to be conclusively clarified before an LTE could be initiated.

2.3.1.2 Recommendation (4): Avoid corrosive environment for steam generator u-tubes

Relates to EDF NRO (2023a) chapter I.2.1 “Accidents without core melt” and especially affaire no TCDI0147

Motivation/Observation:

Damage to the steam generator u-tubes caused by corrosion during operation must be prevented. With this in mind, preventive measures should be taken to avoid operating modes that could lead to corrosion of the steam generator u-tubes. The EPR safety systems are designed against simultaneous failure of two steam generator u-tubes, while the P4/P’4 reactors can cope with just a single failed u-tube.[67]

Recommendation:

The operation mode of 1300 MWe reactors, should ensure that failure of more than one steam generator u-tube can be excluded.

[66] Safety-relevant damage in the safety injection systems of French nuclear power plants, https://www.grs.de/en/news/safety-relevant-damage-safety-injection-systems-french-nuclear-power-plants#SnippetTab

[67] ASN, Published on 28/02/2014, TECHNICAL GUIDELINES FOR THE DESIGN AND CONSTRUCTION OF THE NEXT GENERATION OF NUCLEAR POWER PLANTS WITH PRESSURIZED WATER REACTORS. The key issues in transient analysis calculations which affect the radiological consequences following design-basis steam generator tube rupture accidents , EUR 16244, 1996

2.3.1.3 Recommendation (5): Prestress losses in 1300 MWe containments

Motivation/Observation:

Studies[68] indicate that the tension of steel wires of prestressed concrete containments might drop below acceptable limits after 40 years of operation in 1300 MWe reactors.

Recommendation:

To operate the 1300 MWe reactors beyond 40 years it is recommended to require an assessment of existing containment prestress levels.

[68] E.g. Prestress losses in NPP containments - The EDF experience, Conference: Joint WANO/OECD-NEA workshop on pre-stress loss in NPP containments, Poitiers (France), 25-26 Aug 1997

3 REFERENCES

ASN (2004): Communiqué de presse n°2; Publié le 17/05/2004; https://www.asn.fr/l-asn-informe/actualites/communique-de-presse-n-2

ASN (2005): Inspection n°INS-2005-EDFNOG-0021 au CNPE de Nogent sur Seine; Châlons, le 7 octobre 2005 https://www.asn.fr/Media/Files/INS_2005_EDFNOG_0021.pdf

ASN (2006a): Inspection n°INS-2006-EDFNOG-0015 au CNPE de Nogent sur Seine "Inspection réactive suite à l'incident du 18 février 2006"; Châlons, le 23 février 2006; https://annual-report.asn.fr/content/download/71894/download_file/INS_2006_EDFNOG_0015.pdf

ASN (2006b): Perte des alimentations électriques externes; 10/01/2006 https://www.asn.fr/l-asn-controle/actualites-du-controle/installations-nucleaires/avis-d-incident-des-installations-nucleaires/perte-des-alimentations-electriques-externes

ASN (2013): Sixth National Report for the 2014 Review Meeting under the Convention on Nuclear Safety (CNS); July 2013

ASN (2013a): Lettre ASN CODEP-DCN-2013-013464 du 28 juin 2013 relative au programme générique proposé par EDF pour la poursuite de fonctionnement des réacteurs en exploitation au-delà de leur quatrième réexamen de sûreté

ASN (2013b): Incendie d'un transformateur électrique à la centrale nucléaire de Cattenom; 07/06/2013; https://www.asn.fr/l-asn-informe/actualites/incendie-d-un-transformateur-electrique-a-la-centrale-nucleaire-de-cattenom

ASN (2017): ASN, Olivier GUPTA, Nuclear Safety in France, Upcoming challenges, EUROSAFE 2017

ASN (2017a): Événement dans la salle des machines de la centrale nucléaire de Flamanville 1; 09/02/2017; https://www.asn.fr/l-asn-informe/actualites/evenement-dans-la-salle-des-machines-de-la-centrale-nucleaire-de-flamanville-1

ASN (2019): RAPPORT DE L'ASN sur l'état de la sûreté nucléaire et de la radioprotection en France en 2019

ASN (2019a): Significant safety event rated level 2 on the INES scale during operations to drain the reactor 2 primary system in the Golfech NPP; 05/12/2019; https://www.french-nuclear-safety.fr/asn-informs/news-releases/golfech-npp-significant-safety-event-rated-level-2-on-the-ines-scale

ASN (2020): LES APPRÉCIATIONS DE L'ASN PAR EXPLOITANT, Les centrales nucléaires en fonctionnement, Rapport de l'ASN sur l'état de la sûreté nucléaire et de la radioprotection en France en 2020

ASN (2021): ASN report on the state of nuclear safety and radiation protection in France in 2021, Published on 18/05/2022.

BECKER (et al. 2020): The impacts of climate change on nuclear risk and supply security. Working Paper; Oda Becker, Eszter Matyas, Patricia Lorenz. 26 June 2020

IAEA (2012a): Fire and abnormal primary circuit leak occured at Penly NPP n°2 reactor; News, The Information Channel on Nuclear and Radiological Events. 06 April 2012; https://www-news.iaea.org/ErfView.aspx?mId=dde941ab-d009-4e2c-a996-584fafb92ecc

IRSN (2015): IRSN'S POSITION, Safety and Radiation Protection at Nuclear Power Plants in France in 2014, IRSN 2015

IRSN (2016): IRSN'S POSITION, Safety and Radiation Protection at Nuclear Power Plants in France in 2015, IRSN 2016

IRSN (2019): Avis IRSN/2019-00108: EDF – REP - Analyse du retour d'expérience de l'exploitation des réacteurs électronucléaires - Période 2015-2017

IRSN (2023): DIALOGUE TECHNIQUE SUR LE 4ÈME RÉEXAMEN PÉRIODIQUE DES RÉACTEURS DE 1300 MWE, Réunion du 30 mai 2023 – Agressions d'origine externe

LeMonde (2012): Incident à la centrale nucléaire de Flamanville; 25 octobre 2012 https://www.lemonde.fr/planete/article/2012/10/25/incident-a-la-centrale-nucleaire-de-flamanville_1781087_3244.html

WENRA – WESTERN EUROPEAN NUCLEAR REGULATORS' ASSOCIATION (2019): Report: Practical Elimination Applied to New NPP designs – Key Elements and Expectations, WENRA RHWG, 17 September 2019. http://www.wenra.org/media/filer_public/2019/11/11/practical_elimination_applied_to_new_npp_designs_-_key_elements_and_expectations_-_for_issue.pdf

4 GLOSSARY

AGW ..... Ocean Waves

ALARP..... As far as reasonably practicable

ASG..... Steam Generator Emergency Feedwater System

ASN..... French Nuclear Safety Authority

Bq ..... Becquerel

CCF ..... Common cause failure

CDF..... Core Damage Frequency

CGB ..... Large watershed flooding

CGCS ..... Combustible gas control system

CHRS ..... Containment heat removal system

CLA ..... Local wind waves

CMM..... Maximum thousand year flood

CMS ..... Flood safety margin level

CMSS ..... Core Melt Stabilisation System

CPB ..... Small watershed flooding

Cs-137 ..... Caesium-137

DAC ..... Design Acceptance Confirmation

DBE..... Design Basis Earthquake

DBF..... Design basis flood

DCH ..... Direct Containment Heating

DDOCE ..... Deterioration or malfunctioning of structures, circuits or equipment

DEC..... Design Extension Conditions

DUS ..... Ultimate Backup Diesel Generators

ECMWF..... European Centre for Medium Range Weather Forecasting

EIA ..... Environmental Impact Assessment

ENSREG..... European Nuclear Safety Regulators Group

EPR ..... European Pressurised Reactors

ES	Environmental Statement
EU	European Union
FARN	Rapid Response Nuclear Taskforce
FL3	Flamanville Unit 3
FMEA	Failure Modes and Effects Analysis
FRA	Flood Risk Assessment
G	Ground acceleration expressed as a fraction of the acceleration of gravity of 9.81 m/s²
GDF	Geological disposal facility
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit, Deutschland
GW	Giga Watt hour
HCS	Hardened Safety Core (noyau dur)
HFT	Hot functional testing
HLW	High level waste
HPME	High Pressure Melt Ejection
HRA	Human Reliability Analysis
HSC	Hardened Safety Core
HVAC	Heating, Ventilation and Air Conditioning
I&C	Instrumentation & Control
IAEA	International Atomic Energy Agency
IDAC	Interim Design Acceptance Confirmation
INES	International Nuclear Event Scale
INT	Mechanically induced wave
IRSN	Institut de Radioprotection et de Sûreté Nucléaire
IWRST	In-containment refuelling water storage tank
LOCA	Loss of Coolant Accident
LOOP	Loss of offsite power
LTE	Life time Extension
MW	MegaWatt

MWe ..... MegaWatt electric

MWh ..... Mega Watt hour

NAcP ..... National Action Plan

ND ..... Noyau Dur

NDA ..... Nuclear Decommissioning Authority

NFLA ..... Nuclear Free Local Authorities

NMA ..... Sea level

NPP ..... Nuclear Power Plant

NTI ..... Nuclear Threat Initiative

PAR ..... Passive autocatalytic recombiners

PBq ..... Peta Becquerel, E15 Bq

PCSR ..... Pre-Construction Safety Report

PDS ..... Primary Depressurisation System

PFI ..... high intensity rainfall

PGA ..... Peak Ground Motion

PLU ..... Local rainfall

PRA ..... Probabilistic risk assessment

PRB ..... low-lying close protection

PRH ..... high close protection

PSA ..... Probabilistic Safety Assessment

PSHA ..... Probabilistic Seismic Hazard Assessment

PSR ..... Periodic Safety Review

RCS ..... Reactor Cooling System

RFS ..... Basic safety rules

RFS ..... Reference Flooding Situation

RNP ..... High groundwater level

ROR ..... Failure of a water-retaining structure

RPV ..... Reactor Pressure Vessel

RRC ..... Risk Reduction Category

SBO ..... Station Black Out

SEG ..... Ultimate Heat Sink

SEI ..... Seiche

SEO ..... Sewerage

SGTR..... Steam generator tube ruptures

SMA ..... Seismic Margin Assessment

SND ..... Séisme Noyau Dur

SRI..... Scenario

SSC ..... Structure, Systems, Components

UDG..... Ultimate Diesel Generators

UHS ..... Ultimate Heat Sink

VAG ..... Ocean waves

VP ..... Volumetric Protection

WENRA..... Western European Nuclear Regulators´ Association

umweltbundesamt

Umweltbundesamt GmbH
Spittelauer Laende 5
1090 Vienna/Austria

Tel.: +43-1-313 04

office@umweltbundesamt.at
www.umweltbundesamt.at

EMAS
VERIFIED
ENVIRONMENTAL
MANAGEMENT
AT-000484

ISBN 978-3-99004-780-4