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Safety Assessment of Fire Protection of nuclear facilities in FRANCE

NATIONAL REPORT

Produced Pursuant to Article 8e of Council Directive 2014/87/Euratom

Dated 30 October 2023

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0. PREAMBLE / FOREWORD

This report is written as part of the second European Topical Peer Review (TPR) exercise on the fire protection of nuclear facilities.

The 2014 amendment to the EU Nuclear Safety Directive 2014/87/EURATOM (NSD) requires Member States to undertake, on a coordinated basis, topical peer reviews at least every six years.

At its 41st plenary meeting in November 2020, ENSREG decided that the subject of this second peer review would be the fire protection of nuclear facilities.

This report, which corresponds to the first phase of the exercise as defined in the ENSREG terms of reference [1], is the result of the national self-assessment. It is structured in accordance with the WENRA technical specifications [2].

Given the large number of nuclear facilities in France, the choice of facilities for detailed analysis was an important step. This choice is explained in Chapter 1.

The regulatory framework for fire risk management in French nuclear installations is also presented in Chapter 1.

The second chapter covers the fire safety analysis for each installation.

The measures implemented by each operator to meet the different levels of defence in depth are detailed in Chapter 3. The different levels of defence in depth considered are as follows:

- the first level of defence in depth corresponds to prevention against the start of a fire and is detailed for the various installations in section 3.1 of the report;
- the second level of defence in depth corresponds to the ability to detect the start of a fire and extinguish it quickly; it is dealt with in section 3.2 of the report. This second level is referred to as "active fire protection" throughout the report.
- the third level of defence in depth corresponds to limiting the consequences of a fire that could not be extinguished quickly and is covered in section 3.3 of the report. This third level is called "passive fire protection" in this report.

Finally, Chapter 4 presents the general conclusion of the French nuclear safety authority (ASN) on fire prevention and protection in the French nuclear facilities concerned by the exercise.

Ten basic nuclear installations are covered in detail in this report. Following the plan proposed by WENRA, the sections relating to a given installation are divided into different chapters. In order to simplify the numbering of the paragraphs within the various chapters, the report uses the type and number of the installation as a heading.

The table below summarises the numbering used in this report.

Installation type	Nuclear power plant	Research reactors	Fuel cycle facilities				Dedicated spent fuel storage	On-site storage	Installations under decommissioning	
Installation	**PWR**	**RHF**	**GB II**	**Framatome Romans**	**UP3A - T2**	**MELOX**	**SFP D (T0)**	**Silo 130**	**OSIRIS**	**UNGG**
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1. GENERAL INFORMATION

1.1. Nuclear installations identification

1.1.1. Qualifying nuclear installations

For the purposes of current exercise, there are 101 French nuclear installations qualified according to the various categories of installations (see table bellow) and eligibility criteria set out in reference [2] and considering the status of these installations based on the ASN resolution in reference [3]. These facilities are defined as Basic Nuclear Installations (BNI) under French regulations, and are presented in the table below.

These installations are presented in the following table. The installations selected for the TPR II exercise (see 1.1.2) are given in bold type.

Installation category	Status	Number	Qualified installations (in bold type)
Power reactors	In operation	56	56 nuclear power reactors, i.e.: - 32 x 900 MWe reactors (incl. **TRICASTIN 1**), - 20 x 1,300 MWe reactors - 4 x 1,450 MWe reactors
	Under construction	1	1 nuclear reactor of 1,650 MWe (EPR)
	Undergoing final shutdown / decommissioning	11	FESSENHEIM 1&2 (BNI 75), CHINON A1D (BNI 133), CHINON A2D (BNI 153), BUGEY 1 (BNI 45), **SLA A1&A2 (BNI 46)**, SUPERPHENIX (BNI 91), EL4 D (BNI 162), CHOOZ A (BNI 163)
Research reactor (RR)	In operation	2	**RHF (BNI 67)**, CABRI (BNI 24)
	Under construction	2	RJH (BNI 172), ITER (BNI 174)
	Undergoing final shutdown / decommissioning	9	MASURCA (BNI 39), OSIRIS-ISIS (BNI 40), EOLE (BNI 42), PHEBUS (BNI 92), MINERVE (BNI 95), ORPHEE (BNI 101), ULYSE (BNI 18), RAPSODIE (BNI 25), PHENIX (BNI 71)
Uranium enrichment facility	In operation	1	**GBII (BNI 168)**
	Being decommissioned	1	EURODIF (BNI 93)
Fuel fabrication facility	In operation	3	**Framatome Romans (BNI 63-U)**, **MELOX (BNI 151)**, LEFCA (BNI 123)
	Being decommissioned	2	ATPU (BNI 32), ATUE (BNI 52)
Fuel reprocessing facility	In operation	3	**UP 3-A (BNI 116)**[1], UP2-800 (BNI 117), TU5 (BNI 155),
	Being decommissioned	4	UP2-400 (BNI 33), LPC (BNI 54), STE2 (BNI 38), HAO (BNI 80)
Specific spent fuel storage facility	In operation	2	**Spent fuel pool D (T0) UP 3-A (BNI 116)**[2]**,** APEC (BNI 141)
On-site radioactive waste storage facility	In operation	3	Ecrin – Ponds B1 and B2 (BNI 175), STE3 (BNI 118), UP3 (BNI 116)
	Being decommissioned	1	**STE2 and AT1** (BNI 38)[3]

[1] For the purposes of the exercise, only the T2 unit is studied.

[2] For the purposes of the exercise, only pool D is studied.

[3] For the purposes of the exercise, only the Silo 130 is studied.

1.1.2. National selection of installations for TPR II and justification (brief summary of)

One or more installations were selected in each category on the basis of:

- their representativeness of non-selected facilities;
- the lessons they can provide in terms of fire risk;
- good practices for equivalent facilities in other European countries.

For each category of nuclear installations, the following table presents the installation(s) selected for the TPR II exercise. The detailed justification of the installations selected, the installations represented and the installations excluded from the exercise is presented in Appendix 1.

Installation category	Licensee	Candidate installations	BNI No.
Nuclear power reactors	EDF	TRICASTIN 1- 900 MWe pressurised water reactor, as-is after the 4th ten-yearly periodic safety review. Note: An analysis of the differences in fire protection with regard to the 1,300 MWe, 1,450 MWe (N4) and 1,650 MWe (EPR) reactors will be made	BNI 87
Research reactors	ILL	RHF	BNI 67
Fuel cycle facilities	Orano	George Besse II fuel enrichment facility	BNI 168
	Framatome Romans	Romans sur Isère fuel fabrication facility	BNI 63-U
	Orano	La Hague UP3A – T2 fuel reprocessing facility	BNI 116
	Orano	MOX – MELOX fuel fabrication facility	BNI 151
Spent fuel storage facility	Orano	Spent fuel storage pool at La Hague – Pool D (To)	BNI 116
On-site radioactive waste storage facility		Silo 130 - La Hague	BNI 38
Installations undergoing decommissioning	CEA	OSIRIS research reactor	BNI 40
	EDF	GCR - Saint Laurent des Eaux A1	BNI 46

1.1.3. Key parameters per installation

The key parameters of the selected installations are presented in the following sub-chapters.

1.1.3.1. Power reactors

The Tricastin NPP is located in the Saint-Paul-Trois-Châteaux municipality, in the Drôme département. It is located on an island bounded by the Rhône River to the West and the Donzère-Mondragon canal to the East, at kilometre point 14 on the canal.

The Tricastin NPP comprises four nuclear reactors built according to the 900 MWe CP1 plant series standard. They are in twin pairs of reactors (reactors 1-2 and 3-4), of identical pressurised water reactor (PWR) design, corresponding to a normal thermal power of 2,785 MWth. They are cooled using the once-through system with water from the Donzère-Mondragon canal, which takes water diverted from the Rhône River.

The Tricastin NPP is operated by a single licensee, EDF, and is specifically devoted to the production of electricity from the 4 reactors and comprises no other installations.

Tricastin NPP reactor 1 was commissioned on 4 August 1980. Since then, 4 periodic safety reviews have been performed to improve the safety level of the Tricastin NPP's 4 reactors.

The reactors of the 900 MWe plant series, including the Tricastin NPP, operate with fuel using enriched uranium and/or MOX.

Fuel waiting to be loaded into the core or removed is stored in the "fuel" building pool.

In terms of fire protection, the fire-fighting water, the mobile command post and the mobile fire-fighting equipment are all common to the site as a whole.

In addition to the organisation of the response by the EDF teams, fire fighting relies primarily on the response by the public emergency services. Agreements are established with the public services, which notably specify the performance of periodic joint exercises, visits and training courses.

The Tricastin NPP has water and emulsifier resources which are used by the EDF response teams and then by the public emergency and firefighting services when they arrive.

The Tricastin NPP is located in an area with low urban density, adjacent to the Orano site, which comprises several basic nuclear installations involved in the fuel cycle. Finally, hazardous goods transport routes are located close to the power plant. The industrial installations and the transport routes have a very limited impact on fire risk at the Tricastin NPP.

1.1.3.2. The RHF research reactor

The High Flux Reactor (RHF), BNI n° 67, is a 58 MW research reactor operated by the Institut Laue-Langevin (ILL). This is a heavy water, high neutron flux reactor, which produces extremely intense thermal neutrons beam for fundamental research. The RHF operates with a single fuel element. The irradiated fuel elements are stored in a pool on the La Hague site as no reprocessing solution currently exists.

The RHF construction permit dates from 1969 and its first divergence took place in 1971. The reactor is currently active and should be in operation until at least 2032.

The RHF is located in the town of Grenoble at the confluence of the Drac and Isère rivers. There are no other BNIs near the site, but the ILL has the particularity of being situated in a densely populated area with numerous transport routes nearby. The ILL is the only operator of the installation and makes very little use of subcontractors.

ILL has its own anti-intrusion fence delimiting the BNI perimeter. The emergency power supplies and fire extinguishing water networks are proper to ILL.

The ILL has an agreement with the CEA Grenoble Local Security Force for fighting any fire within the perimeter of the ILL. This system is valued in the installation's safety case. The industrial installations and hazardous goods transport pipelines identified within a 2 km radius around the ILL site are:

- two liquefied propylene and ethylene gas pipelines and a petroleum products pipeline;
- a liquefied natural gas pipeline;
- the gas infeed station, comprising two pressure regulating units;
- the CEA Grenoble centre, housing various chemical, explosive or inflammable products.

The design basis scenarios for these installations cover the explosion rather than the fire risk.

The latest periodic safety reviews of the RHF reactor led to modifications as a result of fire studies. The reactor's protection approach against fire risk is proportionate to the stakes involved, in accordance with the BNI regulations.

1.1.3.3. The George Besse II fuel enrichment facility

The fuel enrichment facility called the Georges Besse II (GBII) is the BNI No.168. Its creation was authorised by decree on 27 April 2007 and it was commissioned between 2010 and 2015.

This facility enriches uranium in its isotope 235 by centrifuging gaseous uranium hexafluoride. Uranium enrichment is an essential activity in the manufacture of nuclear fuel, and forms part of the front end of the French fuel cycle. This BNI comprises two enrichment units known as "North" and "South" and a workshop known as "RECII" for sampling and transferring uranium hexafluoride into various containers. More specifically, the South and North units were commissioned at the end of 2010 and in 2013 respectively, and the RECII workshop was commissioned in 2015.

BNI No.168 is located on the Tricastin nuclear platform, where ICPEs, BNIs and BNISs, also operated by Orano, have complementary functions to those of BNI No.168. These facilities are responsible for:

- the reception and transformation of uranium tetrafluoride (UF_4) into uranium hexafluoride (UF_6);
- the defluorination of depleted uranium hexafluoride generated during enrichment into uranium sesquioxide (U_3O_8), known as U_{app};
- storage of containers of uranium hexafluoride or sesquioxide;
- cleaning and maintenance of uranium hexafluoride containers;
- environmental monitoring and analysis of samples of uranium-bearing materials.

The platform is also home to a nuclear power station with 4 nuclear reactors and a facility operated by EDF that is currently shut down but was formerly used for the maintenance of some NPP equipment.

This platform is located in an industrial zone with extensive road, rail and airport transport infrastructure. The main companies in the surrounding area include in particular a company specialising in the chemistry of fluorinated products, a company manufacturing wall and floor coverings, a company operating a biomass cogeneration plant, and a company manufacturing catalytic elements.

The risks induced by industrial activities were the subject of specific analyses at the design stage of the structures making up the Georges Besse II plant.

With regard to fire-fighting resources, as in any other Orano facility, staff are specifically trained to evacuate personnel and carry out initial extinguishing operations using the resources available at the facility, such as fire extinguishers. The platform also has a dedicated fire-fighting service. This response service is shared with several facilities of the platform, enabling each to benefit from a substantial response force that is not limited to its own needs. This emergency service is equipped with appropriate resources, such as self-contained breathing apparatus, emergency clothing, etc. A dedicated water supply network for extinguishing fires is also installed throughout the platform, and water reserves are also available if necessary. These reserves correspond to a water tower also located on the platform and a river running through it (the Gaffière). Finally, this response service can be supported by the departmental public emergency services.

1.1.3.4. The Romans Sur Isère fuel fabrication facility

The fuel fabrication facility of Romans Sur Isère, called “fuel fabrication plant” is BNI n° 63-U. This BNI operated by Framatome Romans is the result of the merger by a decree of 23 December 2021 between BNI n° 98 called “FBFC” and BNI n° 63 called “fuel elements fabrication plant (CERCA)”. The creations of BNI No.63 and 98 were authorised by the Decrees 1 November 1967 and of 2 March 1978 respectively. These two installations were merged by a Decree of 23 December 2021. BNI No. 63 and 98 were commissioned in 1980 and 1988 respectively.

The former BNI n° 63 fabricates fuel assemblies for nuclear research reactors in France and abroad. This plant also supplies fuel elements for the TRIGA reactors.

The former BNI n° 98 fabricates fuel assemblies for both light and heavy water reactors using natural uranium or produced after the reprocessing of spent fuel assemblies.

BNI No. 63-U is located in the municipality of Romans-sur-Isère, close to an airfield and to the east of an industrial zone. The industrial zone includes two Seveso-classified companies producing polymers or plastics and a mass retailer of everyday products. The risks associated with these industrial activities are subject to specific analyses.

BNI No. 63-U has its own fire protection resources including intervention teams. These teams have appropriate ressources such as self-contained breathing apparatus, emergency clothing, etc. They can be supported by the Departmental Fire and Emergency Services (SDIS – *Services Départementaux d'Incendie et Secours*). Several fire response exercises are held each year.

1.1.3.5. The La Hague UP3A – T2 fuel reprocessing facility

BNI n° 116 called “UP3-A plant” was authorised by a decree of 12 May 1981 and is located on the La Hague site. Its function is to receive, store and reprocess spent fuel assemblies from French and foreign nuclear reactors. This installation was gradually commissioned from 1986 to 2002 and, like all the other BNIs on the La Hague site (BNI n^{os} 117, 118, 33, 38, 47 and 80), it is operated by a single licensee, Orano Recyclage. The T2 unit of this plant separates the fission products (FP) from uranium and plutonium contained in fuel dissolution solutions. The T2 unit receives from the T1 unit (unit performing the fuel element shearing, dissolution and clarification of the resulting solutions) the clarified dissolution solutions for separation of the uranium, plutonium and fission products. A first liquid-liquid extraction step separates the radioactive materials (U, Pu) and fission products. A second liquid-liquid extraction phase is then performed to separate the U and the Pu. Three solutions are then obtained:

- a Uranium solution that will be concentrated in T2 before being transferred to T3;
- a fission products solution concentrated in T2 for storage prior to final processing in T7 (fission products vitrification unit);
- a plutonium solution transferred to T4 (plutonium purification, conversion into oxide and conditioning unit).

The fire risk in the T2 unit is primarily linked to:

- the presence of electrical or electronic equipment;
- the use of a large quantity of flammable liquids in the separation processes.

The main fire risk is rupture of the barriers making up the containment system. The units near to the T2 unit are units T1 and T7 (also making up BNI n° 116) for which the buildings are adjacent to those of unit T2.

The T2 unit shares a part of its process ventilation with T1. Moreover, the supply of vacuum, cooling water for certain equipment, decontamination reagents, and sweep air to T7 and T1 is provided by T2.

Fire-fighting resources, as at any other Orano facility, are similar to those mentioned in section 1.1.3.3. Therefore, the entire La Hague site is within the scope of intervention of the establishment's emergency teams, which are common to all the site's facilities.

1.1.3.6. The MOX – MELOX fuel fabrication facility

The fuel fabrication facility called MELOX is BNI No. 151. Its creation was authorised by a Decree of 21 May 1990. This BNI was commissioned in 1995. It is operated by Orano.

This plant ensures the fabrication of fuel rods and fuel assemblies composed of mixed uranium and plutonium-based oxide for light water nuclear reactors.

The fabrication process used by MELOX comprises three main phases:

- fabrication of pellets;
- fabrication of rods;
- fabrication, transport packaging and shipment of the assemblies.

BNI No. 151 is located on the Marcoule nuclear platform which comprises several other nuclear installations, in particular:

- the Phénix reactor, currently being dismantled and operated by CEA;
- the Atalante research laboratory, operated by the CEA;
- the Centraco nuclear waste treatment and conditioning centre, operated by Cyclife France (a subsidiary of EDF);
- the Gammatec industrial irradiator, operated by STERIS;
- the STEL liquid effluent treatment plant, operated by CEA.

The Marcoule site is located in a predominantly agricultural environment, 5 kilometres north of the nearest industrial zone. This includes a ferroalloy manufacturing company, a fibreglass manufacturing company and a road transport platform. The risks induced by industrial activities were the subject of specific analyses at the design stage of the structures making up the Melox plant.

With regard specifically to fire-fighting resources, as at any other Orano facility, staff are specifically trained to evacuate personnel and carry out initial extinguishing operations using the resources available at the facility, such as fire extinguishers. MELOX has an internal emergency service with appropriate resources, such as self-contained breathing apparatus, emergency clothing, etc. A dedicated fire-fighting water supply network is also in place throughout the platform. The platform also has a fire-fighting service, which is shared with the other nuclear facilities on the Marcoule site, enabling each to benefit from a substantial response force that is not limited to its own needs. Finally, this response service can be supported by the departmental public emergency services.

1.1.3.7. The spent fuel storage pool at La Hague – Pool D (T0)

The spent fuel pool D is integrated in the T0 unit which is part of BNI No. 116 located on the La Hague site. This facility was gradually commissioned from 1986 to 2002 and, like all the other BNIs on the La Hague site (BNI n^os 117, 118, 33, 38, 47 and 80), it is operated by a single licensee, Orano Recyclage.

The unit T0-Pool D constitutes the point to entry for active material in plant UP3-A. It is thus used for unloading and storage of irradiated fuels so that they can be reprocessed on the Orano La Hague site. The unloading phases follow a "dry unloading" process, and with a single reprocessing chain. This unit is also used for the transfer and storage of spent fuel assemblies in baskets in pool D, as well as the underwater transfer of these fuels to another pool (C or E) and to unit T1. It is also possible to transfer assemblies to/from the NPH pool using the existing inter-pools transfer system between pool C and the NPH pool.

Unit T0 is only adjacent to unit T1 (which is also part of BNI n° 116). Pool D in unit T0 is adjacent to its pools C and E as well as to the electrical substation unit 2104 building. Pool D also shares a wall with unit T1.

Given the interconnection between pools C, D and E, the pool cooling systems are shared.

Finally, fire-fighting resources, as at any other Orano facility, are similar to those mentioned in section 1.1.3.3. Therefore, the entire La Hague site is within the scope of intervention of the establishment's emergency teams.

1.1.3.8. Silo 130 - La Hague

The Silo 130 is part of BNI n° 38 and is located in the North-West zone of the La Hague site. This installation is operated by Orano. Silo 130 is relatively remote from the other installations on the site[4]. Silo 130 was operated from 1973 to 1981 for magnesium waste and until 1987 for the graphite sleeves from gas-cooled reactors.

Within BNI n° 38, silo 130 is used for storage:

- of bulk solid waste from gas-cooled reactor spent fuel reprocessing operations performed in the UP2-400 plant (BNI n° 33) between 1966 and 1987, such as structural elements, pellets and uranium residues;
- various other solid wastes, including contaminated earth and rubble from post-operational clean-out works.

The solid waste was initially stored dry and only in the "West" pit (pit 43). Following the fire on 6 January 1981, the storage pits (pits 43 and 44) were partially flooded by the fire-fighting water. Since then, the waste has been partially stored under water.

The Silo 130 unit has been authorised for permanent shutdown and dismantling, which requires the recovery and conditioning of the waste in pit 43. The waste recovery and conditionning has led to the implementation of specific facilities.

[4] The La Hague site comprises 3 basic nuclear installations in operation for reprocessing spent fuels and 4 basic nuclear installations being decommissioned, including BNI n° 38

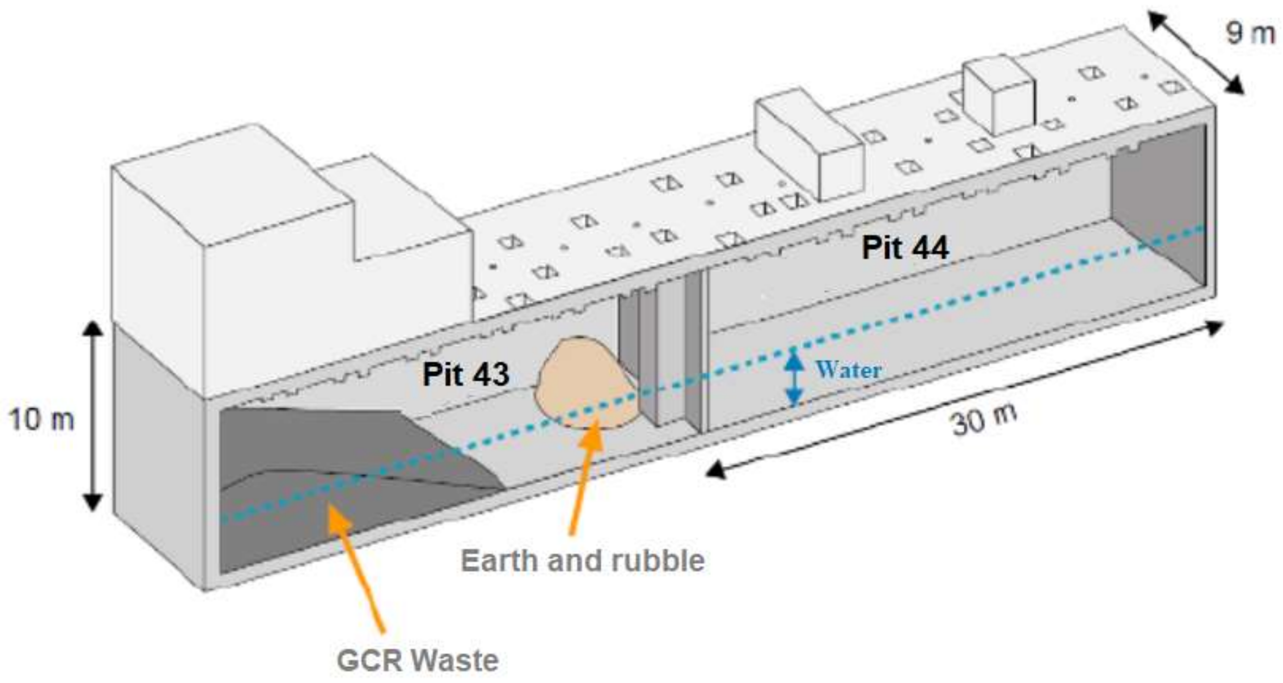


Diagram of silo 130

All the utilities for BNI n° 38 (fluids, energy, etc.) are shared with the other La Hague installations. With regard to the fire protection provisions, BNI n° 38 benefits from the services of the La Hague site's response teams, the associated response resources and the fire detection alarms transmitted to the site's central security post.

1.1.3.9. The OSIRIS research reactor being decommissioned

The Osiris pool type reactor with an authorised power of 70 megawatts thermal (MWth), and its critical mock-up, the Isis reactor, with a power of 700 kilowatts thermal (kWth), make up Basic Nuclear Installation (BNI) n° 40. They are operated by CEA on the Saclay site, which is also home to 3 other nuclear installations which are either shut down or being decommissioned, as well as 3 installations in operation.

The Osiris reactor was primarily intended for technological irradiation of structural materials and fuels for various power reactor technologies. Another of its functions was to produce radionuclides for medical purposes. The Isis reactor was essentially used to perform physical measurments (neutronic, gamma spectrometry, gamma heating…) and for training purposes. These two reactors were authorised by the Decree of 8 June 1965 and commissioned in 1966. The Osiris reactor was shut down at the end of 2015, while the Isis reactor was finally shut down in late 2018. The operation of BNI No. 40 has been definitively shut down in March 2019.

Since the shutdown of the reactors and pending decommissioning of the facility, the removal of radioactive and hazardous materials and the decommissioning preparation operations are underway, with an organisation adapted to this new status of the facility. More specifically, the last of the irradiated fuel stored in the facility was removed in the second half of 2021.

The location of the Osiris and Isis reactors on the Saclay site gave access to various services provided by the CEA licensee for the centre as a whole, including the local security unit (FLS) in charge of the response to a fire and supervision of the fire detection systems. The water network used for fire-fighting is also common to the centre as a whole.

1.1.3.10. The gas-cooled reactors being decommissioned: GCR - Saint Laurent des Eaux A1

The gas-cooled reactors (UNGG) A1 and A2 in Saint-Laurent-des-Eaux reactors, currently being decommissioned, constitute basic nuclear installation (BNI) No. 46 and are operated by EDF on the Saint-Laurent-des-Eaux site in the Loir-et-Cher département (41). This site also comprises a storage facility for the graphite sleeves irradiated during operation of reactors A1 and A2, as well as two pressurised water reactors in operation, with a power of 900 MWe each. These installations are also operated by EDF. These first-generation reactors A1 and A2, with a power of 480 MWe and 515 MWe respectively, used natural uranium as the fuel, graphite as the moderator and were cooled by gas ("GCR" reactors). Their final shutdown was declared in 1990 and 1992 respectively. Complete decommissioning of the installation was authorised by the Decree of 18 May 2010.

The Saint-Laurent A reactor pressure vessels are of the "integrated" type, in other words, the exchangers are inside the reactor pressure vessel. Carbon dioxide gas was used to cool the core and transferred its heat to the conventional water-steam system, with the steam then driving the two turbine generators. The Saint-Laurent A reactor pressure vessels are extremely massive and heavily pre-stressed concrete structures, designed to withstand an internal service over-pressure of 30 bar. Within each pressure vessel, the graphite stack generally takes the form of a cylinder 16m in diameter and 10m high. It consists of 41,967 graphite bricks, divided into 4,663 columns for reactor A1 and 35,432 bricks divided into 4,429 columns for reactor A2.

Since the reactors were shut down, fuel has been unloaded and removed, enabling most of the radioactive substances which were present during the operating phase to be removed. More than 99% of the radioactivity has been removed and the residual total activity of each reactor pressure vessel is evaluated at about 2.7×10^{15} Bq, or 2,700 TBq, as at 31 December 2026. This residual activity is primarily linked to the activation of the reactor internal structures which were close to the fuel and the graphite stack during the operating phase. This activity is contained within the reactor pressure vessel, for which dismantling is envisaged in about 2055, and has been significantly reduced - now about 2,000 times less – by comparison with the operating phase. Outside the pressure vessel, complete dismantling of the installations is continuing, in order to achieve a "secure configuration" status of the pressure vessels by the 2035 time-frame, and they will then enter a surveillance phase for about twenty years, pending the start of dismantling work.

In the coming years, the main risks, including the fire risks, are linked to the dismantling work taking place outside the pressure vessels and thus outside the graphite stack.

Some of the installation's fire protection provisions are shared by the site as a whole (drafting, maintaining and implementing the emergency plans and the corresponding response resources, etc.).

The UNGG reactors being dismantled have been included in this report following the recommendations of the TPR board, despite the very limited fire risk.

1.1.4. Approach to development of the NAR for the national selection

The approach adopted by ASN for drafting this report follows a quality approach comprising the report preparation, drafting, verification and approval steps, followed by an evaluation and operating experience feedback collection phase.

For each step in the process, the drafting process presents the input data, the deliverables and those responsible for the step. All the stakeholders, in particular including representatives of the licensees of the selected installations, the ASN special advisers in charge of the installations concerned by the exercise, and fire specialists, are identified as of the beginning of the project and the role of each of them is defined. A coordinator is appointed within ASN to manage the project and the various interfaces between the stakeholders. Discussion meetings are held and a communication plan is also produced to enhance effectiveness and efficiency. A project schedule for the various phases and deliverables is drawn up and exchanged with all the stakeholders. Finally, a project risk chart of the project is drawn up to identify the critical points and propose measures to control them.

1.2. National regulatory framework

1.2.1. National regulatory requirements and standards

The requirements regarding the control of fire risks are regulated by Title III of the Order of 7 February 2012 (BNI order) [4], supplemented by ASN resolution 2014-DC-0417 of 28 January 2014 [5]. These texts stipulate the provisions to be adopted by all BNI licensees with regard to the control of fire risks.

This regulatory framework concerns all BNIs, whether in the design, construction, commissioning, operation, final shutdown, decommissioning phases or, for radioactive waste disposal facilities, in the closure or surveillance phase. It also concerns the equipment and installations located within the perimeter of the BNI and required for its operation.

Pursuant to the general regulations described above, the licensee shall apply the principle of defence in depth to the control of fire risks. The licensee thus implements successive and sufficiently independent levels of defence designed notably to protect or perform the following functions:

- control of nuclear chain reactions;
- evacuation of the thermal power produced by the radioactive substances and nuclear reactions;
- containment of radioactive substances;
- protection of people and the environment against ionising radiation.

With regard to the fire risk, these levels in particular rely on:

- preventing the outbreak of fire;

- detecting and rapidly extinguishing any outbreaks, on the one hand to prevent them leading to a fire and, on the other, to restore a normal operating situation or, failing this, attain then maintain a safe BNI state;
- limiting the intensification and spread of a fire that could not be controlled, in order to:
  - minimise its impact on nuclear safety, and enable a safe state to be reached or maintained in the BNI,
  - allow the management of accident situations resulting from a fire which could not be brought under control, in order to mitigate the consequences for people and the environment.

The licensee shall incorporate the control of fire risks into the safety case. This safety case is produced using a prudent deterministic approach which integrates the technical, organisational and human dimensions, and takes into account all the possible states of the installation, whether permanent or transient. It is presented in the safety report, the content of which is defined by ASN Resolution 2015-DC-0532 [6].

In this safety case, the licensee shall:

- identify the PIC[5] to be protected from the effects of a fire and the related defined requirements;
- determine the provisions for the prevention of fire risks and protection against their effects.

These PIC are designed and installed in the BNI such as to reduce the probability of a fire occurring, ensure that it is detected and mitigate the consequences.

The safety case shall also include probabilistic analyses of accidents and their consequences, unless the licensee demonstrates that this is irrelevant. In practice, the different nuclear power reactor plant series in operation have probabilistic fire risk studies in addition to their deterministic safety cases. These probabilistic studies were introduced during the periodic safety reviews. Regarding the EPR reactor, this probabilistic study was developed by the licensee at the design phase.

The above-mentioned French regulations do not cite any national or international fire protection standard. It is the responsibility of the licensee to demonstrate the soundness of its fire risk control provisions in its baseline safety requirements.

1.2.2. Implementation/Application of international standards and guidance

For a number of years now, ASN's strategy and policies have incorporated the need to transpose the WENRA safety reference levels [8, 9, 10, 11] into the French regulatory framework. This desire on the part of ASN is reflected in its operational guidance documents and the annual action plans of its entities. ASN's ability to transpose the WENRA safety reference levels into the regulations and guides applicable to French installations is assessed via performance indicators which are

[5] Protection Important Component

periodically reviewed by the ASN Director General's office and by the Commission. Progress in the implementation of the safety reference levels in the French regulations is periodically reported to WENRA's ad-hoc working groups. All the safety reference levels from 2014 have been integrated, for both research reactors and power reactors.

The situation regarding the transposition of the WENRA fire safety reference levels, at the date of 3 August 2023 is thus as follows:

Type of installation	Total number of requirements	Number of requirements transposed (Category A)	Number of requirements being transposed (Category B)	Number of requirements not transposed (Category C)
Nuclear power reactors Reference Levels – 2020 - Issue SV [8]	31	13	13	5
Research reactors Reference Levels – 2014 - Issue S [9]	19	19	0	0
Waste and Spent Fuel Storage Safety Reference Levels - Version 2.2, April 2014 – (S-30) – [10]	1	1	0	0
Decommissioning Safety Reference Levels - Version 2.2 April 2015 [11]	-	-	-	-

2. FIRE SAFETY ANALYSIS

2.1. Nuclear power plants

I- TRICASTIN 1 - 900 MWe series – post-4th periodic safety review

I-2.1.1. Types and scope of the fire safety analyses

In accordance with French regulations, the safety analysis report includes the Fire Risks Management Case (DMRI).

The purpose of the DMRI is to confirm that the design, construction and operating provisions made with regard to fire risks are appropriate and defined in compliance with the principle of defence in depth. It is drawn up using a deterministic approach proportionate to the issues involved and different methods are therefore presented for the radiological risks and the non-radiological (conventional) risks.

With regard to the radiological risks, protection against fires guarantees the performance of the fundamental safety functions needed to control the radiological risks (see I-2.1.2). The DMRI is notably based on the principle that a fire postulated in a deterministic manner should not simultaneously disable redundant equipment performing the same safety function.

In addition to the deterministic safety analysis, fire Probabilistic Safety Assessments (PSA) – which provide a more global view of the installation's robustness to a fire – are used in the periodic safety review associated with the fourth ten-yearly outage of the CPY[6] reactors. They include a level 1 fire PSA, which assesses the risk of core melt, and a level 2 fire PSA, which assesses the risks associated with radiological consequences. The CPY fire PSA is carried out for the Tricastin 1 & 2 reference pair of reactors, for all the buildings and all operating states, with core in vessel, in which a fire is liable to generate a thermohydraulic transient. For an assessment of the fuel storage building (BK), the case of the core unloaded into the spent fuel pool is also assessed.

I-2.1.2. Key assumptions and methodologies

Objectives

The safety objective of protection against the "fire" reference internal hazard is to guarantee that there will be no fuel melt in the core and in the spent fuel pool (BK pool) and to limit any radiological releases.

The reference hazard assessments are supplemented by an analysis of the radiological consequences of the hazards.

[6] CPY is the name of the 900 MW reactor series (also called "900 plant series"), which includes the Tricastin reactors.

The safety case is based on control of the fundamental safety functions related to radiological accidents:

- control of reactivity;
- residual heat removal;
- containment of radioactive substances.

The provisions implemented to ensure these three fundamental safety functions ensure the protection of persons and the environment against ionising radiation.

The installation shall be designed in such a way as to ensure that in the reference fire hazard situation, the following are guaranteed:

- emergency shutdown and maintaining in a safe state;
- prevention and mitigation of the radiological consequences of any incident or accident scenarios considered.

Operating state

The fire is postulated as breaking out in normal conditions of plant unit operation, or in long-term post-accident conditions, that is after a time of about 6 to 12 hours. In practice, depending on the accident (see further on for the combined situations considered), this time is sufficient for the backup systems to be in the acquired configuration or to be configurable by local actions.

Scenarios

The reference scenarios consider all the fuels present. They are drafted on a simplified and worst-case basis (one scenario per room or group of rooms depending on the configuration) in the case of sectorisation design studies (PEPSSI method) or exhaustively starting from each potential initial fire source in the case of residual common mode studies (Fire Risk Analyses of the vulnerability analyses). In the light of this worst-case approach, a situation involving two or more simultaneous fires with independent causes and affecting the rooms in the same plant unit or different plant units, is not postulated.

Location of the fire

The fire is postulated to occur inside the installation, in any room of the plant regularly containing or designed to regularly contain combustible materials. The presence of an ignition source is postulated: the initial outbreak of fire is thus supposed to be able to occur whatever the nature, quantity, type and configuration of the combustible masses present.

In addition, the impact of fires outside the buildings, whether on or off the BNI (Basic Nuclear installation), is analysed probabilistically as a hazard. For example:

- fire linked to the transport of hazardous goods on the site;
- road or inland waterway accident;
- neighbouring industrial installations;
- external fire.

Combinations

Moreover, in accordance with the BNI Order, the safety case regarding the fire hazard takes into consideration the plausible combination of this hazard with other trigger events, in particular other internal or external hazards.

EDF does not specifically study the combination of a fire and a reference initiator independent of the fire. However, the fire protection equipment, in post-accident operating conditions, is qualified according to its safety role and the ambient conditions in which it is required to function. The fire-related common mode analyses cover the fire initiating an accident condition.

The deterministic approach to the plausible combinations of hazards consists in considering the combinations of initiating and induced hazards when there is a causal link and in considering any independent combinations.

Owing to the preventive measures, notably with respect to the electrical switchboard anchors, an earthquake is not assumed to be a fire initiator in the safety-classified civil engineering structures. Nonetheless, the fire protection equipment required by the safety case complies with the Operating Basis Earthquake (OBE)[7] requirements in terms of seismic resistance and is confirmed for the Safe Shutdown Earthquake (SSE)[8].

In any case, the fire protection equipments are checked to ensure that should it fail in the event of an earthquake it does not represent a hazard for safety-classified equipment or is not itself damaged by the possible failure of any non-seismic classified equipment.

The availability or non-deterioration of equipment required for fire protection in extreme cold or extreme heat (heatwave) situations is verified.

A causal link is envisaged with the following internal hazards, in that these hazards could cause a fire:

- Internal explosion: the impact of the internal explosion on the fire safety sectorisation items is taken into account;
- Lightning: it should be noted that the design of the safety-classified civil engineering structures contributes to protection against lightning.

[7] The operating basis earthcake corresponds to half of the sizing spectrum. The Design Spectrum(s) (DSS) is a standardised response spectra used in the seismic design of civil engineering structures and equipment. There may be several design spectra for an installation, for example, one for the generic part of the installation (repeatable over a period of time) and one for the site-specific part.

[8] Safe Shutdown Earthquake (SSE): hypothetical earthquake producing an intensity on the site one degree greater (on the MSK scale) than that of the corresponding Maximum Historically Probable Earthquake (SMHV). The SMHV is the earthquake likely to produce the greatest effects on the site in terms of macroseismic intensity, and is defined by an analysis of historical observations, covering a period of around 1,000 years, and of geological and seismotectonic data for the region around the site. The SSE is the safety level of the seismic stress in the reference domain: a structure or component with a seismic resistance requirement must be capable of performing its function after an SSE. To achieve this, they are generally sized and qualified to the DSS.

Analysis method

The safety approach adopted consists in demonstrating that a fire occurring inside the BNI does not lead to the simultaneous unavailability of redundant equipment performing a safety function needed for safe shutdown and for maintaining in this state and does not compromise the design basis operating conditions.

The following should also be checked:

- During and after the fire, the licensee's ability to access equipment for which local operation is required in order to reach and maintain a safe state;
- That the radiological consequences of the fire hazard comply with the limits associated with the design-basis operating conditions corresponding to the frequency of occurrence equivalent to that of the worst-case scenario adopted.

For a given room, the reference fire is that which takes account of all the combustible items in this room and with the most serious consequences in terms of duration and severity.

The design of the fire risk protection is based on levels of defence in depth explained in Chapter 1.

The provisions concerning the fourth level of defence in depth are contained in the On-Site Emergency Plan.

The subdivision of buildings classified in fire safety sectors and zones was established by the PAI (Fire Action Plan [1999-2006]) and is re-evaluated at each periodic safety review. The fire sectors (SFS) (see A-I-3.3.1.2) are entirely closed fire volumes whereas the fire zones (ZFS) can have openings related to structural constraints, which are compensated for by demonstration of non-propagation and the lack of common modes between adjacent fire zones.

The following sectorisation analyses were carried out for each building studied:

a. Risk evaluation: calculation of the fire load density and the significant fire duration (DsdF) per safety volume and per room;
b. Demonstration of the effectiveness of the Fire Safety Zones;
c. Analysis of vulnerability to common cause failures.

The fire safety sectorisation analysis is based on deterministic hypotheses. The initiating fire is supposed to exist whatever the nature, quantity, type and configuration of the combustible masses present.

The risk evaluation is performed taking account of the following:

- the heat load value per room (fixed equipment and permanent storage potential) and then per level for a given fire volume;
- the potential heat load transfers between rooms;
- the identification, location, concentration and nature of the combustible masses;
- the fire propagation risk evaluation;
- the building structural elements that could act as hot gas and smoke screens or containments.

The heat load and potential heat load transfer values are used to determine the reference theoretical fire duration (DsdF) based on a fire resistance curve[9], with deduction of the required degree of fire resistance for the walls on the sectorisation boundary (walls, doors) as per curve ISO834.

The identification, location, concentration and nature of the combustible masses are taken into account to characterise the fires to be studied.

The following criteria are used:

- room with generalised fire potential (PFG): a room is said to be PFG when a large amount of combustible mass, concentrated in it, leads the studies to consider a generalised spread of fire throughout the room (possible propagation to other rooms in the fire volume);
- room with localised fire potential (PFL): a room is said to be PFL when a significant combustible mass, concentrated in it, leads the studies to consider a localised fire. This type of fire cannot lead to generalised spread throughout the room and cannot propagate to other rooms in the fire volume;
- room with no localised fire potential (non-PFL): a room is said to have no localised fire potential if the concentration of combustible masses is not sufficient for the studies to consider a developed fire.

These criteria are established using principles similar to those expressed in the Annex A of the standard ISO 18195.

In the case of fire zones, the identified spread vectors are justified. The spread vectors may be direct, via openings in walls, or indirect, through the ventilation ducts. For each ZFS the impact on the adjacent zones, non-partitioned volumes and vice-versa is studied.

The envisaged fire spread modes are conduction, convection and radiation. Flaming flows or spatter are also considered whenever plausible.

Vulnerability analysis

The functional failure of all the equipment in a fire safety sector or a fire safety zone where the fire breaks out is studied through the vulnerability analysis. This analysis (study of fire common modes) aims to demonstrate that the fire does not generate confirmed unacceptable common modes within the fire safety volumes or between fire safety zones. This is a detailed verification study based on the fire sectorisation and on the justification of non-propagation of a fire between fire zones.

The vulnerability analysis is performed in all classified buildings, with verification of the following criteria:

- safety-classified mechanical equipment or electrical connections belonging to two redundant channels of the same system performing a safety function (criterion a);

[9] Normalised thermal approach taken from RCC-I 97 – RFS 1.4a (85)

- safety-classified mechanical equipment or electrical connections belonging to one channel of a system performing a safety function, on the one hand, to systems required for operation of the redundant channel, on the other (criterion b);
- electrical connections which do not fall into the previous categories but which are supplied by redundant electrical switchboards and for which the number is such that the selectivity of the protections provided by these switchboards is liable to be compromised (criterion c);
- equipment which, in the event of a failure as a result of fire, is liable to lead to an accident or incident operating condition and equipment required to perform a safety function needed to process the event concerned (criterion d).

Protection-important components and activities (PIC and PIA)

The DMRI includes the identification of the protection important components (PIC) and activities (PIA) to be protected from the fire, along with their associated requirements. The studies make a distinction between two main families of safety important elements:

- The potential "targets" of the fire are all the PICs (PIC contributing directly to control of the radiological safety functions), corresponding to all the elements classified as safety-important and to be protected from the fire. A PICs is to be protected from fire if needed for management of the studied scenario associated with the fire and if at least one of its defined requirements, stipulated in this scenario, is liable not to be met owing to this fire;
- The equipment participating directly in safety sectorisation (SFS and ZFS see A-I-3.3.1.2– e.g.: caulking, doors, valves, seals, cable duct passages, flame traps) or in the justification of its design (e.g.: extinguishing systems installed for this purpose), along with all the components and systems contributing to the additional protection of the elements to be protected (cable-wrapping, electrical boxes, etc.).

PIA status is given to the design, construction or operating activities which, if performed incorrectly, would directly compromise the DMRI. The PIA are associated with heightened technical inspection and traceability requirements.

Protected routes

In the event of a fire, protected routes shall allow access to the locations needed to bring the installation to and maintain it in a safe state. The studies define the routes, notably the demarcated fire volumes, to be taken by trained personnel, so that – while remaining protected from the fire – they can perform the reactor control actions needed to achieve and/or maintain the installation's safe state.

Additional studies performed as part of the 4th Periodic Safety Review of the 900 MW plant series:

Note: *In the rest of this text, the notation RP4 900 shall be used to refer to the fourth periodic safety review of the 900 MWe reactors. Similarly, the notation RPn 900/1300/N4 corresponds to the nth safety review of the plant series in question (900 MWe, 1300 MWe or N4).*

New method for Justification of sectorisation

Based on the EPRESSI method (method for the Evaluation of the Real Performance of Fire Sectorisation Elements – see ISO 18195) applied to the EPR, EDF developed a new method called PEPSSI (Principle of Evaluation for the Sufficiency of Fire Sectorisation Elements) to check the robustness of fire safety volume sectorisation elements, appropriate to the NPP fleet in operation.

This method consists in comparing the fire resistance performance of the sectorisation elements (built up from qualification tests and other tangible data enabling them to be characterised) in the face of the reference fire determined for each room by calculation (zone or field code).

The studies to verify the robustness of the design of the sectorisation elements were in particular carried out on the cabling common mode protections of the electrical building of the CPY plant series. They conclude that the installation is robust provided that the protections are replaced on certain plant units, including Tricastin 1, by systems with a higher fire rating.

Following these studies, EDF is therefore implementing additional protection provisions, for example: cable protections, replacement or addition of fire doors, reinforcement of Fire sectorisation elements in the pump house, fire protection reinforcement of “passive protection” type sectorisation elements. EDF is also implementing operational measures to reduce the heat load in certain rooms identified as rooms with safety implications.

Effects induced by smoke from fire

The R&D carried out by EDF since the 2000s on the complex subject of smoke-induced malfunctions (development of the MAFFé mock-up) led to the following industrial choices:

- inclusion in the vulnerability analysis of the effects induced by smoke from fire on the most sensitive equipment (electronic equipment) by adopting criteria (temperature, smoke zone, exposure duration) reflecting the possibility of the deposition of soot;
- this malfunction criterion is also introduced into the probabilistic safety assessments;
- EDF is continuing its R&D work on this topic in collaboration with IRSN.

For the Tricastin site, the studies to take account of the effects of smoke conclude that the installation is robust to these effects or enable the necessary equipment modifications to be identified and carried out.

Pressure effects induced by the fire

An analysis of the pressure rise phenomenon in the rooms in the event of a fire and its potential effect on the sectorisation elements (fire doors) was performed on the CPY plant series.

The following principles were adopted for analysis of the effects of pressure in the event of a fire:

- identification of the configurations liable to lead to sectorisation breaks;
- calculation of the pressure levels covering the most unfavourable conditions that could be encountered as a result of a plausible fire.

For the Tricastin site, the RP4-900 studies to take account of the pressure rise phenomenon in the event of a fire conclude that the installation is robust to these effects.

Re-ignition of unburned gases in the ventilation ducts

The sectorisation studies were supplemented by an analysis of the risk of re-ignition of unburned gases by fresh gases in the ventilation ducts.

The robustness of the installation to this risk is primarily based on the presence of fire dampers at the perimeter of the safety fire zones. For the fire safety zones not equipped with fire dampers, the safety case is based either on additional fire risk assessments based - for a few situations - on fire models demonstrating that there is no risk of the propagation of unburned gases through the ventilation ducts, or on functional analyses demonstrating that there is no impact on safety.

The studies of the implementation of the methodology for taking account of the risk of re-ignition of unburned gases in the ventilation ducts concluded that the existing provisions are robust. No modification is required for the 900 MWe plant series.

Impact of a fire on systems carrying hydrogenated fluids (flame jet)

In the event of a fire leading to the loss of containment of systems carrying hydrogenated fluids, the sectorisation studies were supplemented by the addition of heat loads and an assessment of the risk of creating a flaming jet of hydrogen.

Following these studies, EDF is implementing a modification on the 900 MWe plant series, wich is the automatic closure of the H_2 isolation valve of the SGZ system (H_2 supply system) if a fire is detected by the JDT system (fire detection system) in certain premises.

Aggravating factors (WENRA)

For each reference hazard, a sensitivity study has been conducted, considering the plausible combinations with an aggravating factor applied to the active equipment, such as to prevent the hazard or limit its consequences (Active Hazard Equipment). This analysis confirmed that despite the inclusion of a failure of an equipment item considered in the hazard assessment, the release criteria defined for the category 4 design-basis accidents are met.

In accordance with the general approach, the application of an aggravating factor in the fire studies led to failure of the following being considered:

- Fire dampers and fire door control mechanisms slaved to the fire detection system: The aggravating factor studies confirmed the absence of common modes on the equipment of systems subject to application of the Single Failure Criterion (CDU) and their support systems.
- Active equipment of fixed extinguishing systems: Only the nuclear auxiliary buildings, the reactor and diesel buildings contain fixed pre-action “in-air” sprinkler systems, for which failure is postulated. The existence of functional redundancies associated with manual activation of the extinguishing systems (with application of the defined operator intervention times) guarantees the availability of the functions to be protected from the effects of the fire if a fire were to break out in the rooms concerned.

- Fire-fighting pumps: the consideration of an aggravating factor on a pump does not compromise the system's ability to provide the quantity of water required for the worst-case fire on the nuclear island, owing to the interconnections between plant units and the respective electrical back-ups (electricity generating sets) on the 2 pumps allocated to each A/B train.

No modification is required for the 900 MWe plant series.

In addition, and in response to the ASN prescriptions during *RP4 900*, an analysis approach was implemented for the particular case of the failure of passive equipment for the fire studies. This approach first of all targets fire volumes "with major safety implications" which were identified as requiring heightened vigilance owing to their importance for safety. Similarly, sectorisation elements "with major safety implications" are identified, owing to the importance of the separation they provide. These lists were drawn up on the basis of PSA and/or deterministic assessments:

- Passive sectorisation equipment: Application of the approach for the particular case of failure of non-static passive equipment led to certain fire doors, not slaved to the fire detection systems, being considered as having major safety implications. For them, EDF installs "door open" alarms design to ensure that they are kept closed. In addition, other passive sectorisation elements have been identified as having safety implications. This equipment will all be dealt with during operation by giving it a maximum importance level that is as sectorisation element situated between opposite trains.
- Fixed extinguishing systems: For rooms with major safety implications, the non-inclusion of fixed extinguishing systems (including "passive" sprinkler systems) allowed identification of those for which sectorisation alone was insufficient to prevent the spread of a fire. If necessary, a modification is carried out to ensure that sectorisation is robust without considering the fixed extinguishing system.

Operator intervention times

The hazard studies, including the fire studies, take account of the operator intervention times similar to those of the design-basis accident studies, that is:

- an intervention time for the operator in the control room of 20 minutes;
- local intervention times of 25 minutes for actions in the electrical building or the immediate vicinity, and 35 minutes for actions in the other buildings.

With regard to sensitivity, the following studies were carried out:

- intervention time by operator in control room of 30 minutes in order to check that there is no "cliff-edge effect";
- operator intervention time of 1h locally on the configurations identified as the most sensitive.

Analysis of the manual actions carried out in the control room or locally identified no "cliff-edge effect" linked to the consideration of these operator intervention times.

An equipment modification designed to automate sprinkling of the RCV rooms enables these rooms to be excluded from the analysis.

Other common mode studies

EDF reassessed the consequences of a fire in the rooms producing chilled water for the electrical building (DEL), following replacement of the chillers, in the light of new data such as an improved understanding of the dynamics of temperature rises in the electrical rooms further to DEL losses. Following these studies, EDF is implementing a modification aimed at circumventing the DEL loss by fire common mode. This modification only concerns the odd plant units. It consists in protecting the DEL pump train B power supply cable by wrapping.

The acceptability of the radiological consequences of hazards of internal origin, including fire, was determined and the conclusions of the studies were able to demonstrate the acceptability of the radiological consequences of the hazards with regard to the targeted objectives of the *RP4 900*.

Fire PSA

The methodology chosen for the fire PSA on the CPY plant series is inspired by reference international practices and the state of the art (NUREG CR-6850) and is implemented in several successive phases targeting the detailed analyses on the most sensitive fire volumes.

<u>Compartmentation and scope of coverage (Phase 0)</u>

The CPY fire PSA allows:

- an evaluation of the risk of core melt (RFC) following a fire (on the basis of a “BR model”) for the reactor at power or shut down states (level 1 PSA);
- an evaluation of the risk of uncovering of the fuel present in the spent fuel pool (on the basis of a “BK model”) for the reactor at power or shut down states (level 1 PSA);
- an evaluation of the risk of releases to atmosphere in the event of an onset of an accident with core melt following a fire (level 2 PSA).

The scope of the study covers the nuclear island and the conventional island of the Tricastin NPP units 1 and 2.

<u>Qualitative selection of fire volumes (Phase 1)</u>

The functional impact of a fire scenario on the plant unit studied is determined by identifying the potentially induced initiators and the equipment rendered unavailable by the hazard.

<u>Quantitative selection of fire volumes (Phase 2)</u>

The aim of the second phase is to perform an initial estimate of the risk of core melt and identify the primary fire volumes requiring an in-depth analysis.

<u>Detailed analysis of fire scenarios (Phase 3)</u>

The aim of this phase is to refine the quantification of the risk of core melt induced by a fire for the fire volumes selected as preponderant during phase 2, characterising the nature of the sources of an incipient fire, the physical spread of the fire, and the fire detection and extinguishing systems (automatic and manual).

The analysis is supplemented by multi-volume scenarios taking account of the probability of failure of sectorisation (fire dampers and doors) between two adjacent fire volumes of the Electrical Building.

The overall risk of core melt (RFC) associated with the fire PSA is then the sum of the worst-case estimated RFCs for the fire volumes quantified in phase 2 and the more realistic RFC of the fire volumes quantified in phase 3.

<u>Sensitivity studies and summary of results (Phase 4)</u>

This final phase of the fire PSA consists in:

- identifying the uncertainties affecting the measurements of the contributions to the fire risk;
- evaluating and analysing the impact of these uncertainties on the quantifications of the contributions to the risk.

The Fire PSA highlights the preponderant contribution of the Electrical Building to the risk of core melt following a fire, when the reactor is at power.

The family of preponderant scenarios revealed by the Fire 900 PSA, corresponds to an incipient fire constituting a hazard for the instrumentation and control (I&C) of the Pressuriser Relief Valves (SDP) triggering unwanted opening of the SEBIM valve tandems. A modification deployed during the *RP4 900* counters this risk of unwanted opening of the SDP following a fire in the RRA (residual heat removal system) not connected states.

In addition the sensitive fire volumes of the Electrical Building are given particular attention owing to the safety implications of these rooms in operation.

The multi-volume fire PSA revealed the importance of sectorisation and fire detection for managing the fire and controlling its spread.

The risk of core melt estimated for this hazard is about 10^{-6}/reactor.year.

Role of on-site and off-site fire-fighting

Fire-fighting is based on an organisation capable of carrying out the actions needed to respond to the fire, pending the arrival of the off-site emergency resources. It is not however included in the safety case.

Additional studies and sensitivities

The codes are used within their validity range (Scientific Computing Tool). Management of uncertainty for the deterministic numerical studies is generally based on the use of penalizinghypotheses.

Additional studies are carried out on the passive protections required by safety sectorisation. They show that these protections at least offer a positive margin of 10 minutes with respect to the Significant Fire Duration of the room in which they are located.

I-2.1.3. Fire phenomena analyses: overview of models, data and consequences

The numerical studies of a compartment fire (PEPSSI studies, smoke studies, pressure effects) are primarily based on the MAGIC zones code. This code developed for the fire domain by EDF is an internationally recognised qualified code backed up by an extensive experimental validation dossier.

For the studies not covered by the validity range of the MAGIC code, the FDS (Fire Dynamics Simulator) code is occasionally used. This field code is a globally recognised international reference developed by the NIST laboratories (USA).

These codes can be used to assess the thermal constraints (conduction, convection, radiation) and the pressure effects on the sensitive sectorisation equipment (doors). They provide information on the encroachment by and characteristics of the smoke (opacity, soot levels, oxygen or unburned gases concentrations, etc.).

For the environmental impact assessments concerning fire and the domino effects studies related to outdoor fires, EDF uses different codes to model the thermal effects by radiation (DOMINO) and specific codes for the airborne radiological consequences (codes developed in-house at EDF or by IRSN, such as SYMBIOSE). The liquid-borne impacts are based on the CALVIN method for estimating effluents linked to fire-fighting water.

I-2.1.4. Main results / dominant events (licensee´s experience)

Each safety-classified building is broken down into fire safety volumes which guarantee that the fire does not spread and that there are no common modes.

The use of fire protections informed by a two-fold deterministic and probabilistic approach, enables the magnitude of the level of the core melt risk to be made comparable to that of the latest generation reactors (EPR).

On the occasion of the latest review (RP4 900), EDF reinforced its safety requirements and took advantage of progress in modelling in order to improve how fire-related phenomena are taken into account, notably for verification of the correct design and sizing of sectorisation.

Without changing the fire protection principles, various improvements resulting from these analyses were made to the installations in order to reinforce this protection. For more details, see I-2.1.2.

I-2.1.5. Periodic review and management of changes

I-2.1.5.1. Overview of actions

From the outset, the design of the 900 MWe plant units includes protection against fire risks. The implementation of the Fire Action Plan [1999 - 2006] has already led EDF to significantly reinforce fire prevention, detection and fighting on all the plant units, in both hardware and organisational terms.

Fire is the subject of an analysis regularly updated on the basis of OEF[10], as part of the continuous improvement approach. A process to analyse modifications on the topic of fire (sectorisation, heat loads, etc.) creates a link with the DMRI.

Modifications were thus made on the occasion of the *RP3 900*, notably following the existing margins evaluation studies (additional margin of 10 minutes) for the sizing of the protection against cabling common modes and the minimum operating resources with regard to their fire resistance.

Review approach

In accordance with Article L.593-18 of the French Environment Code, EDF carries out periodic safety reviews of its reactors every ten years, to "assess the situation of the installation with respect to the rules applicable to it and to update the assessment of the risks or detrimental effects that the installation presents for the interests mentioned in article L.593-1, taking into account more specifically the condition of the installation, acquired operating experience, advances in knowledge and changes in the rules applicable to similar installations".

The periodic safety review approach is thus based on taking account of the following:

- lessons learned from national and international experience feedback;
- the results of Research and Development (R&D) studies and progress made possible by improved knowledge and technologies;
- adaptations and changes studied to comply with more ambitious objectives, aiming notably to reinforce risk management.

The periodic safety review comprises a "generic" phase common to all the plant units of the Series (e.g.: 900 MWe-CPY). This phase takes advantage of the standardisation of the reactors in the same plant series. The studies performed during the "generic" phase are thus common to all the reactors of the plant series.

The results of the generic phase of the RP4 900 MWe were examined by the Advisory Committee of experts for reactors (2020).

After consultation of the public, ASN then issued the applicable prescriptions in February 2021 in order to regulate the continued operation of the reactors of the 900 MWe plant series.

The Review Concluding Report for the Tricastin 1 first-off reactor presents the main lessons learned from all the investigations carried out as part of the generic phase of this periodic safety review and the generic prescriptions.

I-2.1.5.2. Implementation status of modifications/changes

EDF's industrial programme involves work on its installations in three phases, owing to the scale of the works and the resulting impacts on people and the organisations in place on the nuclear sites:

[10] OEF : Operational Experience Feedback

Phase A corresponds to the modifications made before (Unit Operating) or during Ten-yearly type outages (VD), the duration of which allows the deployment of hardware modifications with large-scale works, as well as the associated RGE (general operating rules) changes.

Phase B enables the deployment of hardware and intellectual modifications to be completed. The deployment of these modifications is scheduled for no later than 5 years after submission of the Review Concluding Report for each reactor concerned.

The "Supplements" phase only concerns reactors for which the beginning of outage VD4 comes before 31/12/2021. It allows the deployment of certain modifications resulting from the examination of the fourth periodic safety review by ASN, which, given their nature (such as the need to qualify a new item of equipment for very harsh ambient conditions), require a preparatory period of about 5 years. For the reactors concerned, the deployment of these modifications is scheduled for no later than 6 years after submission of the Review Concluding Report. For the other reactors, these modifications are deployed during the above-mentioned 2 phases.

The major modifications concerning fire protection of the RCV (chemical and volume control system) pump houses and the overall renovation of the fire detection system have been performed in full on Tricastin NPP units 1 and 2.

Modifications will be deployed under phase B of the *RP4 900* modifications on Tricastin unit 1, for example: keeping the fire doors closed, handling cabling common modes in the BL.

I-2.1.6. Licensee's experience of fire safety analyses

I-2.1.6.1. Overview of strengths and weaknesses identified

EDF's fire protection design approach is complete and extensive: deterministic with four levels of defence in depth, probabilistic, incorporating unlikely failures or situations, and is periodically improved on the occasion of the ten-yearly periodic safety reviews. It is based on proven standards or codes.

It is reflected in the operations baseline requirements, which for example comprise fire protection equipment availability requirements.

Significant changes were introduced on the occasion of the *RP4 900*, notably with the improvement of how the effects of fire are taken into account in the deterministic studies and the introduction of the WENRA 2014 reference levels (aggravating factor, operator intervention time). The studies carried out during this review and the lessons learned from them led to modifications, most of which were made on the occasion of the 4th ten-yearly outage of the TRI 1 reactor. The balance are to be completed according to the schedule presented in § I-2.1.5.2.

These studies were able to confirm the robustness of the installation with regard to the WENRA reference levels and, as applicable, to identify the modifications needed in order to meet the safety requirements linked to protection against the fire risk.

EDF incorporated non-radiological risks into the Fire Risk Management Case. The objective of fire protection is to guarantee that the non-radiological consequences of a fire are not liable to prejudice the interests to be protected mentioned in Article L 593-1 of the Environment Code (public health and safety, protection of nature and the environment). The approach implemented in this respect is based on the methodologies and practices taken from the Installations Classified for Protection of the Environment (including "Seveso" installations). It consists in evaluating the potential impact of a fire on the basis of the inventory of hazardous substance and their potential effects on the public or the environment and, in the case of unacceptable consequences, in justifying the measures to reduce the probability of occurrence and/or the effects of these accidents in order to make them acceptable.

Apart from the objectives presented in the above paragraph, fire protection also aims to ensure the safety of people, limit the spread of the fire and facilitate access by the emergency services in the event of a fire, in particular pursuant to the regulations concerning occupational safety.

I-2.1.6.2. Lessons learned from events, reviews, fire safety related missions, etc.

In its 2020 report, the EDF General Inspector for Nuclear Safety and Radiation Protection stresses the fact that the design has regularly progressed: more detailed evaluations of the equipment heat loads, improvements to the fire doors and plugging materials, and more complete modelling of the effects of a fire (effects induced by smoke and pressure, propagation by unburned gases, etc.). Considerable work is being carried out by EDF R&D in fields related to fire.

The ongoing fire R&D project is ambitious and involves high-level experts. It notably aims to assess the effects of pressure as a result of fires, the production and impact of soot on equipment, the physics of confined fires, etc. It has significant resources and is developing high-level modelling. It is based on test resources at various scales (full-scale material, components and premises).

EDF has thus developed recognised numerical codes: Magic, to characterise and model fires, Saturne, used in addition for large volumes and complex geometries. The Ignis experimental facility, which was commissioned in 2021, is used for full-scale tests. There are also many collaborative programmes with other research centres.

EDF is or has been a stakeholder in shared research programmes such as the OECD's PRISME (IRSN laboratory in Cadarache) or FAIR projects as well as the OECD's HEAF project (NRC).

In collaboration with IRSN, EDF is a participant in OECD's FIRE operating experience feedback programme.

EDF has taken on-board the lessons learned from the earthquake-induced fire at Kashiwasaki-Kariwa in 2007. The safety analysis carried out on the power transformer fires concluded that even without the planned extinguishing resources, a fire did not lead to any safety consequences.

I-2.1.7. Regulator's assessment and conclusions on fire safety analyses

I-2.1.7.1. Overview of strengths and weaknesses identified by the regulator

ASN considers that having probabilistic safety studies specific to fire is a positive point, enabling the rooms or equipment with the greatest fire safety implications to be better identified. For example, the work to identify major fire risk fire sectors, which alone account for nearly 80% of the core melt risk due to fire, is an improvement which enables EDF to take reinforced operational measures in these premises.

I-2.1.7.2. Lessons learned from inspection and assessment as part of the regulatory oversight

The periodic safety reviews enable progress to be made in controlling fire-related risks. It is notably on these occasions, rather than during inspections, that the fire analysis part is dealt with. All the additional studies performed during RP4-900 improve safety, even if it should be noted that some of these studies have not yet been examined by ASN.

On the other hand, inspections may cover compliance with the hypotheses used in the studies and in the DMRI, notably with regard to the heat load actually present in the installations, which shows the difficulties the licensee sometimes has with complying with these values (see Chapter 3).

I-2.1.7.3. Conclusions drawn on the adequacy of the licensee's fire safety analyses

On the whole, ASN has a positive view of the incorporation of the DMRI into the safety case and of the carriying out of additional studies in RP4-900.

II- 1300 MWe & N4 series

II-1 Differences of the fire safety analyses for 1300 MWe & N4 series

The design of the plant units of the N4 plant series included application of a specific code for protection against fire-related risks (RCC-I 97). The 1300 MWe plant series for its part was the subject of a Fire Action Plan (PAI) which corresponds to the application of this code to the existing NPPs (Fire Directives).

Over and above the general objectives applicable to all the hazards considered during the *RP2 N4* and *RP3 1300*, the goal of improving the safety requirements targeted by EDF for the fire-related risks concerns the verification of the correct design of the sectorisation. The justification of the design of the sectorisation elements for the VD2 N4 and VD3 1300 status is based on the PAI approach. Nonetheless, a 10-minute margin with respect to the significant fire duration calculated with the standardised thermal approach (as per RRC-I-97) was verified on the cable protection fire-break elements and the minimum equipment for operation and cabling common modes.

In addition to the sectorisation studies, an analysis of the pressure rise phenomenon in the rooms in the event of a fire and its potential effect on the sectorisation elements was performed on the 1300 MWe and N4 plant series.

The deterministic approach is supplemented by a probabilistic approach which provides a more overall evaluation of the robustness of the installation to fire: Level 1 Fire PSAs (*RP3 1300* and *RP2 N4*) were carried out to assess the risks of core melt following a fire.

EDF is continuing its R&D work on the topic of the effects of smoke. At the *RP2 N4* and *RP3 1300* stage, the issue of the effects of smoke was incorporated into the fire PSA studies through the adoption of a criterion reflecting the presence of soot on the most sensitive equipment (electronic equipment).

The sectorisation studies were supplemented by an analysis of the risk of re-ignition of unburned gases by fresh gases in the ventilation ducts.

II-2 EDF' assessment and conclusions on the fire safety analyses for 1300 MWe & N4 series

RP3 1300

The studies were carried out on the passive protections required for safety sectorisation. They show that these protections at least offer a positive margin of 10 minutes with respect to the Significant Fire Duration (DSdF) of the room in which they are located, with the exception of a fire-break chamber in the RB of the reactors of train P4[3]. This will therefore be reinforced in order to increase its fire resistance duration and comply with the objective in terms of margin. In addition, the PEPSSI method (see I-2.1.2) will be deployed during RP4 1300.

The results of all the "pressure effects" studies confirm that there are no risks linked to the effects of pressure in the event of a fire in the fire volumes identified as being a potential risk on the 1300 MWe reactors. However, during the RP4 1300 periodic safety review, EDF will extend the studies concerning pressure effects following a fire to rooms equipped with fixed sprinkler systems, assuming the worst-case situation in which they are inoperative, either as a result of decoupling or as a result of an aggravating factor.

The studies performed during *RP4 1300* will be based on those of the RP4 900 (see I-2.1.2) and supplemented with respect to certain aspects such as extension of the studies of the effects of smoke to equipment other than PCBs or the sensitivity to failure of sprinklers in rooms with major safety implications.

RP2 N4

With regard to the verification of the correct sizing of the fire sectorisation and as the study revealed a 10-minute margin for each of the protections identified on the plant units of the N4 plant series, the PEPSSI method (see I-2.1.2) will be deployed during *RP3 N4*.

The studies on implementation of the methodology to take account of the fire-induced pressure rise phenomenon concluded that the sectorisation was robust and that there was thus no risk.

The robustness of the installation with regard to the re-ignition of unburned gases in the ventilation ducts is primarily based on the presence of fire dampers at the perimeter of the fire safety zones. For the N4 plant series, the fire dampers are directly slaved to the fire detection system. Consequently, in the event of a fire, rapid closure of the fire dampers means that the risk of re-ignition of the unburned gases in the ventilation ducts becomes negligible.

In short, the studies carried out confirmed the robustness of the installations of the N4 plant series to fire, and it also enjoys a more recent design than that of the 900 / 1300 MWe plant series.

The Fire PSA highlighted the preponderant contribution of the electrical building (BL) to the risk of core melt following a fire, when the reactor is at power. In certain situations, a fire in the electrical building (BL) could lead to the loss of electrical train A and the off-site electrical power supplies.

The family of preponderant scenarios revealed by the N4 Fire PSA, corresponds to an incipient fire constituting a hazard for the I&C of the Pressuriser relief valves triggering unwanted opening of the SEBIM valve tandems.

A hardware modification deployed during the *RP2 N4* counters this risk of unwanted opening of the Pressuriser relieve valves following a fire in the RRA not connected states.

The risk of core melt associated with a fire hazard is about 10^{-5} / reactor.year.

The complete convergence of the study rules for the *RP4 900* (see I-2.1.2) is scheduling during the *RP4 1300* MWe and the *RP3 N4*, which have now been started. An update of the PSAs following the modifications arising from the reviews is also being incorporated.

II-3 Regulator's assessment and conclusions on fire safety analyses for 1300 MWe & N4 series

ASN ensures that the improvements made during the *RP4 900* are correctly taken into account in the subsequent periodic safety reviews for the other plant series of the fleet, that is *RP4 1300* and *RP3 N4*. The studies performed during *RP4 900* are thus reproduced during these reviews, taking account where applicable of the results of the *RP4 900* examination and ASN will be vigilant in ensuring that any new knowledge arising from OEF is indeed taken into account.

III- EPR

III-1 Differences of the fire protection of 1300 MWe & N4 series

Hypotheses and methodologies

In accordance with regulations, the safety analysis report for the Flamanville 3 EPR includes the Fire Risks Management case (DMRI). The objectives of this DMRI are identical to those described in §I-2.1.1. Just as for the NPP fleet in operation, the DMRI for the Flamanville 3 EPR is based on a deterministic approach.

Generally speaking, the studies carried out on the Flamanville 3 EPR reactor used more recent baseline requirements than those of the previous plant series, with the *RP4 900* being extensively based on them. The notions of aggravating factor and justifications by calculation were applied as of the design stage.

The main differences concerning the hypotheses and methodologies used are as follows:

a. The postulated event and dependent fire

The fire protection measures shall be designed so that in the event of a fire caused by an external or internal hazard, the safety requirements are met. More specifically, an incipient fire is postulated in the event of a failure of rotating machines containing combustible fluids (e.g.: lubrication). Fire is envisaged as a probable consequence: of a transient; of a reference incident or accident; of a multiple failures scenario; or a severe accident, owing to the potential release of hydrogen inside the containment. Measures needed for controlling the hydrogen, for the design of the containment and the equipment needed to prevent the potential combustion of H_2 or prevent its effects, are defined.

b. The EPRESSI methodology

The use of the EPRESSI methodology (Evaluation of the Real Performance of Fire Sectorisation Elements – see ISO 18195) is able to check the robustness of the fire sectors to the reference fire. This method is based on an approach involving both the realistic growth of a fire in a semi-confined environment and the actual performance of the sectorisation equipment.

c. Fire Risk Analyses (ARI)

Step 3 of the vulnerability analysis (ARI – Fire Risk Analysis) for the Flamanville 3 EPR reactor is based on an analysis using a more realistic calculation of the behaviour of a fire and of equipment malfunctions (MAGIC). These ARI are performed outside the BR on the basis of a specific methodology taking account of numerous parameters such as the nature of the fuel, the geographical situation of the equipment in the room, the heat load concentration, the presence of initiating fires or propagating fires, the equipment malfunction temperature, etc.

d. Studies of non-dispersible loads

In addition to the EPRESSI studies, fire risk analyses are performed to demonstrate that certain specific heat loads, not liable to generate an incipient fire themselves, will not become dispersed in any fire occurring nearby.

e. The vulnerability analysis and identification of common modes

On the Flamanville 3 EPR reactor, the safety case shall be made for each internal hazard, assuming that all the unprotected equipment items are lost, considering a single aggravating factor and the first operator actions according to the same rules as for the transients and reference incidents and accidents. The analysis shall take account:

1. Of the single failure, applied deterministically in the analysis of the scenarios in which an internal hazard is the initiator, whether or not it triggers an event (such as a reference transient, incident or accident), and in the analysis of the internal hazards following reference transients, incidents or accidents.
2. Preventive maintenance of systems, according to the preventive maintenance programme.
3. That a manual action from the control room can be carried out no earlier than 30 minutes after the first significant information received by the operator. For a local manual action, that is outside the control room, this intervention time is increased to one hour after the first significant information.

In addition to the approach presented in §I-2.1.2, two additional criteria are analysed in order to study the combinations between an independent fire and a reference initiator independent of the fire or multiple failure situations or a severe accident:

a) The equipment involved in the study of a reference transient, incident and accident as of the controlled state located in the same fire safety volume as the equipment for which failure is postulated with respect to the single aggravating factor (criterion e).
b) The equipment required to maintain the final state of a multiple failure accident after 15 days, or prevent large-scale releases for severe accidents (criterion f).

Criterion c is also analysed differently. The common mode analyses are not carried out on a case-by-case basis but generically through analysis of the architecture of the distribution and I&C, the equipment used, the cable installation rules, the failure modes of the electrical connections and the insulation properties of the circuits.

f. H_2 singularity

Fire risk analyses are performed on the Nuclear Island (IN) in order to check that a fire is not liable to generate leaks on the lines carrying hydrogenated effluents (which could create jets of flame). These studies rule out the risk of generating a jet of flame in all the structures of the IN.

The fire studies carried out on the conventional island and the pump house demonstrated that the fire hazard leading to flaming leaks on lines carrying hydrogenated effluents generates no common modes.

1. Phenomenological analyses

In a manner similar to the safety case for the previous plant series (see §I-2.1.3), the numerical fire studies are primarily based on the MAGIC zones code and the FDS fields code for the complex cases.

2. Management of modifications and configuration status

The design modifications are the subject of a change tracking process. Each necessary modification is tracked by an NME (EDVANCE Modification Notice) or an FDM (Modification request sheet) and shared with all participants concerned. The NME and FDM describe the origin of the need for the modification, the details of the modifications to be implemented and the details of the actions, the contracts concerned and the documentation affected.

Configurations management is defined as management of the knowledge – at any moment – of the state (physical or design) of the plant unit (or part thereof) at a project progress milestone. It consists in managing the technical description and the modifications made to it as it evolves. At present, the Fire studies are consistent with the commissioning file (DMES) milestone.

g. Probabilistic safety assessments

A simplified fire PSA was produced at the design stage.

The Fire PSA approach for the Flamanville 3 EPR reactor is limited to estimating the risk of core melt and identifying the preponderant fire volumes (phase 2). This conservative study shows no design weaknesses.

III-2 EDF' assessment and conclusions on fire safety analyses on the other series

Deterministically, the conclusions of the DMRI for the Flamanville 3 EPR show that the fire protection safety objective has been reached, this being to guarantee the performance of the safety functions despite a fire occurring inside the installation

Probabilistically, the fire-related core melt frequency obtained in the simplified design PSA complies with the probabilistic safety objectives of the SAR (frequency of core melt linked to fire evaluated at $4.5.10^{-7}$/reactor.year). These results will be consolidated by a more complete probabilistic evaluation after the initial operating phase.

III-3 Regulator’s assessment and conclusions on fire safety analyses on the other series

By taking account, as of the design of the EPR, of a certain number of aspects which had only been considered for the NPP fleet during the periodic safety reviews and also a DMRI, real improvements have been made by comparison with the other reactors in the NPP fleet. Compliance with the hypotheses used in this DMRI must still to be verified. A significant number of deviations were detected and have to be dealt with before commissioning; they encourage ASN to be very vigilant on the subject.

2.2. Research reactor – RHF – BNI 67

2.2.1. Types and scope of the fire safety analyses

Pursuant to Article 3.1 of the regulations applicable to basic nuclear installations (BNI), the ILL, operator of the RHF, applies the principle of defence in depth to the control of fire risks. The ILL’s fire risk management case is thus based on a general safety analysis approach, involving four levels of defence in depth:

- 1st level of defence in depth: preventing incipient fires by minimising the occurrence of these incipient fires in normal operation of the installation through material and/or organisational preventive measures;
- 2nd level of defence in depth: the installation of systems for detecting and/or extinguishing any incipient fires, on the one hand to prevent them leading to a fire and, on the other, to restore a normal operating situation or, failing this, to attain then maintain a safe installation state;
- 3rd level of defence in depth: adoption of material and/or organisational provisions to limit the aggravation and the spread of a fire which could not be controlled, in order to minimise its impact on the protection of interests and enable a safe state to be reached or maintained on the installation;

- 4th level of defence in depth: manage accident situations resulting from a fire which could not be brought under control, in order to mitigate the consequences for the public and the environment.

2.2.2. Key assumptions and methodologies

The fire risk analysis covers all the rooms of the BNI housing nuclear or conventional activities.

One of the first steps in the analysis is to make a room-by-room identification on the one hand of the presence of components important for the protection or interests (PIC) or structures, systems and components (SSC) which contribute to the installation's safety case and, on the other, the presence of hazardous substances which, in the event of fire, could have consequences for the personnel, the public and the environment.

The steps in the risk analysis approach are therefore:

Approach to identify the PIC to be protected from a fire

The safety analyses lead to the identification as PIC with respect to safety (called PIC-S) of a sub-set of structures, systems and components in the installation. This analysis leads to these PIC-S being ranked according to their importance in the safety case. The PIC-S of the RHF are thus classified in four levels, with the associated requirements then being proportionate to the safety issues in terms of protection of interests.

The safety analysis for the operating conditions consists in studying the installation's response to the postulated loss of the various SSC making up the installation.

With regard to analysis of control of the fire risk, this is deterministic and takes account of the impact of the postulated loss of a PIC on the operation of the installation and on the safe state to be achieved.

Initially, all the PIC-S are in principle considered to be potential targets for a fire, whether directly or indirectly.

Identification of potential targets of the fire

A simple sorting process is used to exclude from the list of potential targets those PIC-S which, for evident physical reasons, cannot be the targets of a fire. This is in particular the case of PIC-S immersed in a fluid such as water, which is a normal arrangement in pool type reactors.

Finally, with regard to the control of impacts and detrimental effects on the protected interests, the list of safety targets among the PIC-S is supplemented by all the rooms liable to lead to a release of hazardous substances into the environment in the event of a fire.

Vulnerability study

The vulnerability study also checks that the lines of defence needed to return to and maintain a safe state, following the loss of the PIC-S being studied, are not also impacted by the fire. If this is the case, a particular study is carried out per operating condition, assuming that all the lines of defence used in the safety case have been rendered unavailable by the postulated fire. This study should conclude that the installation returns to and is maintained in a safe state or, otherwise, propose prevention and/or protection measures able to preserve the minimum lines of defence needed for this safe state.

Risk quantification method per room (whether or not containing PICs)

The ILL has adopted a fire rating method able to estimate the fire risk of a room, with this rating taking account of:

- the characteristics of the room in terms of the permanent or temporary fuel loads present;
- the available means of prevention and protection;
- the level of ease with which intervention by the internal resources or external fire brigades is possible.

The more important the PIC in the installation's safety case, then the more stringent the objective (rating) to be achieved for each room containing it.

With regard to hazardous substances: an impact assessment is performed for each TRICE target identified. With regard to radioactive releases, the worst-case dispersion hypothesis selected is that following a generalised fire (CF3), with the target value chosen thus being that of the General Safety Objectives for the 3rd category operating conditions. The INERIS rules and calculation method are used for the impact assessment of other hazardous substances. Additional lines of defence are put into place if necessary.

Hypotheses specific to the fire risk analysis

The Reactor in service state was considered for all rooms containing PICs needed for the safety case per operating condition specific to the reactor. This is in fact the most penalising situation (given that all the safety systems must be available because an irradiated item is in the pile block and the reactor is operating).

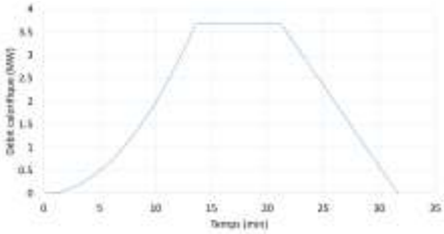
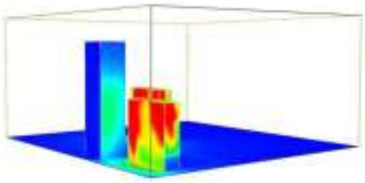
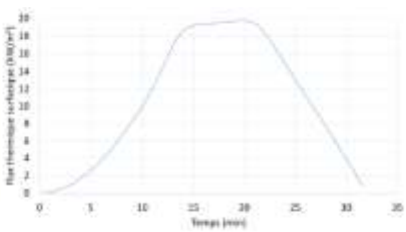
2.2.3. Fire phenomena analyses: overview of models, data and consequences

For the purposes of the fire risk analysis, the ILL performs fire simulations only when the deterministic vulnerability analysis so requires (CFAST, FDS - Fire Dynamics Simulator, etc.). The results enable the ILL to decide whether the existing margins in relation to the thermal constraints are acceptable or whether additional steps must be taken to protect the target.

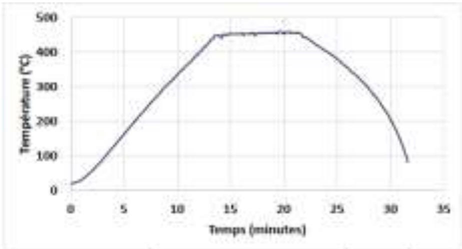
<u>Example of the vulnerability study on the gaseous deuterium tank of the Horizontal Cold neutrons source (SFH)</u>

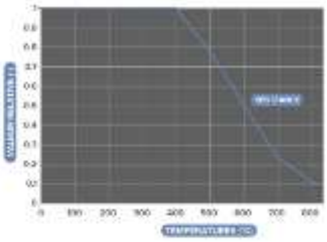
Scenario: Simultaneous fire in the two electrical cabinets closest to the SFH. Feared event: deuterium leak from the gaz tank, or even explosion.

- Flow curve from the two cabinets (NUREG test) and FDS modelling (heat flux):

- Comparison of gaz tank temperature and mechanical strength:





- Conclusion: Installation of thermal protection on the gaz tank to provide margins for this (simulated) fire scenario confirms these results and rules out the destruction of or leakage from the gaz tank.

2.2.4. Main results / dominant events (licensee´s experience)

The main results of the ILL fire risk analysis are presented below per safety function, notably with regard to the reactor.

<u>Control of reactivity:</u> The I&C fail-safe approach and falling of the safety rods, the redundancy of the lines of defence and their physical separation guarantees that a safe state is reached in the event of a fire. It is physically impossible for the safe state to cease to be maintained once the safety rods have dropped in the event of a fire.

<u>Control of cooling:</u> Control of the reactivity and the RHF reactor's design which ensures natural convection cooling of the fuel by passive opening of spring-loaded valves, guarantees that a safe state is attained and maintained in the event of a fire. There is no fire scenario which can lead to the loss of the safe state attainment function with regard to cooling.

<u>Control of containment:</u> There is no identified fire scenario in the reactor building involving radioactive substances and constituting a hazard for the third containment barrier which could lead to a risk of exterior dissemination, because the reactor building can be isolated while ensuring overpressure between its concrete and metal double containment. Moreover, in the event of an incipient fire in the reactor building, containment isolation is triggered, which, in the envisaged deterministic worst-case fire scenarios, enables the fire decay phase to be reached by consumption of the oxygen present, before any structural damage can occur to the building and before a containment isolation function can be compromised.

2.2.5. Periodic review and management of changes

At the ILL, there are various internal reviews that enhance the fire risk analysis.

- The “fire risk management” process is specific to consideration of the fire risk and is reviewed annually. The year’s operating experience feedback is thus taken into account and an action plan can be implemented;
- For those events related to the fire risk, the "anomaly management” process enables fire risk prevention or mitigation action plans to be drawn up and enhances operating experience feedback;
- The “Modifications management” process enables each modification to the installation to be analysed from the standpoint of safety risks and also systematically considers the first risk in order to prescribe the appropriate means of prevention, protection or mitigation;
- From an operational and day-to-day viewpoint, the “Operational management of the fire risk in the premises” procedure provides for an authorisation system for each sensitive room in the BNI, which depends on the result of the risk analysis rating process. This procedure provides a framework for the activities which do not fall within the scope of the “Modifications management” process.

With regard to external reviews, the periodic safety review is an ideal opportunity to examine the installation’s situation, notably in terms of control of the fire risk, and to formulate recommendations for improvement (see section below); it also enables lessons to be learned from equivalent installations.

2.2.5.1. Overview of actions

During the latest periodic safety review of the ILL (2017), the fire safety analysis methodology used in the overhaul of the fire management safety case identified several areas for improvement; these led to an undertaking to perform modifications work in BNI No. 67, a few examples of which appear below:

- Installation of a manual water sprinkler system in the radiological zone rooms housing the most important PIC-S in order to make up for the difficulty of intervention with the reactor operating (in service since the end of 2022);
- Installation of protection on electrical cables at the reactor building concrete containment penetrations, in order to prevent the spread of a fire (in service since the end of 2022).
- Installation of a heat screen between the electrical cabinets and the gaz tank of the Horizontal cold neutron source (containing Deuterium gas) ruling out the possibility of destruction of or leakage from the gaz tank in the event of an electrical cabinet fire (in service since the end of 2022);
- Installation of fire protection on one of the trains of the “Hardened safety core” backup systems, to ensure separation of the trains in the event of impact by a fire (in service since the beginning of 2023);

- Installation of a sprinkler type control system over all of level C of the reactor building, providing fire stability margins for certain metal structures (polar crane and slabs of the reactor building) and controlling the growth of a fire in the reactor experimentation hall (project ongoing);
- Installation of a sprinkler type active control system in the bunkers of reactor building level C, in order to prevent a fire impacting the thimbles retaining flanges (project ongoing).

2.2.5.2. Implementation status of modifications/changes

The milestone dates for the various fire protection improvement projects were specified in §2.2.5.1

For the work mentioned above in §2.2.5.1, regular progress reviews are held by the structure monitoring ILL projects and the undertakings made to ASN.

2.2.6. Licensee's experience of fire safety analyses

2.2.6.1. Overview of strengths and weaknesses identified

The strong points identified by the fire risk analysis stem from the reactor's very design, which enables the main safety functions – reactivity, cooling, containment – to be controlled in the event of an uncontrolled fire.

Reactor I&C is located in a fire sector of the building adjoining the reactor, equipped with an automatic gas extinguishing system. Even assuming the destruction of this control assembly by the fire, attainment of the safe state is guaranteed. The implementation of specific additional systems as part of the work done post-Fukushima provides safeguard functions that can be activated and controlled by a remote secure emergency command post in a specially designed building, with redundant, separate control lines for taking the installation to a safe state.

The renovation and upgrading of the fire safety systems at the ILL over the years proved to be a positive point in achieving the methodological objectives (risk level) for the various rooms containing safety targets or combustible materials.

The weak points identified following the fire risk analysis during the latest periodic safety review, led to a number of fire protection improvement projects being launched, the main ones being indicated in §2.2.5.1 (passive protection of the target PIC-S, electrical cable penetrations, sprinkler extinguishing systems to protect the PIC-S or to improve defence in depth by controlling any growth of a fire in the experimentation level of the reactor building).

2.2.6.2. Lessons learned from events, reviews, fire safety related missions, etc.

Few lessons were learned from the few events related to the fire risk (about 2 per year) other than demonstrating the effectiveness of the detection system extensively installed at the ILL: during equipment overheating, during work generating dust or aerosols, as a result of forgetting to inhibate detectors, etc. This confirmed the need to continue in this direction (installation of detectors in the rooms with safety implications or flame detectors on particular ignition sources).

Among these events related to the fire risk, a few rare fires did actually break out, outside sensitive areas (waste bins, ashtray, etc.). These were the result of human negligence and apart from enabling the response instructions to be put into practice, they highlighted the need to periodically recall common-sense operational instructions (correct use of electrical appliances, compliance with smoking and no-smoking zones, etc.) and to regularly make the ILL personnel and visiting scientists aware of the fire risk within the BNI. Another lesson learned was to reinforce the internal "fire permit" procedure regarding hot-spot work.

2.2.7. Regulator's assessment and conclusions on fire safety analyses

2.2.7.1. Overview of strengths and weaknesses identified by the regulator

During its periodic safety review in 2017, the ILL updated its fire risks assessment, notably by implementing the requirements of the ASN resolution of 28 January 2014 concerning the rules applicable to basic nuclear installations with regard to the control of fire risks. This new method for the RHF takes account of the hazard risk for the PIC-S. The failure of the PIC following a fire and its consequences are also examined. These are good practices implemented by the licensee.

2.2.7.2. Lessons learned from inspection and assessment as part of the regulatory oversight

The demonstration of the effectiveness of the fire protection measures is not systematically incorporated into the studies performed as part of the periodic safety review. The large number of experiments carried out in the reactor building leads to complex control of the heat loads: limitations on the quantity of combustible material authorised per zone must be defined by the licensee and the users must be regularly reminded of them.

2.2.7.3. Conclusions drawn on the adequacy of the licensee's fire safety analyses

The method used by the ILL to perform its fire risk assessment (ERI) is improved with regard to the PIC-S fire hazard risk. The ILL has made a number of commitments to improving fire prevention and mitigating the consequences of any fire.

2.3. Fuel cycle facilities

I- Fuel enrichment facility - George Besse II – BNI 168

I-2.3.1. Types and scope of the fire safety analyses

The baseline safety requirements for the George BESSE II (GBII) nuclear facility were examined by ASN and its technical support organisation IRSN, which led to a creation decree in 2011.

The GBII enrichment plants can enrich natural uranium from 0.71% ^{235}U up to 6%. To do this, containers are heated to emit UF_6 to the centrifuges. The enriched UF_6 is then drawn off into the "cold" stations.

The functions important for the safety of the facility are the containment of radioactive substances, the protection of people and the environment against ionising radiation, the control of nuclear chain reactions and control of the use of hazardous substances.

The elements vulnerable to fire are the PIC (protection-important components) which must be maintained in the event of a fire (see list of PIC to be protected from a fire).

I-2.3.2. Key assumptions and methodologies

The fire risk analysis for the enrichment plants is deterministic: the incipient fire and the combustion of the entire heat load present are systematically postulated conservatively. The rooms are grouped in room families according to their characteristics. In rooms containing PICs to be protected from the effects of a fire (UF_6 containers, cold traps, UF_6 piping), plausible fire scenarios are defined for each family.

This approach meant that electrical equipment (electrical distribution cabinets, I&C systems, etc.) were whenever possible grouped in sectorised rooms (fire-break volumes, see C-I-3.3.1.2) containing no safety targets to be maintained in the event of a fire.

In addition, fires breaking out in the I&C cabinet / electrical cubicle and on the auxiliary units (+60/+20 °C) were modelled with the real characteristics and layout of the electrical equipment.

Moreover, a probabilistic assessment of the accidents related to a fire and their consequences was carried out. This Probabilistic Safety Assessment does not take the place of the deterministic safety assessments, but rather supplements them. The methodology followed by GBII consists in:

- identifying the feared situations on the basis of studies of the accident situations in the Safety Analysis Report;
- defining the scale of severity and probability of these situations;
- defining the probability/severity pair assessment chart.

After a qualitative estimate of the probability and severity of the feared situations, all the feared situations are positioned in the assessment chart.

The aim of this analysis is to check that all the envisaged scenarios or situations have acceptable consequences given the probability of occurrence of the scenarios. During the 1st periodic safety review of BNI 168, this probabilistic analysis was performed on fire scenarios. Its conclusion was that of acceptability without any modification.

I-2.3.3. Fire phenomena analyses: overview of models, data and consequences

The evaluation of the impact of the fire in each scenario relies on a simulation of the growth of the fire using the 2005 version of the CDI software developed by CEA/DPSN.

The calculation is able to determine the changing temperature of the gases in the rooms during the fire, as well as the incident radiant flux on the safety targets. The CDI software is considered to provide worst-case results.

The impacting hazards are considered to be electrical cabinets and the heat load used for each cabinet is calculated according to its volume. The evaluations are made with a worst-case representative of a group of rooms, in order to ensure that the distance of the targets from the fire sources is sufficient.

In addition, during the 1st periodic safety review, the plausible combinations of trigger event situations were examined.

The approach used to analyse combinations of trigger events comprises three main steps:

1. Definition of trigger events to be considered in the light of the installation: this step consists in defining the pertinent internal and external hazards for the installation, as well as the equipment or types of equipment to be considered with regard to internal failures.
2. Determination of the combinations of trigger event situations to be analysed: this step consists in a qualitative analysis to define the plausible event combinations requiring a detailed analysis of the prevention, monitoring and consequences mitigation provisions for the installation.

The choice of the combination is based on criteria defined and substantiated during this step. The minimum criteria to be used are those relating to:

- the probability (or frequency) of occurrence of the combinations;
- the internal equipment failures;

3. Analysis of combination situations selected. This step consists in analysing the combinations selected, by checking that the safety functions of the installations are maintained, considering the planned or existing provisions and supplementing them, if necessary, by other specific provisions. This analysis is based on all the levels of defence in depth (any remediation means).

For BNI No. 168, the analysis of the plausible trigger event combination situations revealed no aggravating situation.

These data will be incorporated into the safety analysis report during the update of the regulations in May 2024.

I-2.3.4. Main results / dominant events (licensee´s experience)

In addition to the sectorisation elements, the safety analysis identified the following fire risk control measures:

- in the UF_6 process rooms or the sheltered rooms, the non-aqueous coolant or refrigerant fluids are chosen with high flashpoints; the refrigerant fluids are non-flammable in the process rooms;
- the installation may be stopped in an emergency and placed in a safe state if necessary: closure of needle valves isolating the containers in the station, shutdown of UF_6 equipment heating, isolation of vent and drainage treatment system lines for the cascades.

The PICs to be protected against the effects of a fire are thus:

- the equipment containing radioactive or toxic materials that could be dispersible in significant quantifies in the event of a fire, in terms of environmental risks;
- sheet metalworked equipment containing enriched material and to be protected from the risks of significant deformation or loss of tightness following a fire, when the control modes adopted are geometry or moderation respectively;
- the I&C systems needed to bring the installation to and maintain it in a safe state in a fire situation, in order to guarantee the integrity of the first containment barrier and control sub-criticality;
- the control rooms, from which the installations are brought to a safe state, and the access to them;
- the rooms containing fire safety systems.

Which led to the following safety requirement being applied and maintained during operation: the PICs to be maintained in the event of a fire are positioned so that a fire in an electrical cabinet or of the coolant fluid in the cooling/heating units of the cold traps cannot compromise their integrity. Failing which, this equipment is protected.

I-2.3.5. Periodic review and management of changes

I-2.3.5.1. Overview of actions

The fire risk was taken into account as of the design of the installation, with physical separation between the numerous electrical rooms, the rooms containing fuel (for the diesel generators), and the rooms containing radioactive material. This separation, which compartmentalises any fire and it effects, entails no operational problems.

The analysis led to fire detectors being installed in most of the rooms. Thus in the event of detection or a fault, the operator in the control room is able to locate the alarm, so that any fire can be rapidly dealt with.

Moreover, during the installation's first periodic safety review, compliance with ASN resolution 2014 – DC - 0417 (Fire Resolution) led to scenarios comprising a single aggravating factor being incorporated into the fire risk analysis.

I-2.3.5.2. Implementation status of modifications/changes

During the periodic safety review of BNI 168 in 2022, the satisfactory design of the installation was confirmed.

This is because:

- the various scenarios with a single aggravating factor concluded that the current provisions are sufficient;
- the new fire scenarios were modelled with no modification to the installation being needed;
- the probabilistic assessment and the assessment of the plausible combinations of trigger event situations were carried out (see previous §) and revealed no aggravating situation.

These data will be incorporated into the safety analysis report during the update in May 2024.

I-2.3.6. Licensee's experience of fire safety analyses

I-2.3.6.1. Overview of strengths and weaknesses identified

Application of the principle of defence in depth via a deterministic method enables a robust demonstration to be achieved.

However, the large number of rooms and the differences between them required numerous models to be made, thus making it difficult to gain an overall appreciation of the assessment as a whole.

I-2.3.6.2. Lessons learned from events, reviews, fire safety related missions, etc.

The analysis of the events did not call into question the initial fire risk assessment at the design stage.

I-2.3.7. Regulator's assessment and conclusions on fire safety analyses

I-2.3.7.1. Overview of strengths and weaknesses identified by the regulator

The isotope 235 uranium enrichment plant, called "Georges Besse II" (GBII), gradually commissioned between 2011 and 2017, is a particularly recent BNI. It was designed on the basis of the regulations then in force, principles, including that of defence in depth, modern design tools and national and international operating experience feedback associated with all representative installations in terms of design and operation. For example, as of the design stage, fire detectors were installed in all rooms with a fire risk or containing equipment itself containing radioactive or toxic materials in significant quantities and the walls of these rooms are designed to prevent the spread of a fire. The heat loads in all the rooms were of course minimised to the extent possible.

Orano mainly carried out deterministic analyses to demonstrate that the prevention, detection and response provisions were sufficient and that the consequences of a fire were limited. In addition, Orano uses calculations whenever necessary to model dangerous phenomena or structures, in order to identify the behaviour in the event of a fire. In order to consolidate or supplement its analysis based on a deterministic approach, Orano also carried out probabilistic assessments for all fire scenarios with a potentially high probability of occurrence and associated consequences. Such a probabilistic assessment consists in checking the very low probability of occurrence of major consequences when one or more protection provisions are lost.

Some regulatory texts have changed since the commissioning of the installation but, in the same way as any other Orano group installation on French territory, the licensee has always made efforts to comply with the regulations in force, including the Order of 7 February 2012 (BNI order) setting the general rules for BNIs, and the ASN resolution of 28 January 2014 regarding the rules applicable to BNIs for the control of fire risks.

Moreover, all licensees are required to review control of the risks and detrimental effects associated with their installations. The purpose of such a periodic safety review is notably to improve the level of control of the risks and detrimental effects of an installation, in particular from the viewpoint of the fire risks, notably taking account of the regulations in force and international experience feedback, including accidents. This BNI has undergone a first periodic safety review, the conclusions of which were sent to ASN in 2022; these include the licensee's improvement actions related to fire risks. This review, currently being examined, contributes to the process of continuous improvement.

Finally, it should be noted that this BNI is located on a nuclear site comprising other nuclear installations. The fire response services are shared by all these BNIs, thus enabling the facility to benefit from a large-scale response force not limited to its own requirements alone.

I-2.3.7.2. Lessons learned from inspection and assessment as part of the regulatory oversight

The Georges Besse facility has experienced no significant fire-related event since it was commissioned and no major anomaly has been found during the inspections made within BNI No. 168 on topics related to fire risk control provisions. The inspectors concluded that the fire risk control provisions were satisfactory and that the handling of any anomaly or observation made during the inspections also contributed to the process of continuous improvement.

I-2.3.7.3. Conclusions drawn on the adequacy of the licensee's fire safety analyses

The regulations in force are complied with.

In addition to the regulations, the licensee demonstrates that the fire risk control provisions are sufficient, by means of a deterministic approach taking account of the principle of defence in depth and supplemented by a probabilistic approach to the various fire scenarios (see I-2.3.7.1). Regular inspections verify compliance with these provisions throughout the installation and the review of the sufficiency of these provisions currently under way ensures continuous improvement of the installation's level of safety.

II- Fuel fabrication facility Romans Sur Isère / CERCA – BNI 63-U

II-2.3.1. Types and scope of the fire safety analyses

In accordance with the regulations, the installations of BNI 63-U are covered by a Fire Risks Management case (DMRI). The aim of the DMRI is to demonstrate control of the fire risks or detrimental effects on the protection of the interests mentioned in Article L.593-1 of the Environment Code (public health and safety, protection of nature and the environment; from now on referred to "interests to be protected"). This management case shows that the risk of accidents and the scale of their consequences are, given the current state of knowledge, practices and the vulnerability of the environment of the installation, as low as achievable under acceptable economic conditions.

The DMRI identifies the fundamental functions ensuring the nuclear safety of the BNI. For BNI 63-U, these safety functions are the following:

- control of nuclear chain reactions;
- containment of radioactive substances;

- protection of people and the environment against ionising radiation;
- control of the non-radiological risks.

In the same way as the other internal or external hazards such as explosion, flooding or earthquake, fire is a source of danger for these functions and thus risks compromising the nuclear safety of the BNI. Similarly, fire can present direct risks, such as toxic, thermal or over-pressure effects. These effects may directly affect the interests to be protected, but also the BNI personnel.

The DMRI is based on the principle of defence in depth, that is the use of the following successive levels of defence:

- preventing the outbreak of fire;
- detecting and rapidly extinguishing any incipient fires, on the one hand to prevent them leading to the spread of fire and, on the other, to restore a normal operating situation or, failing this, attain then maintain a safe BNI state;
- mitigating the aggravation and propagation of a fire which could not be brought under control in order to minimise its impact on nuclear safety and enable a safe BNI state to be attained or maintained;
- allow the management of accident situations resulting from a fire which could not be brought under control, in order to mitigate the consequences for people and the environment.

The definition of the plausible fire scenarios considered in the DMRI is based on a deterministic approach.

The plausible combination of events (lightning, earthquake, freezing, loss of electrical power supplies, etc.), whether or not they are possible triggers of a fire, is taken into account. These combinations are considered whenever there is a confirmed dependency relationship and that no design provision is capable of ruling them out.

II-2.3.2. Key assumptions and methodologies

The DMRIs established within BNI 63-U are – for those buildings with significant safety implications – based on the application of a Framatome methodology guide. This guide presents all the data needed to produce a DMRI and the analysis method to be followed to demonstrate control of the fire-related risks.

The input data to be collected, described and, as applicable, analysed, are the following:

- The general description of the BNI (type, technical characteristics, operating principles, operations or processes, drawings);
- the different states of the installation (normal operation, maintenance, scheduled outages, other situations, whether or not transient). The particular operations not covered by the safety baseline requirements (modifications) are the subject of a prior specific analysis, notably with regard to fire-related risks. Plausible combinations of events are associated with these states (see paragraph II-2.3.1);

- the fire hazard sources, differentiating between the combustible materials (type, location, quantity, division status) and the ignition sources (thermal, electrical, electrostatic, mechanical, chemical, physico-chemical, climatic). The coupling between heat loads and ignition sources is analysed. The hazard sources inside and outside the room and the installation analysed are considered;
- the targets, that is all the elements which should not be affected by a fire, so that the safety functions are guaranteed and the installation maintained in a safe state. A distinction is made between:
  - the targets which could compromise the installation being maintained in a safe state in the event of a fire (radioactive or hazardous substances, protection-important components – PIC – and activities important for the protection of interests – PIA – performing a safety function to be guaranteed in a fire situation, protected routes and exits used for personnel evacuation), and,
  - targets said to be "aggravating", which if impacted could have repercussions on the previous targets owing to a domino effect (civil engineering structures, pressure equipment, fluids networks, adjacent rooms with a high surface calorific potential, etc.);
- the "fire PIC / PIA" (sectorisation elements, automatic extinguishing systems, response, etc.). From among the fire risk control provisions, the fire PIC / PIA play a key role in the DMRI, because they take part in protecting the targets identified in the previous paragraph;
- the target performance criteria. In order to determine whether a fire can compromise a target, performance criteria are defined (heat flux or maximum temperature to avoid the spread or to maintain the integrity or functionality of a target, maximum pressure differential to maintain the integrity of sectorisation systems, etc.);
- the provisions in place for controlling fire-related risks. The prevention measures are identified (see paragraph C-II-3.1: construction and outfitting materials, heat load limitation, control of ignition sources, prevention plan and fire permit, and experience feedback taken into account), as are the protection provisions (see paragraphs C-II-3.2, C-II-3.3 and C-II-3.4: fire detection, associated safeguard equipment and automation systems, material response and fire-fighting resources, operational organisation, access and circulation routes, fire sectorisation elements, ventilation control, smoke extraction, filtration of potentially contaminated smoke).

The analysis to be carried out to demonstrate control of the fire-related risks is performed as follows:

- define then select plausible fire scenarios. For each room or area, fire scenarios are established on the basis of drawings, the inventory of combustible materials and the ignition sources present. The fire is assumed to be growing freely, with no attempt to extinguish it. This step allows filtering of the rooms in order to differentiate between, on the one hand, rooms with limited safety implications, which could be the subject of a qualitative analysis and, on the other, those with significant safety implications, which are then the subject of a specific analysis;

- define the reference scenarios. Of the scenarios identified, one or more "reference" scenarios are defined as being those with the most severe effects (according to the combustible materials dispersed, the kinetics, etc.);
- analyse the vulnerability of the targets. With the targets to be protected identified and located, their vulnerability is analysed by cross-checking with the reference scenario(s). If the analysis leads to hazards impacting the targets, a specific analysis is carried out. For each of the targets, this analysis consists in more precisely estimating the effects of the reference scenarios, in order to compare them with the confirmed target performance criteria. Numerical models may be made (see paragraph II-2.3.3). If necessary, reinforcement of the fire-related risk control provisions is specified;
- check the robustness of the safety case. The robustness of the provisions to control fire-related risks is verified, for each reference scenario, by postulating the failure of a fire PIC in the room concerned, such as the failure of closure of a fire door or a fire damper. Moreover, for rooms containing significant quantities of radioactive material, a scenario with a generalised fire of the combustible materials in the room is defined. The aim is then to ensure that this scenario has no unacceptable consequences outside the site. The consequences evaluated are, as applicable, radiological or non-radiological (toxic, thermal effects, or even overpressure if an explosion is to be considered).

II-2.3.3. Fire phenomena analyses: overview of models, data and consequences

For some of the rooms in the installations, the fire scenarios must be studied quantitatively. The effects of the reference fire versus time are compared with the performance criteria of the targets present and the risk of propagation can be quantified.

Depending on the configuration of the room, the stakes and the available data, the analysis to be performed is:

- Semi-quantitative. Simple thermal equations and tabulated values recognised by the scientific community are used. They for example allow calculation of the radiant flux on a target using the point source or solid flame model. By comparing it with the target performance threshold, a minimum safety distance between the flame and the target can be deduced (this zone should contain no combustible materials to which the initial fire could spread).
- Quantitative, using computer codes based on specific models, such as zone or field codes, which have undergone qualification.

For the evaluation of the radiological consequences, the source term released into the environment is calculated using the inventory of radioactive materials present and dispersible affected by the fire in the room. The fraction of material present and dispersed depends on its physico-chemical form, the nature and means of its containment and the intensity of the postulated fire. This fraction is evaluated on a case-by-case basis. The suspension coefficients are chosen consistently with the data in the literature. As a conservative measure, re-deposition of the material in suspension on the walls of the rooms or in the ventilation ducts is not generally considered. Filtration (from first to last level of filtration) is considered to be not faulty, that is maintained at the effectiveness level defined by design for each filter.

The quantification of the radiological consequences of the scenario on the population is then based on the following parameters:

- the source term released;
- the height of the release;
- the meteorological conditions (diffusion and wind speed);
- the distance between the measurement point and the release point;
- the targeted population;
- the exposure duration.

The hypotheses adopted for these parameters are conservative.

The acceptability of the radiological consequences is evaluated in the light of the reference value of 1 mSv at the perimeter of the BNI 63-U site, that is the annual effective dose limit for the population defined by the regulations (Public Health Code).

The toxic effects are evaluated using an approach similar to that used to estimate the radiological consequences. Computing tools can also be used to evaluate the toxic effects at a given distance. These tools follow the physical models taken from the literature: Gaussian models for the far field and Computational Fluid Dynamics (CFD) for the near field. The values obtained are compared with the toxic effects thresholds defined in the Order of 29 September 2005 (threshold of effects that are reversible – SER, irreversible – SEI, lethal – SEL, significantly lethal – SELS), from which the demarcation of the areas of danger to human life is determined.

The thermal effects on the population are evaluated on the basis of the radiant flux in the case of a large-scale fire in a building. The values are compared with the exposure thresholds for effects on humans (SEI, SEL, SELS) defined in the Order of 29 September 2005. The SEI value (3 kW/m^2) is selected as the reference value at the site perimeter.

Finally, for effects linked to explosions, the evaluations are based on the guides published by INERIS.

II-2.3.4. Main results / dominant events (licensee´s experience)

For example, for certain buildings or workshops, the DMRI revealed a large-scale fire risk that could compromise the stability of the building concerned. The major modifications required were thus performed in order to rule out this scenario. This consisted in the following measures being taken since 2016:

- reduction in the quantity of combustible materials present in the premises, notably by reorganisation entailing the removal of equipment or furniture, or replacement by equipment with a better reaction to fire, or even non-combustible when possible;
- replacement of old equipment by new equipment compliant with the applicable regulations and standards;

- moving combustible elements away from ignition sources;
- surveillance to ensure that combustible materials are not accumulated in the rooms;
- installation of automatic extinguishing systems for the electrical cubicles and cabinets;
- installation of fire-proof cabinets for storage of combustible materials (documentation, small combustible objects, etc.) and to protect pressurised gas bottles at risk;
- sectorisation of the equipment storage rooms, the electrical rooms or the rooms for storage of uranium-bearing materials;
- installation of fire shields or flame arresters between equipment for which there is a risk of an outbreak of fire or between fire zones which are not sufficiently far apart;
- fire-break protection of building structural load-bearing elements;
- installation of smoke vents;
- reduction and limitation of the quantities of uranium-bearing materials utilised;
- protection of the criticality accident detection system by distribution of the sensors around different fire volumes to prevent their simultaneous failure caused by the same fire.

II-2.3.5. Periodic review and management of changes

II-2.3.5.1. Overview of actions

The site DMRIs are part of the safety baseline requirements. On the occasion of the ten-yearly periodic safety reviews, they represent input data for the examination of the conformity of the installations with the applicable baseline safety requirements. When the safety cases are reassessed, they are themselves also reassessed. This reassessment is based on:

- an examination of conformity with the regulations and internal standards;
- a safety reassessment which takes account of changes to regulations and standards, experience feedback, technical and organisational changes, the industrial environment, climatic and seismic hazards, the state of the art and the results of the conformity check.

For each ten-yearly periodic safety review, the scope of the reassessment is specified in the safety review guidance file, and communicated to the authorities prior to drafting and transmission of the review file.

In addition, the installations modification process used on the site requires updating of the baseline safety requirements, including the DMRI(s) concerned. It applies to noteworthy and non-noteworthy modifications (articles R.593-55 to R.593-59 of the Environment Code). In the case of a new building, the DMRI, which is a pre-requisite for start-up, is produced in compliance with the requirements currently applicable. In the case of a modification, the updated DMRI is one of the file output items.

II-2.3.5.2. Implementation status of modifications/changes

As set out in paragraph II-2.3.5.1 above, the DMRIs are either reassessed during the ten-yearly periodic safety reviews, or created or modified using the installations modification process. The previous and current ten-yearly periodic safety reviews led to significant updates, carried out between 2018 and 2019, for the buildings containing uranium-bearing materials. They were mainly required owing to the need to bring the DMRI into conformity with the Order of 20 March 2014, which repealed the Order of 31 December 1999 and consequently the "joint licensees guide" document, on which the analyses had hitherto been based. Additional updates were started in 2022 for two buildings and completion thereof is scheduled for 2023.

II-2.3.6. Licensee's experience of fire safety analyses

Framatome has more than fifteen years of experience in the drafting of DMRIs, along with the necessary expertise. BNI 63-U relies on Framatome engineering for the drafting of new DMRIs. The update proposals for the existing DMRIs following modifications to the installations are made by safety engineers. All the DMRIs created or modified are checked by the site's fire correspondent, who is specifically trained for this role. They are the guarantor of DMRI conformity and of the robustness of the safety cases developed in them.

II-2.3.6.1. Overview of strengths and weaknesses identified

Strengths

- Framatome has more than fifteen years of experience in the drafting of DMRIs, along with the expertise needed for this drafting.
- The DMRIs for the buildings with significant safety issues have been brought into conformity with the applicable regulations and standards.

Weaknesses

- The time taken to deploy the improvement measures identified following the recent updates of the DMRIs should be reduced.

II-2.3.6.2. Lessons learned from events, reviews, fire safety related missions, etc.

As set out in paragraph II-2.3.5.2, the DMRIs previously relied on the order of 31 December 1999 and the "joint licensees guide" (GIE). In its report DSU/SERIC 305 of 2012, the French Institute for Radiation Protection and Nuclear Safety (IRSN) assessed the GIE. This assessment and the resulting requirements concerned numerous methodological and technical elements provided in the GIE. The Framatome methodology guide used to establish the DMRIs within BNI 63-U took account of all the requirements resulting from IRSN's assessment of the GIE.

In addition, the experience feedback concerning the provisions to control fire-related risks to be implemented for the electrical cubicles and cabinets revealed the need for harmonisation and consolidation of the analyses. A specific guide was therefore drawn up, based on the proportionate approach mentioned in Article 1.1 of the Order of 7 February 2012 (BNI order). It has been in application since 2021 within BNI 63-U (also see paragraph C-II-3.1.1). It presents an analysis method which must be systematically implemented for the electrical cubicles and cabinets, with the aim of evaluating the need to protect them with an automatic gas extinguishing system. Failing which, the guide makes provision for additional provisions (improving the fire reaction of the materials making up the equipment or targets, moving the targets further away, automatic cutting of the electrical power supply, internal detection, protection of targets, separation using fire screens, etc.).

II-2.3.7. Regulator's assessment and conclusions on fire safety analyses

II-2.3.7.1. Overview of strengths and weaknesses identified by the regulator

BNI 63-U, called the "fuel fabrication plant", resulted from the merger between BNIs 63 and 98 finally commissioned in 1980 and 1988 respectively.

Framatome carries out deterministic analyses to demonstrate that the prevention, detection and response provisions are sufficient and that the consequences of a fire are limited (in accordance with the defence in depth principle). These analyses take account of the elements contributing to the protection of the environment and liable to be directly or indirectly impacted by the effects of a fire. Whenever necessary, these analyses are also based on numerical models of dangerous phenomena or the behaviour of structures or elements in the event of a fire. The performance of additional probabilistic analyses could further consolidate the deterministic analyses. However, Framatome is assessing the potential consequences of any fire in order to confirm that the risk control provisions are sufficient. Furthermore, the fire scenarios adopted are also associated with other additional hazards.

These analyses aim to ensure a high level of protection. Moreover, the licensee is required to review control of the risks and detrimental effects associated with their installations every ten years. A periodic review such of this is notably aims to improve the level of its control of the risks and detrimental effects, notably from the fire risk viewpoint. This review and the inspections performed contribute to the process of continuous improvement. Framatome shall transmit the conclusions of any such review during the course of 2023.

In addition, a fire broke out in BNI 63-U in September 2022. This incipient fire linked to a printer was rapidly brought under control and led to no dispersal of radioactive material and no exposure to ionising radiation.

Finally, it should be noted that the licensee has in recent years improved the control of fire risks in BNI 63-U whether proactively or further to inspections.

II-2.3.7.2. Lessons learned from inspection and assessment as part of the regulatory oversight

No major anomaly has been found during the inspections made within BNI 63-U on topics related to fire risk control provisions. The inspectors concluded that these provisions were satisfactory and that the handling of any anomaly or observation made also contributed to the process of continuous improvement (see Chapter III). For example, Framatome in particular recently improved:

- the permanently operational condition of the automatic extinguishing system actuators;
- the definition of the actions of the first response teams and it also undertook to improve the training of the personnel in charge of fire-fighting.

II-2.3.7.3. Conclusions drawn on the adequacy of the licensee's fire safety analyses

The regulations in force are complied with.

Over and above the regulations, the licensee demonstrates that the fire risk control provisions are sufficient by means of a deterministic approach taking account of the principle of defence in depth concerning the fire risk for its installations.

In addition, the inspections and periodic safety reviews allow continuous improvement, notably with regard to the definition and implementation of risk control provisions.

III- Fuel reprocessing facility – La Hague UP3A – T2 - BNI 116

III-2.3.1. Types and scope of the fire safety analyses

For all basic nuclear installations, the general objectives are to limit exposure of workers, members of the public, and the environment to ionising radiation and to chemical substances or, in certain cases, to thermal or mechanical effects.

In order to comply with these general safety objectives, Safety Functions (SF) are defined for the T2 unit in compliance with the following fundamental principles which guarantee:

- the containment of radioactive substances;
- the control of nuclear chain reactions (criticality risk);
- the removal of the thermal power produced by the radioactive substances and the nuclear reactions;
- the protection of people and the environment against ionising radiation;
- the controlled distribution of the auxiliary functions;
- the controlled use of hazardous substances.

The main objective of the fire risk analysis is to verify that these safety functions remain functional in a fire situation. Therefore, based on the Protection-Important Components (PIC) participating in these functions, the analysis of each safety function is able to determine whether or not the loss of these PICs leads to the loss of the safety function in which they participate. If so, they are to be protected against the effects of a fire.

The PIC to be protected from the effects of a fire are those which meet the following three criteria simultaneously:

- the PICs can be impacted by the postulated plausible fire scenarios;
- the PICs have no functional redundancy or the functional redundancy can be impacted simultaneously with the redundant PIC by the same plausible fire scenario;
- the PICs for which the loss (regardless of the type of hazard) leads to the loss of the safety function in which they participate.

This choice is worst-case because:

- It is independent of the existing and recommended provisions for controlling fire-related risks;

- It is based solely on the notion of the inherent design of the PIC.

For each room in the installation, the analysis approach allows:

- identification of the potential ignition sources present and the vulnerability of the PICs to a fire, along with the fire propagation modes;
- an evaluation of the consequences of a fire on the safety of the installation, taking account of the failure of a fire risk management provision;
- presentation of the associated measures for prevention, monitoring and mitigation of the consequences implemented pursuant to the principle of defence in depth.

This entire approach aims to confirm that the safety functions identified are maintained in a fire situation. More specifically, no foreseeable incident due to a single cause should lead to a fire liable to lead to the failure of a safety function.

Moreover, the approach is deterministic because it postulates the outbreak of fire and the combustion of the entire heat load present in the room on fire.

III-2.3.2. Key assumptions and methodologies

The fire risk analysis method for the rooms in the T2 unit is as follows:

- The equipment constituting the safety functions and their locations are determined;
- The potential importance of a fire is evaluated using:
    - The calorific potential,
    - The systematic qualitative and quantitative inventory of the combustible materials present,
    - The physico-chemical characteristics of these combustible materials,
    - The fire spread characteristics: kinetics that are rapid (powders, liquids or gases) or slow (solid combustible materials);
- The maintained functional integrity of the safety functions in fire situations is checked, by considering all the feared effects of the fire and by studying the adequacy of the provisions:
    - For protection of the PICs needed for the safety functions present in the unit in a fire situation. By virtue of the proportionality principle, a grading of the PICs (rating 1 to 4 from highest impact to lowest impact) has been defined according to the consequences resulting from their failure,
    - For the routes needed by the personnel and the emergency services for access to the locations in the event of a fire (“protected routes”) necessary for attaining and maintaining a safe state in the installation in a fire situation,
    - For fire sectorisation.

At this level of the study, the incipient fire is always postulated deterministically, barring special cases to be substantiated (such as the presence only of non-combustible materials in an inaccessible room). Its growth is studied on a worst-case basis by considering the combustion of all the combustible materials present and its effects.

Application of the fire risk analysis method to the T2 unit is based on:

- classification of the rooms according to the activities taking place in them (storage for example). This classification per type of room ensures application of the generic and minimal fire risk management provisions for a given risk situation. It is drawn up following a systematic inspection of all the inspectable rooms;
- the analysis of the unavailability or failure of a fire risk management provision in a fire situation. This unavailability or this failure should not compromise the safe state of the T2 unit;
- a detailed and extensive analysis pursuant to the proportionality principle, to highlight the correct treatment of the PICs with significant safety implications. These PICs are defined on the basis of a time needed to attain the feared event of less than 8 hours;
- identification of the protected route rooms if they are the sole possibility for accessing a location needed to bring the unit to or maintain it in a safe state in a fire situation. Bringing the unit to and maintaining it in a safe state are determined in conjunction with the planned unit safeguard and remediation actions. Using a prudent, worst-case deterministic approach, and according to the environment of the room, a plausible and developed fire is postulated in order to reach a conclusion regarding the impact on the protected route. The fires selected here concern rooms classified as “protected routes” and the rooms adjacent to them.

For example, for the T2 unit, the following are notably classified as:

- “PIC to be protected from the effects of a fire”, the boosters and pumps needed for the “tank headspace sweeping” and “cooling” safety functions respectively for the fission products concentrates storage tanks;
- “Protected routes”, the sole access corridors to this equipment.

In order to check the adequacy and overall consistency, the rooms with the previous classifications and their adjacent rooms are identified and taken into consideration. The analysis of the unavailability or failure of a fire risk management provision contributes to this objective. To constitute a worst-case basis, this analysis ignores the emergency teams response step. For information, an analysis is devoted to the safety functions to be restored within a time of less than 8 hours in the event of failure.

III-2.3.3. Fire phenomena analyses: overview of models, data and consequences

The fire is assumed to be confirmed in the methodology applied to the T2 unit. The impact on the targets in the rooms is thus adopted on a worst-case deterministic basis. This approach systematically leads to the adoption of active and passive fire protection measures in order to maintain the unit in a safe state.

The particular case of the solvent cells underwent thermal and pressure calculations in a fire situation using the CDI software described below. The aim is, on the one hand, to check the thermal and pressure hazards in the cells and, on the other, the maintained integrity of the Last Filtration Level (DNF). Given the calorific potential in these units and the kinetics of the fire, these specific configurations are considered to be worst-case. The results show that the temperature front penetrates the walls very little and that the pressure peak is managed by the ventilation duct selected for these solvent cells (extraction is kept open as long as possible). In addition, the DNF is actually protected by the beneficial effects of the existing dilution points on the ventilation networks.

The CDI software is a computer software developed by CEA in order to predict the phenomena caused by a compartment fire and its consequences for the structures, equipment and environment. It is thus positioned upstream of the zone code or CFD calculations and allows a rapid verification of a design and of the orders of magnitude used. The cells studied can be considered to be compartments, which falls within the scope of application of the CDI. It is designed to make a conservative and reasonable determination of the thermodynamic changes. The software has a forced ventilation control algorithm dependent on the quantity of fuel and the quantity of oxidising substances present in the room before the fire and that contributed by blowing (mechanical or by transfer). It also manages the calculation of the thermal hazards for the targets (safety targets or targets consisting of a simple fuel) and the stability of the load-bearing structures of the room.

III-2.3.4. Main results / dominant events (licensee´s experience)

The impact calculations evaluated in the safety analyses are made:

- independently of a plausible fire scenario;
- ignoring the presence of DAI and the beneficial effects of a response (failure principles);
- on the basis of dispersion of all of the source terms by the fire, regardless of time;
- using the return to suspension coefficients taken from the literature or from tests.

The integrity of the construction provisions of the civil engineering structures (concrete walls and absence of glazed walls) and the DNF (monitored through the operation of the ventilation notably in the event of a fire) is considered.

In addition, calculations to study the phenomenology of the fire have been carried out for situations with specific risks, such as the solvent cells in the T2 unit (see III-2.3.3).

No experience feedback from fire in the T2 unit led to any modification of the methodological baseline requirements for the T2 unit.

III-2.3.5. Periodic review and management of changes

III-2.3.5.1. Overview of actions

The methodological baseline requirements for the T2 unit incorporated the changes to fire protection regulations.

III-2.3.5.2. Implementation status of modifications/changes

The changes to the fire protection regulations for the T2 unit and the fire safety reviews led to the recommendation and then installation of new active and passive protections, taking account of:

- the nature of the heat loads in addition to their size, in order to understand the growth of the fire;

- the PICs;
- the routes needed for access in the event of a fire to the locations necessary for attaining and maintaining a safe state;
- the unavailability or failure of an active or passive fire risk protection provision;
- the classification of new types of rooms with minimal active or passive fire risks protection provisions.

The changes to the methodology enable the design principles to be consolidated through the use of new basic data. This approach more specifically improves the robustness of the safety case by specifically addressing situations with safety implications under the proportionality principle. In accordance with defence in depth and by virtue of the deterministic approach and the failure principle previously described, additional provisions are defined.

III-2.3.6. Licensee's experience of fire safety analyses

III-2.3.6.1. Overview of strengths and weaknesses identified

The regulatory changes led to consolidation of the categories of rooms identified in the design. The following additional categories of room types with comparable fire risk treatment procedures were in particular defined:

- rooms with PIC;
- rooms classified as protected routes;
- warehousing and storage rooms;
- rooms on the front of zone 4[11] and rooms with blowing transfer to the zone 4 rooms containing solvent.

The common provisions per standard family of rooms are listed and detailed in the methodological baseline requirements.

Moreover, these changes overcame the weakness in the design, based solely on heat load thresholds below which no provision was made.

In addition, the changes in the methodology since the design were implemented through a visit to each room. The benefits of this visit are to confirm:

- the characteristics of the room (type and quantities of heat loads, ignition sources, presence of targets, etc.);
- the configuration of the room (environment, accessibility, existing active and passive fire protection provisions, etc.).

[11] A Zone 4 premises corresponds to the radiological classification of a "red" zone and is subject to radiation protection criteria, in particular an effective dose threshold above 100 mSv/h. Access to these premises is prohibited due to the radiological conditions inherent to the process.

III-2.3.6.2. Lessons learned from events, reviews, fire safety related missions, etc.

The discussions with ASN during the latest periodic safety review led to the adoption of additional principles:

- the analysis of the unavailability or failure of a fire risk management provision;
- the classification of the rooms using the revised methodological baseline requirements;
- the detailed and extensive analysis pursuant to the proportionality principle, to highlight the correct treatment of the PICs with significant safety implications.

The documentary baseline requirements were consolidated accordingly.

In addition, the treatment of the protected routes shall ensure that their accessibility is maintained. Experience feedback shows that defining sectorisation measures in the rooms served and with a fire risk is an improvement that facilitates the response.

III-2.3.7. Regulator's assessment and conclusions on fire safety analyses

III-2.3.7.1. Overview of strengths and weaknesses identified by the regulator

In 2019, the licensee updated its "fire safety baseline requirements" in response to a request from ASN issued during the last periodic safety review. This led to a certain number of improvements to management of the fire risk. For example, the licensee explicitly defines the provisions for each of the principles of defence in depth. Or, in its fire risks analysis, Orano also explains that it uses a deterministic approach to study incipient fires in rooms containing certain PIC, as well as in adjacent rooms. ASN considers that the work done by the licensee is acceptable.

III-2.3.7.2. Lessons learned from inspection and assessment as part of the regulatory oversight

The periodic safety reviews offer an opportunity to observe a continuous improvement in the fire risk management provisions in the installation. The latest inspections used a "field" approach to confirm the implementation of these improvements, deemed by the inspectors to be on the whole acceptable.

III-2.3.7.3. Conclusions drawn on the adequacy of the licensee's fire safety analyses

The data considered in the fire risk analyses are acceptable. The licensee shall continue with its efforts in order to maintain a satisfactory level of fire risk management.

IV- Fuel fabrication facility - MELOX – BNI 151

IV-2.3.1. Types and scope of the fire safety analyses

The fire risk analysis which contributes to the Mélox nuclear safety case is performed using a prudent deterministic approach which includes the principle of defence in depth applied to the management of fire risks. The analysis aims to guarantee that the following safety functions are performed in a fire situation, so that the installation can be brought to and maintained in a safe state:

- containment of radioactive substances and hazardous chemical substances;

- control of nuclear chain reactions;
- removal of the thermal power produced by the radioactive substances and nuclear reactions;
- protection of people and the environment against ionising radiation.

Defence in depth as applied to a fire comprises:

- preventing fires from breaking out;
- detecting and rapidly extinguishing incipient fires, on the one hand to prevent them from growing and, on the other, to restore a normal operating situation;
- mitigating the growth and spread of a fire which could not be brought under control in order to minimise its impact on nuclear safety and enable a safe installation state to be attained or maintained;
- allowing the management of accident situations resulting from a fire which could not be brought under control, in order to mitigate the consequences for people and the environment.

In addition, a probabilistic analysis is performed for the generalised fire scenario in a production room using nuclear material in powder form. This scenario corresponds to an installation design-basis accident. This probabilistic analysis aims to confirm the adequacy of the various defence barriers defined with the deterministic approach and, failing which, to reinforce this adequacy.

IV-2.3.2. Key assumptions and methodologies

Identification of protection-important components (PIC)

The fire risk analysis identifies the PICs to be protected from the effects of a fire, taking account of the safety functions to be maintained in a fire situation. These being:

- PICs directly performing static and dynamic containment protection functions;
- PICs directly performing protection functions to maintain sub-criticality by geometry control, moderation and poisoning;
- PICs directly performing protection functions to maintain a cooling flow rate (for rooms with significant risk of heat release), and remove the heat produced by storage of fuel rods (STE) and assemblies (TAS);
- PICs directly performing criticality accident detection, monitoring of stack releases and ionising radiation source detection functions;
- PICs directly performing power supply functions for the back-up and remediation functions;
- PICs participating in fire detection and the corresponding auxiliary systems, in extinguishing and in fire sectorisation.

The fire risk analysis also identifies the structures of buildings containing or supporting safety targets, which must be stable in the presence of a fire.

The requirements associated with these PICs may differ according to the nature of the PIC:

- design requirements concerning the room containing the PIC (case of requirements relating to the room's detection, extinguishing, sectorisation means);
- design requirements concerning the PIC (case of requirements relating to the fire reaction or resistance of the equipment);
- requirements concerning fire-fighting procedures (particular case of rooms in which the use of water is prohibited dur to a risk of criticality);
- periodic checks and tests requirements.

Identification of protected routes

Despite the presence of a fire in the installation, certain rooms must be accessible in order to bring the installation to and maintain it in a safe state.

The fire risk analysis thus identifies the local actions needed to bring the installation to and maintain it in a safe state. These actions are:

1. Monitor the filtration systems for the gases extracted upstream of the stack discharges and, if necessary, configure the network.
2. Locally actuate the required fire-fighting devices (fire dampers on the ventilation networks, ventilation valves, activation of fixed gas extinguishing systems). These local actions are carried out if the remote-control system is unavailable or has failed.

The rooms containing these actions shall be accessible by means of at least 2 routes. When this is not the case, the parts of the single route are classified as a "protected route". The protected routes have fire resistant (EI) floors, walls and doors. They are marked and kept clear at all times, to facilitate the circulation and intervention of the emergency teams.

Identification of fire risks and risk control provisions

For each room or group of rooms, the risks analysis identifies the presence of potential safety targets previously identified and the potential fire sources (fuels, oxidising substances and ignition sources).

These rooms or groups of rooms are distributed into five types of fire scenarios, referenced A to E. These types of scenarios are defined according to their potential severity and their impact on the safety targets:

- Fire in a room containing nuclear material:
    - situated on the boundary of the 3rd containment barrier, containing glove boxes or waste containers, — type A
    - not meeting the type A criteria. — type B
- Fire in a room not containing nuclear material:
    - containing a PIC to be protected against the effects of a fire, — type C
    - constituting a protected route, — type D
    - without a PIC to be protected against the effects of a fire. — type E

The fire risk management provisions are then specified for each type of room: means for detecting an incipient fire, extinguishing means, sectorisation provisions to limit the spread of a fire.

The adequacy and sufficiency of the risk management provisions are evaluated qualitatively, ensuring that the levels of defence in depth are complied with and are whenever possible independent of each other.

If necessary, additional quantitative analyses using a computer code are able to check particular points: robustness of sectorisation element, civil engineering stability.

IV-2.3.3. Fire phenomena analyses: overview of models, data and consequences

Several studies have been carried out, with the support of an engineering firm specialised in fires, as part of the installation's periodic safety review. The approach is the following:

1. Definition of a reference fire scenario taking account of the characteristics of the room analysed and these fire risks.
2. Evaluation of the effects of temperature and pressure by modelling the reference fire.
3. Verification of the robustness of the fire sectorisation elements to the thermal effects.
4. Verification of fire stability by thermomechanical modelling of the civil engineering elements.
5. Verification of the robustness of the containment sectorisation elements to the effects of pressure by calculation of the mechanical integrity of the system.

Application case

<u>Verification of the fire robustness of a sectorisation panel</u>

In the unit fabricating the powder mixtures, panels are installed in certain concrete walls. These panels, which are not used in normal operation, enable large items to be brought in or out when modifications are made to the units or during decommissioning. In normal or accident operating situations, these panels have a fire resistance requirement and a nuclear materials tightness requirement.

The reference fire scenario is characterised by a fire in the biological shielding located on the gloveboxes. The initial fire is located close to the sectorisation panel. The combustible material is PMMA [poly methyl methacrylate] which makes up the biological shields. The kinetics of fire growth are rapid. The ventilation conditions are studied in several configurations:

- outbreak and growth of the fire with blowing and extraction maintained in the room's ventilation;
- fire driven by the ventilation with blowing shutdown and extraction maintained in the room's ventilation;
- fire driven by the ventilation with shutdown of blowing and of extraction in the room's ventilation;
- release of extinguishing gas with extraction being maintained in the room's ventilation.

The evaluations of the effects of temperature and pressure are made by modelling of the reference fire using the CFAST computer code, developed by the National Institute of Standards and Technology (NIST), in these various ventilation configurations.

Verification of fire stability of the floor

The study aims to evaluate the modelled effects of a realistic fire on the ceiling of the rooms of a unit containing nuclear material powder. The reference fire scenario is characterised by a fire in the biological shielding located on the gloveboxes. The initial fire is located close to the ceiling. The combustible material is the material which makes up the biological shields, that is PMMA [poly methyl methacrylate]. The kinetics of growth are rapid. The room considered in the model is not real: it is a volume containing the most unfavourable conditions of all the rooms in the unit. The software used for this study is FDS 6 (Fire Dynamics Simulator) developed by the National Institute of Standards and Technology (NIST). The thermomechanical study used to check the stability of the civil engineering structure is performed using the SAFIR software.

Analysis of the fire resistance of the rooms classified as fire sector and containment sector

The studies on the one hand concern a group of laboratory rooms, and on the other, a waste treatment room. These rooms comprise walls or a ceiling which are at the boundary of the last containment barrier. The studies take account of:

- the overall behaviour of the structural elements;
- the penalising stresses linked to any contact with the flames;
- the potential effects of the ageing of the concrete and steels.

The fire is located, in a conservative manner, so as to obtain the maximum effects on the structures. The fuel consists of polycarbonate (glove box panels) and cellulose materials. The kinetics of growth are considered to be rapid. The software used for this study is FDS 6. The thermomechanical study used to check the fire resistance of the civil engineering structure is performed using the SAFIR software. The thermomechanical study on the structures also evaluates the thickness of the compressed concrete in a fire situation, in order to demonstrate that static containment is maintained.

IV-2.3.4. Main results / dominant events (licensee´s experience)

Modelling results

Verification of the fire robustness of a sectorisation panel

The maximum effects are observed for the ventilation configuration corresponding to growth of the fire with blowing and extraction maintained in the room’s ventilation.

With regard to the fire sectorisation elements, the analysis of the worst-case fire growth curve and the fire resistance performance curves demonstrates the robustness of the panels and the door unit for the duration of the fire.

With regard to the containment sectorisation elements, the mechanical integrity of the door unit under the maximum pressure effects is demonstrated. However, the deformation observed during the initial tests associated with the calculated pressure effects cannot rule out a significant increase in the play in the door unit in a fire situation. Mechanical reinforcement to prevent all opening of the door under the effects of pressure has thus been started.

Verification of fire stability of the floor

The load-bearing structure of the powders unit is demonstrated to be:

- stable to fire for three hours, in a conventional fire;
- stable to fire for the entire duration of exposure to a real fire (i.e. 48 hours considering the maximum heat load of the rooms).

Analysis of the fire stability of the rooms classified as fire sector and containment sector

The structure of the rooms studied is demonstrated as being stable to fire for the entire duration of exposure to a real fire.

Thus, the fire risk management provisions were appropriate for limiting growth of the fire and its propagation to the entire heat load, thus preventing loss of the containment provided by the concrete walls.

Estimation of potential consequences of fires

For each room containing nuclear material, the safety analysis presents an estimate of the radiological consequences in the event of a fire. On the basis of a plausible scenario, some or all of the quantity of nuclear material is considered to be dispersible by the fire. The factors governing return to suspension are taken from the literature or from scientific tests and vary according to whether or not there is static containment of the nuclear material. The first level of filtration is considered to be lost and the last level of filtration is considered to be operational, with a decontamination factor of 5.10^{-4}. The fire duration postulated is set at two hours.

The values obtained are compared with the values defined by the general safety objectives for a target population located 2 km from the site. An accident situation should not lead to exposure of the public in excess of 1 mSv. A design-basis accident situation (case of a fire in a room containing significant quantities of MOX powder) should not lead to exposure of the public in excess of 10 mSv.

Otherwise, additional fire risk management provisions shall be adopted until the estimated consequences comply with these limit values.

IV-2.3.5. Periodic review and management of changes

IV-2.3.5.1. Overview of actions

The 2021 review file, which includes the elements presented above, is currently being examined. Any improvements to the analysis method as a result of this review will be taken into account following this examination.

IV-2.3.5.2. Implementation status of modifications/changes

In addition to the risk of occurrence, growth and spread of the fire, the fire risks analysis includes an analysis of their effects on bringing the installation to and maintaining it in a safe state in a fire situation: identification of the PICs and routes to be protected, demonstration that safety functions are maintained, verification that the consequences of the fire comply with the general safety objectives.

IV-2.3.6. Licensee's experience of fire safety analyses

IV-2.3.6.1. Overview of strengths and weaknesses identified

Strong points

<u>Consideration of the common mode risk</u>

The redundancy of the PICs to be protected from the effects of the fire and their physical separation avoids the loss of the function owing to a common mode effect.

This is in particular the case of all the equipment taking part in safeguarding the installation, which is installed in separate rooms; this is for example:

- the gloveboxes ventilation extraction fans;
- the ventilation extraction fans for ventilation of the rooms containing nuclear materials;
- back-up electricity generating sets;
- back-up cables (power and I&C);
- etc.

<u>Consideration of the risk of internal failure</u>

Through a deterministic approach, the plausible failures of the fire protection provisions are determined in order to ensure that despite the unavailability of the PIC required, the fire growth scenario cannot on its own experience a cliff-edge effect and lead to unacceptable consequences.

Thus, for a group of PICs participating in management of the fire risk (detectors & analysers, safety automation, sectorisation elements, extinguishing systems, remote-control system), the safety analysis identifies the protective measures in the event of unavailability or failure.

IV-2.3.6.2. Lessons learned from events, reviews, fire safety related missions, etc.

The regulatory context has notably changed since the installation was created. The fire risks analysis is supplemented by data demonstrating that the installation is maintained in a safe state despite the occurrence of a fire. The safety case goes well beyond the heat load density threshold considerations identified in the design of the plant.

IV-2.3.7. Regulator's assessment and conclusions on fire safety analyses

IV-2.3.7.1. Overview of strengths and weaknesses identified by the regulator

The fire response services are located on a nuclear site where other nuclear installations are located and are shared, thus enabling this BNI to benefit from a large-scale response force not limited to its own requirements alone.

In addition, Orano mainly carried out deterministic analyses to demonstrate that the prevention, detection and response provisions are sufficient and that the consequences of a fire are limited (in accordance with the defence in depth principle). These analyses take account of the elements contributing to the protection of the environment and liable to be directly or indirectly impacted by the effects of a fire, including the civil engineering of the buildings, gloveboxes, electrical power supply cables, etc. Orano also uses computing whenever necessary to model hazardous phenomena or structures to find out their behaviour in the case of a fire. In order to consolidate or supplement its analysis based on a deterministic approach, Orano also carried out a probabilistic assessment for all fire scenarios with a potentially high probability of occurrence and associated consequences. For each of these scenarios, this analysis consists in checking that the major consequences are only associated with the loss of one or more protection provisions, leading to a very low probability of occurrence.

These analyses aim to ensure a high level of protection. Moreover, the licensee is required to review control of the risks and detrimental effects associated with their installations every ten years. A periodic review such as this notably aims to improve the level of its management of the risks and detrimental effects, notably from the fire risk viewpoint. This review and the inspections performed contribute to the process of continuous improvement.

As the facility uses materials that present a criticality risk, the use of water as an extinguishing agent is strongly restricted in many premises, which means that particular attention must be paid to fire protection measures to prevent fires from starting and spreading.

IV-2.3.7.2. Lessons learned from inspection and assessment as part of the regulatory oversight

No major anomaly has been found during the inspections made within BNI No. 151 over the past five years on topics related to fire risk management provisions. The inspectors concluded that the risk management provisions were satisfactory and that the handling of any anomaly or observation made also contributed to the process of continuous improvement (see Chapter 3).

IV-2.3.7.3. Conclusions drawn on the adequacy of the licensee's fire safety analyses

The licensee demonstrates that the fire risk management provisions are sufficient, by means of a deterministic approach taking account of the principle of defence in depth and supplemented by a probabilistic approach with various fire scenarios. Regular inspections verify compliance with these provisions throughout the installation and the ten-yearly reviews of the sufficiency of these provisions ensure continuous improvement of the installation's level of safety.

2.4. Dedicated spent fuel storage facility La Hague – SFP D (T0) BNI 116

2.4.1. Types and scope of the fire safety analyses

For all basic nuclear installations, the general objectives are to limit exposure of workers, members of the public, the environment and, more generally, the protected interests, to ionising radiation and to chemical substances or, in certain cases, to thermal or mechanical effects. In order to comply with these General Safety Objectives (OGS), Safety Functions (SF) are defined for the pool D building in compliance with the following fundamental principles which guarantee:

- the containment of radioactive substances;
- the control of nuclear chain reactions (criticality risk);
- the removal of the thermal power produced by the radioactive substances and the nuclear reactions;
- the protection of people and the environment against ionising radiation;
- the controlled distribution of the auxiliary functions;
- the controlled use of hazardous substances.

In accordance with the French regulations, the management of fire risks takes account of the defence in depth principle, with the following four levels:

- the prevention of the outbreak of fire through the management and monitoring of the heat load and ignition sources;
- the early detection and rapid extinguishing of incipient fires to:
    - on the one hand, prevent them from growing,
    - and on the other, to restore a normal operating situation or, failing which, reach and then maintain a safe state in the BNI;
- mitigating the aggravation and propagation of a fire which could not be brought under control in order to minimise its impact on nuclear safety and enable a safe BNI state to be attained or maintained;
- the management of accident situations resulting from a fire which could not be brought under control, in order to mitigate the consequences for people and the environment.

All the technical measures associated with these levels of defence are defined using the regulatory approach of proportionality with the safety issues identified.

In a fire situation, the main objective is to verify that these safety functions remain functional. The analysis of each safety function determines whether or not the loss of their PICs (Protection-Important Components) leads to loss of the safety function in which they participate and thus identify the "PIC to be protected from the effects of a fire" which simultaneously meet the following three target criteria:

- the PICs can be impacted by the postulated plausible fire scenarios;

- the PICs that have no functional redundancy or for which the functional redundancy can be impacted simultaneously with the associated PIC by the same plausible fire scenario;
- the PICs for which the loss (regardless of the type of hazard) leads to the loss of the safety function in which they participate.

This choice is worst-case because:

- It is independent of the existing and recommended provisions for controlling fire-related risks;
- It is based solely on the notion of the inherent design of the PIC.

2.4.2. Key assumptions and methodologies

The fire protection at the design of the pool D building is based on acceptability criteria according to the evaluation of the "probability-radiological consequences" combination. The risks are arranged in probability classes. A threshold of acceptable consequences is set for each class. This method is applied to the configurations that are in principle favourable to the growth of a fire with nuclear consequences. It leads to the definition of prevention, monitoring and extinguishing means.

The analysis is carried out in the following situations:

- in normal operating conditions;
- in maintenance operating conditions;
- in the event of an accident with an origin outside the Facility (i.e. lightning, earthquake).

The evaluation of the potential importance of a fire is characterised by:

- the calorific potential;
- the systematic qualitative and quantitative inventory of the combustible materials present;
- the physico-chemical characteristics of these combustible materials;
- the fire spread characteristics: kinetics that are rapid (powders, liquids or gases) or slow (solid combustible materials).

Furthermore, the current fire safety review of the pool D building, which includes regulatory changes regarding fire risk management, confirms the validity of the fire risk analysis. This reinforcement in particular incorporates the verification that the safety functions remain entire and functional in fire situations, by studying:

- the PICs needed for the safety functions present in the unit, to bring it to and keep it in a safe state;
- the routes needed by the personnel and the emergency services for access in the event of a fire to the locations necessary for attaining and maintaining a safe state in the unit ("protected routes").

In all the analyses, the incipient fire is always postulated deterministically, barring special cases to be substantiated (such as the presence of only non-combustible materials in an inaccessible room). Its growth is studied on a worst-case basis by assuming the combustion of all the combustible materials present and its effects.

The methodology adopted to confirm the validity of the fire risk analysis of the pool D building is based on:

- A classification of the rooms which ensures application of the generic and minimal fire risk management provisions. It is drawn up following a systematic inspection of all the inspectable rooms;
- The study of the unavailability or failure of a fire risk management provision. This procedure allows an assessment of the compensatory measures planned in the event of unavailability or failure of the provision and thus reinforces the level of validity.

2.4.3. Fire phenomena analyses: overview of models, data and consequences

The fire is assumed to be confirmed according to the methodology applied to the pool D building. The impact on the targets identified in the rooms is thus adopted on a worst-case deterministic basis. This approach systematically leads to the adoption of active and passive fire protection measures in order to maintain the unit in a safe state.

The impact calculations evaluated in the safety assessments are made:

- independently of a plausible fire scenario;
- ignoring the presence of DAI and the beneficial effects of a response (failure principles within the framework of the defence in depth principle);
- on the basis of dispersion by the fire of all of the source terms, regardless of time;
- using the return to suspension coefficients taken from the literature or from tests.

The integrity of the construction provisions of the civil engineering structures (concrete walls and absence of glazed walls) and the DNF (monitored through the operation of the ventilation notably in the event of a fire) is considered.

2.4.4. Main results / dominant events (licensee´s experience)

None of the experience feedback about fire in the pool D building led to any change to the fire risk analysis methodology for the pool D building.

2.4.5. Periodic review and management of changes

2.4.5.1. Overview of actions

The methodological baseline requirements for the pool D building incorporated the changes to the fire protection regulations (see 2.4.2).

2.4.5.2. Implementation status of modifications/changes

The changes to the fire risk analysis consolidate the design principles through the use of new basic data. It more specifically improves the robustness of the safety case by specifically addressing situations with safety implications. In accordance with defence in depth and by virtue of the deterministic approach and the failure principle previously described, additional provisions are defined.

2.4.6. Licensee's experience of fire safety analyses

2.4.6.1. Overview of strengths and weaknesses identified

Since the drafting of the design baseline requirements for Basic Nuclear Installation 116 (BNI No. 116), which contains the pool D building, the definition of standard rooms has been adopted. This approach is a means of applying the same minimum fire protection provisions for the same danger situation.

The changes to the regulations (see 2.4.2) led to the reinforcement of the typology of rooms identified in the design. Thus, the following additional room types with an identical fire risk were notably defined:

- rooms with PIC;
- rooms classified as protected routes.

These changes also overcome the weakness in the design, based solely on heat load thresholds below which no provision was made.

During the ten-yearly outage reviews, each room is inspected in order to confirm the following from the fire risk viewpoint:

- the characteristics of the room (type and quantities of heat loads, ignition sources, presence of targets, etc.);
- the configuration of the room (environment, accessibility, existing active and passive fire protection provisions, etc.).

2.4.6.2. Lessons learned from events, reviews, fire safety related missions, etc.

The discussions with ASN during the latest periodic safety review led to the adoption of the rooms' classification using the revised methodological baseline requirements.

2.4.7. Regulator's assessment and conclusions on fire safety analyses

2.4.7.1. Overview of strengths and weaknesses identified by the regulator

In 2019, the licensee updated its "fire safety baseline requirements" in response to a request from ASN issued during the latest periodic safety review. This led to a certain number of improvements to management of the fire risk. For example, the licensee explicitly defines the provisions for each of the principles of defence in depth. Or, in its fire risks analysis, Orano also explains that it uses a deterministic approach to study incipient fires in rooms containing PIC of level 1 and 2, as well as in adjacent rooms. ASN considers that the work done so far by the licensee is acceptable.

2.4.7.2. Lessons learned from inspection and assessment as part of the regulatory oversight

The periodic safety reviews allow continuous improvement in the fire risk management provisions in the installation. The latest inspections used a "field" approach to confirm the implementation of these improvements, deemed by the inspectors to be acceptable.

2.4.7.3. Conclusions drawn on the adequacy of the licensee's fire safety analyses

The data considered in the fire risk analyses are acceptable. The licensee shall continue with its efforts in order to maintain a satisfactory level of fire risk management.

2.5. On-site storage radioactive waste storage La Hague – Silo 130 - BNI 38

2.5.1. Types and scope of the fire safety analyses

For all basic nuclear installations, the General Safety Objectives (OGS) are to limit exposure of workers, members of the public, the environment and, more generally, the protected interests, to ionising radiation and to chemical substances or, in certain cases, to certain thermal or mechanical effects. In order to comply with the OGS, Safety Functions (SF) are defined for silo 130 in compliance with the following fundamental principles which guarantee:

- the containment of radioactive substances;
- the control of nuclear chain reactions (criticality risk);
- the removal of the thermal power produced by the radioactive substances and the nuclear reactions;
- the protection of people and the environment against ionising radiation;
- the controlled distribution of the auxiliary functions;
- the controlled use of hazardous substances.

Silo 130, which was commissioned in 1973, was mainly used for dry storage of waste from the removal of cladding from spent fuels (magnesium plugs, graphite sleeves, etc.) from the gas-cooled reactor (GCR) plant series, between 1966 and 1987. A fire in 1981 led to the pits being flooded and contaminated soil being stored alongside the waste. Silo 130 was given final shutdown and decommissioning authorisation, which requires the retrieval and conditioning of the waste (RCD) present in pit 43. RCD led to specific work being carried out:

- The initial building was extended in order to house the waste retrieval and sorting cells and the harrow operations room;
- A new waste conditioning building comprising the cells for waste quantification and filling of the ECE drums (storage drums for hulls and end caps underwater), which are removed from the building. The conditioning cells are connected to the retrieval and sorting cells by a connecting gallery allowing transfer of the waste on a trolley;

- Several modular buildings, essentially containing the control room, the electrical rooms and the back-up electricity generating set room providing back-up electrical power for the retrieval installations (including the fans of the ventilation, fire detection and extinguishing system).

This final shutdown and this decommissioning changed the unit's fire risk management in order to take account of the fire risk generated by the new layouts linked to the process of this RCD. The Silo 130 unit is notably designed to control the fire risks generated by the storage and handling activities and by its environment. In accordance with the regulations, fire risk management (MRI) is based on the following four levels of defence in depth:

- the prevention of outbreaks of fires through the management and monitoring of the heat load and ignition sources;
- the detection and rapid extinguishing of incipient fires to:
    - on the one hand, prevent them from leading to a declared fire,
    - and, on the other, to restore a normal operating situation or, failing which, reach and then maintain a safe state in the unit;
- mitigating the aggravation and propagation of a fire which could not be brought under control in order to minimise its impact on nuclear safety and enable a safe BNI state to be attained or maintained;
- The management of accident situations resulting from a fire which could not be brought under control, in order to mitigate the consequences for people and the environment.

All the technical measures associated with these levels of defence are proportionate to the unit's safety implications.

Owing to the specific nature of the silo and the specific risks linked to the waste retrieval operations, the analysis of the fire risk consists of two steps:

- Study of the fire risk in silo 130;
- Specific study of the fire risk linked to the RCD process, due to the presence of the following among the waste stored in the pit:
    - Uranium hydride (UH_3) in divided form, possessing low ignition energy and which is therefore easily flammable at ambient temperature and consequently a potential source of an incipient fire, with UH_3 forming through oxidisation of uranium in contact with water,
    - Magnesium (Mg) and uranium (U) in flammable chemical form (divided and not completely oxidised), which can cause an incipient fire to spread,
    - Graphite which can also take part in the spread of a fire, in certain temperature conditions and in certain physico-chemical forms,
    - Technological waste (plastics in particular) participating in the spread of any incipient fire.

2.5.2. Key assumptions and methodologies

The study of the fire risk in silo 130 is based on:

- Determination of the sensitivity of the rooms to an incipient fire, based on:
  - the potential flammability defined according to the combustible materials present in the rooms (nature, quantity and distribution around the rooms),
  - the characteristics of the ignition sources present in the rooms;
- The identification of the Protection-Important Components (PIC) that could be impacted by a fire, along with the rooms and routes needed for evacuation of the personnel and access by the emergency services.

The specific study of the fire risk linked to the process consists in defining the targets, studying the ignition sources and demonstrating the adequacy of the prevention, monitoring and consequences mitigation means. This study is particular in that it is carried out jointly with a research and development (R&D) and tests programme. The targets identified following an incipient waste fire, are, taking account of the propagation risk:

- the waste present in the silo, in the retrieval, sorting and conditioning cells and in the transfer tunnel;
- the evacuation and response routes (by spread of a fire to the rooms accessible to the personnel);
- the equipment participating in bringing the installation to and keeping it in a safe state in a fire situation (notably the filters of the first filtration barrier at extraction from the cells).

2.5.3. Fire phenomena analyses: overview of models, data and consequences

The R&D and tests programme performed for the fire risk analysis comprises:

- corrosion and crushing tests in order to characterise the layer of magnesium oxidised in this way and evaluate the effects of the retrieval gripper's actions on the risk of generating an incipient waste fire;
- tests of fire spreading to the waste to study the conditions for inflammation of a mixture of waste containing uranium hydride and the spread of the fire which is thus initiated to the other waste present in the pit;
- detection and extinguishing tests to:
  - Define a numerical model in order to simulate the growth of the fire and the effectiveness of the detection and extinguishing means,
  - Using the results of the tests, check the validity of the numerical model and perform a sensitivity study using this model.

The extinguishing tests were carried out according to the following phases:

1. Theoretical analysis and preliminary tests;

2. Laboratory scale tests: extinguishing, prevention and quantification of particle emissions;
3. Large-scale tests: representativeness in terms of the silo's actual environment with:
    - a modelling phase allowing a preliminary evaluation of the phenomena and a sensitivity study on the influence of the various parameters;
    - a large-scale testing phase aiming to reproduce the conditions for extinguishing a fire in a pit on an 80 m3 mock-up;
    - a modelling phase initially allowing validation of the pertinence of the modelling tool by comparison with the experiment (reproduction of the experimental results using the model) and secondly allowing extrapolation of the experiment results to the scale of the storage pit.

During these tests, the following were studied:

- the behaviour of the ventilation;
- the changes to the head loss in the filters;
- the effectiveness of extinguishing: fire extinguishing phase by high-flow argon injection then transition to half-flow for the waste cooling phase.

2.5.4. Main results / dominant events (licensee´s experience)

The tests were able to demonstrate:

- the large quantity of energy needed to ignite the magnesium, given its storage conditions;
- the effectiveness of the optical detection system placed in the ventilation extraction duct;
- the effectiveness of the extinguishing strategy adopted;
- the low thermal power of the fire should a fire break out;
- a slight increase in the temperature in the room;
- a slight entrainment of particles to the atmosphere of the pit and thus to its ventilation network;
- the absence of clogging of the filters placed on the extraction network.

These tests also revealed the factors limiting the risks of the appearance of an incipient fire in the pit during the retrieval operations:

- the energy generated by the foreseeable impacts (gripper, rearrangements, falls, etc.), which is on the whole insufficient to initiate the outbreak of a magnesium fire;
- the humidity of the air which encourages cooling and slows down the spread of inflammation of the uranium hydride;
- sufficient humidity of the mixtures of uranium and uranium hydride, which prevents inflammation during impacts, in particular during the gripper operations;
- the sludges which are not ignited by a temperature rise (spread of a fire initiated by other waste) in dry or humid air;
- sufficient humidity to prevent the inflammation of the sludges in the case of impacts.

Moreover, the extinguishing tests enabled the scale of the monitoring and extinguishing means in the pit to be calculated.

2.5.5. Periodic review and management of changes

2.5.5.1. Overview of actions

Thanks to the fire studies carried out for RCD, it was possible to gain a clearer understanding of the hazardousness of the waste and the retrieval mechanisms defined.

2.5.5.2. Implementation status of modifications/changes

The changes to the fire protection of silo 130 led to the recommendation and installation of new active and passive protections on the design of the RCD system (see chapter 3).

2.5.6. Licensee's experience of fire safety analyses

2.5.6.1. Overview of strengths and weaknesses identified

The original design of the storage pit comprised no fire detection or extinguishing systems. The methodological changes led to specific analyses being conducted, concluding that fire risk management provisions were needed, in particular an automatic argon extinguishing systems for the pit. The effectiveness of this system has been confirmed by R&D tests.

2.5.6.2. Lessons learned from events, reviews, fire safety related missions, etc.

In 1981, a fire broke out in the storage pit. It was extinguished by flooding with water using means deployed by the site's emergency response teams through a hatch above the pit. There was no specific water injection system for this pit.

Since this event, most of the waste stored has been immersed in this volume of water. To meet any possible need, an additional water injection system has been installed.

The studies associated with the RCD operations supplemented and evaluated the adequacy of the levels of defence against a fire. ASN thus requested an evaluation of the time needed for "manual" implementation of argon extinguishing in the pit. The implementation time was too long and the licensee automated the operation of the pit argon extinguishing system.

2.5.7. Regulator's assessment and conclusions on fire safety analyses

2.5.7.1. Overview of strengths and weaknesses identified by the regulator

Silo 130 in BNI No. 38 was commissioned in 1973 and is currently being decommissioned. A fire occurred in 1981. Lessons were learned, leading to the implementation of new and specific prevention, monitoring and response provisions. The decommissioning of this facility now requires completion of the Waste Retrieval and Conditioning (RCD) operations for the waste produced from 1966 to 1987 and which is still in pit 43 where the fire occurred. These RCD operations began in 2021 and required the renovation of the facility. A fire risk safety analysis enabled the most recent fire regulation standards to be adopted. A significant R&D and tests programme was thus carried out in order to ensure the robustness of the fire risk evaluation and ultimately enable ASN to authorise the commissioning of the legacy waste retrieval equipment. These tests also revealed the factors limiting the risks of the appearance of an incipient fire in the pit during the retrieval operations and enabled the monitoring and extinguishing means in the pit to be reinforced (installation of automatic argon extinguishing).

The fact that part of the fire risk is due to the composition of the waste, which is not always fully characterised when it is removed from the pits, means that controlling the fire risk imposes constraints on RCD operations that can slow down the rate (need for identification or characterisation) or limit productivity (limited filling of drums).

2.5.7.2. Lessons learned from inspection and assessment as part of the regulatory oversight

The latest inspections on fire risk management show improvements in the licensee's material and organisational provisions. Fire safety standards have been taken into account and no major anomalies are now observable at this level.

2.5.7.3. Conclusions drawn on the adequacy of the licensee's fire safety analyses

Following the fire which occurred in the storage pit of silo 130 in 1981, the licensee has significantly improved the prevention, monitoring and response provisions. These provisions had to be adapted to the operating context of this facility (undergoing decommissioning, involving the retrieval of legacy waste (RCD)). The licensee's analysis of the fire complies with the safety requirements, primarily based on a deterministic approach, with implementation of the principle of defence in depth specifically adapted to the risks associated with the operation of this facility. For the sensitive RCD operations, the licensee is required to perform regular awareness-raising and training of the personnel with regard to the response to a fire, even if the pit is now equipped with an automatic argon extinguishing system.

2.6. Installations under decommissioning

I- Research reactor OSIRIS – BNI 40

I-2.6.1. Types and scope of the fire safety analyses

The fire risk analysis is part of the general safety approach for a nuclear facility. It's aim is to demonstrate that all technical and organisational provisions identified and implemented are able to prevent the risk of fire and mitigate the effects to a level as low as economically and technically achievable.

This analysis is carried out in accordance with the proportionality principle applied to nuclear safety issues. It should be able to demonstrate compliance with the facility's general safety objectives, taking account of fire accident situations identified by the risks analysis.

It ultimately allows a determination of the intensity and acceptability of the hazardous radiological and non-radiological phenomena liable to prejudice the interests to be protected (public health and safety, protection of nature and the environment).

To do this, the analysis is performed across the entire perimeter of the nuclear facility (inside and outside the buildings). The fire risk analysis also takes account of fire hazards located outside the perimeter of the facility (for instance: forest fires). This analysis concerns all the plausible operating states and the associated operations (operating transients, scheduled maintenance, etc.).

The two main documents containing the detailed demonstration of fire risk management and which are summarised in the facility's safety report, are:

- the fire risks management study;
- the fire stability study.

In short, the analysis allows:

- definition of an operating range authorised with regard to the fire risk and its incorporation into the facility's operating rules;
- identification of the fire protection activities and equipment important for the safety of the facility, allocating an appropriate level of requirements to them (sizing, monitoring, etc.).

This analysis takes account of the effects induced by the fire (prejudice to the stability of a load-bearing structure, bursting of a pressure vessel, etc.).

It is however carried out independently of the notions of combinations of induced fire events or scenarios (for example: fire following an earthquake) in order to take account of the fire risk independently. Additional studies are performed whenever the frequency of occurrence of combined events exceeds a magnitude of 10^{-7} per year and per facility.

I-2.6.2. Key assumptions and methodologies

The fire risk analysis is carried out on the first three levels of defence in depth (prevention, detection and mitigation of consequences). For the aspect relating to the fire safety of people, it is supplemented by verification of compliance with the prescriptions (evacuation, etc.) of the Labour Code contained in French legislation. It is performed using a geographical approach per study system (room, group of rooms, sector, fire zone or outdoor area) within the perimeter of the facility.

It is based on the following two main phases:

- a transverse methodological analysis consisting in ensuring compliance with the regulatory requirements and the sufficiency of the main fire risk management provisions (fire sectorisation, means of detection and extinguishing, etc.);

- a specific analyses phase consisting in determining the acceptability of the risk of the targets being impacted by the hazard.

It thus requires identification of the following:

- the targets which, following their deterioration, could lead to consequences for the protection of interests (hazardous substances, components important for the protection of interests, pressure vessels, etc.);
- potential fire scenarios (coupling between ignition sources and heat loads).

First of all, the identification of the safety targets carried out during the fire risk management study is based on the strategy used to achieve and maintain a safe state in the facility in a fire situation, which allows definition of the configuration of the facility in which the safety functions are controlled in a fire accident situation.

Secondly, the Structures, Systems, Components (SSC) needed to achieve and maintain the safe state are identified. Of these SSC, those requiring a specific analysis are the following:

- the SSC vulnerable to the direct (temperature, etc.) or indirect (fall of a load-bearing structure) effects of a fire;
- the SSC for which there is no segregated functional redundancy to ensure that they are robust to the effects of a given fire scenario.

Similarly, the activities needed to achieve and maintain the facility in a safe state are identified. An analysis specific to the activities to be maintained or performed in a fire situation (for example: management of facility containment) is carried out.

Specific analyses are designed to demonstrate that the Fire risk Management Provisions (DMRI) are sufficient to guarantee the integrity of the targets to be protected from the effects of the plausible fire scenarios liable to occur within the perimeter of the facility.

To do this, the “reference” scenarios are selected, which are the scenario(s) representative of a plausible fire:

- leading to the direct or indirect effects most prejudicial to the targets in question;
- for which the analysis should demonstrate the sufficiency of the existing DMRI and as applicable those recommended following the analysis.

On the basis of the reference scenarios, the internal failure of one of the DMRI considered for management of the reference scenario considered leads to a scenario called the "aggravated scenario”. This internal failure is postulated independently of the consequences of the trigger event, that is the fire. It should not result from a failure induced by the effects of the fire scenario considered. This internal failure does not apply to the passive, static, robust, correctly sized and maintained provisions. The analysis of the aggravated scenarios is able to verify the robustness of the demonstration and the absence of any “cliff-edge effect”.

These specific analyses are able to identify the scenarios most liable to generate dangerous radiological and non-radiological (toxic, thermal, etc.) effects, for which the consequences must thus be evaluated.

I-2.6.3. Fire phenomena analyses: overview of models, data and consequences

The fire risks analysis may require a quantification of the direct effects (thermal, etc.) or indirect effects (structural deformation, extinguishing water, quantity of radioactive substances emitted into the environment, etc.). Various tools can thus be used depending on the phase of the analysis and the values to be quantified.

The main values quantified and the tools used are as follows:

- Direct effects of fire (thermal, etc.): raw test data (flame temperature, production of species ratio, etc.), empirical formulas (flame height, temperature in the plume, etc.), zone models (hot layer temperature, etc.), numerical fluid dynamics models (soot, 3D representation of the geometry, etc.);
- Heat transfer and mechanical strength: The Eurocodes (fire parts: steel, concrete), finite element models (beams, plates, shells, etc.).

I-2.6.4. Main results / dominant events (licensee´s experience)

For most of the installations being decommissioned, the fire scenarios represent the accident scenarios most likely to lead to the mobilisation and dispersal of a non-negligible quantity of radionuclides within the facility or into the environment. The environmental releases may be gases/aerosols and/or liquids.

- Liquid: The control of liquid releases consists in ensuring that extinguishing agents are retained by various technical means to ensure that there is no flow of contaminated effluent into the environment (for example: leaktight basements, sluice gates, rainwater network isolation/transfer plugs/valves, retention ponds/equipment). The sizing of these retention means (volume of extinguishing agent to be recovered, etc.) uses the national rules recognised by the French nuclear safety regulator (ASN).
- Gas/aerosol: The control of gas/aerosol releases consists in placing the largest number of independent physical barriers between the radioactive source terms and the environment, that are resistant to the effects of a fire and relatively leaktight (static containment). Given the potential impact of the effects of a fire (thermal, pressure, etc.) on the static containment barriers, it is very hard to ensure that they remain leaktight in an accident situation. Thus, in the event of a fire scenario dispersing a non-negligible quantity of radionuclides into the facility, dynamic containment (airflow direction) and purified/filtered releases monitored for as long as possible must be maintained. The main fire scenarios liable to generate releases into the environment are identified by the fire risks management study and the radiological consequences thereof are evaluated. This evaluation notably takes account of the quantity of radioactive substances affected, the fraction placed in suspension, the re-deposition onto the walls of the facility and the

effectiveness of the filtration / purification. It shall be possible to justify each of these hypotheses. Hypotheses are also made for the calculation specific to the evaluation of the consequences (weather, height of releases, etc.).

Ultimately, the acceptability of the consequences of the scenarios analysed enables the sufficiency of the technical and organisational provisions to be verified, and then supplemented if necessary.

For the facilities undergoing decommissioning, the radioactive source term may require inspection and reconditioning prior to removal. The associated operations may increase the risk of dispersal of the substances (which are radio-toxic or even irradiating) owing to the effects of a fire (for example: cutting). For the purpose of these operations, it is therefore vital to place emphasis on the first levels of defence in depth (for example: use of cold cutting techniques).

I-2.6.5. Periodic review and management of changes

I-2.6.5.1. Overview of actions

All the actions (improvement plan, periodic checks and tests, maintenance, training, etc.) regarding the management of fire risks is managed by the licensee's Integrated Management System (IMS) which provides for the resources and means needed to perform them within the allotted time.

I-2.6.5.2. Implementation status of modifications/changes

The periodic safety reviews include a conformity analysis and a safety reassessment. The first consists in checking that the baseline requirements match the existing situation, with correction of any deviations observed. The second consists in improving the facility's level of safety, insofar as this is possible, by applying the safety baseline requirements in force and by implementing the Best Available Techniques (BAT).

Following the review, a conformity and/or safety level improvement action plan is defined. This plan is the result of the studies carried out by the licensees, any commitments made as a result of the examination by ASN and its technical support organisation and, as applicable, the technical prescriptions issued by ASN.

However, certain new operations scheduled (notably for a facility being decommissioned) cannot be incorporated into the risk analysis performed as part of the periodic safety review. These modifications require an authorisation level which depends on their importance (ASN, licensee) systematically based on a safety analysis which determines the fire risk management actions.

I-2.6.6. Licensee's experience of fire safety analyses

I-2.6.6.1. Overview of strengths and weaknesses identified

The fire safety analysis is part of a performance obligation approach enshrined in the regulations relating to the fire safety of nuclear installations. This approach, which is the opposite of the best-efforts obligation approach, enables the provisions to be adapted to the safety issues. It is particularly well-suited to the diversity of CEA's nuclear installations.

In this context, CEA conducts its analyses using proven methods recognised by ASN and its technical support organisation. Moreover, the emphasis placed on the first level of defence in depth (prevention) enables the number of outbreaks of fire in the installations to be significantly limited.

This method/approach nonetheless has drawbacks and advantages, that is:

- the complex nature of the analysis and the scale of the human resources needed;
- the need for a high level of expertise (contractors, licensee), involving:
  - the selection of “expert” contractors (production of framework agreements with stringent technical selection criteria),
  - a strong CEA internal organisation (support, oversight, internal rules, etc.).

I-2.6.6.2. Lessons learned from events, reviews, fire safety related missions, etc.

The experience acquired by CEA reveals incipient fires linked to hot-spot work within the nuclear installations. The risk analysis and the compensatory measures defined in the fire permit must be carried out rigorously.

In addition, the performance of fire safety analyses also highlights the importance of the following points:

- the application of operating instructions appropriate to the requirements (for example: avoid excessive management of heat loads in areas with low safety implications);
- the need to involve the site fire-fighters in these analyses in order to ensure that they are able to respond rapidly and effectively in the installation;
- the fire protection equipment included in these analyses being appropriate in terms of their level of confidence/qualification (periodic checks and tests, maintenance, etc.).

I-2.6.7. Regulator’s assessment and conclusions on fire safety analyses

I-2.6.7.1. Overview of strengths and weaknesses identified by the regulator

The safety report comprises the inventory of hazards in the installation, regardless of origin, along with the analysis of the provisions made to prevent these hazards and a description of the measures designed to limit the probability of accidents and their effects. The fire risks and the corresponding protection means are dealt with in the third volume of the Osiris safety report currently in force. For the examination of the decommissioning of the installation, a preliminary version of the safety report revision and a risk control study covering all the installation decommissioning operations which will be produced by CEA.

In addition, the fire risk management study (EMRI), on which the fire risks analysis is based, was updated in 2018 as part of the periodic safety review. This study comes with a monitored action plan in which CEA considers that there are six actions with level 1 priority (out of 3 levels), one with level 2 priority, and two with level 3 priority. Two P1 actions have been finalised, while the other four are in progress. The P2 and P3 actions are to be initiated and should be completed respectively for the second quarter 2025, and for the third and fourth quarters of 2024. The resulting improvement process should be seen as a strength. On the other hand, in the case of an old facility that was shut down several years ago, the systems involved in controlling fire risk are ageing, and the monitoring and maintenance requirements are not always easy to prioritise, which can be a source of weakness.

I-2.6.7.2. Lessons learned from inspection and assessment as part of the regulatory oversight

The EMRI presents the various means used in the installation to control the spread of a fire and mitigate the consequences. The ASN inspections on the topic of “fire and internal hazards” demonstrated that certain systems considered in the EMRI were not regularly inspected.

As part of the action plant resulting from the review EMRI, a feasibility study was carried out into the closing off of fire hatches in several rooms. The inspectors consulted the conclusions of this study, which rules on the technical feasibility of the use of additional thermal protections in these rooms. The performance of these works has yet to be scheduled.

I-2.6.7.3. Conclusions drawn on the adequacy of the licensee’s fire safety analyses

The fire topic action plan defined as part of the periodic safety review file has to a large extent been started but some actions are behind schedule and its monitoring and oversight could be improved.

As CEA is required to provide new data concerning the decommissioning file and the periodic safety review report for the installation before the end of 2023, it has not yet been possible for ASN to examine these data - notably concerning the changing fire risk in the light of decommissioning.

II- UNGG Saint-Laurent des Eaux - BNI 46

II-2.6.1. Types and scope of the fire safety analyses

In France, installations undergoing decommissioning remain Basic Nuclear Installations (BNI) until the final post-operational clean-out step.

In accordance with the regulations, the safety file includes the Fire Risks Management Case (DMRI).

Installations being decommissioned, such as the Saint Laurent GCR reactors present very limited risks for the environment and the populations. This is because there is no longer any fissile material present in these installations, as the fuel has been removed, and with it more than 99.9% of the radioactivity present in the installations. The safety functions still to be guaranteed are the containment of radiological material, and protection of the public against ionising radiation.

With regard to the non-radiological risks, the safety functions to be guaranteed are the containment of non-radiological hazardous materials and the protection of people and the environment against toxic, over-pressure and thermal effects and effects linked to the impact from projectiles.

The remaining radioactive source term is mainly located inside the reactors and primarily consists of non-dispersible radioactive materials (activated waste in the form of inert materials, mainly metal structures and equipment and large graphite bricks).

The main sources of the risks of dissemination of radioactive materials are the contamination and dust present on the activated waste in the reactor or in the systems, which can be set in motion during the dismantling operations or accidentally. The analyses and methods are thus appropriate for these issues.

The safety analyses for a BNI being decommissioned, such as BNI 46, consist in justifying management of the fire risk through a deterministic identification of the worst-case fire scenarios in terms of radiological or non-radiological effects (direct or indirect) on the protected interests (population and environment).

With regard to radiological releases, the safety objective is set for accident scenarios, divided into two distinct time periods:

- Short-term: The radiological consequences of accidents should not lead to the implementation of population protection measures. The lowest (effective) dose level set by ASN resolution 2009-DC-0153 of 18 August 2009 for the implementation of population protection measures is 10 mSv and corresponds to the response level for sheltering of the population in a radiological emergency situation. with regard to the scenarios identified for BNI 46, a maximum dose value of 10 mSv is thus identified for the short-term phase of accidents.
- Medium term: In the case of installations being decommissioned, owing to the low potential for radiological risk, a rapid return to a normal exposure level is aimed for. A check is performed to ensure that the sum of the effective doses received by the target population, as a result of the accident, remains of the same order of magnitude as the value mentioned in the Public Health Code for the sum of effective doses received by any member of the public as a result of nuclear activities in a normal situation (1 mSv/year).

With regard to non-radiological releases, the safety objective is set for accident scenarios as follows:

- The accidents with non-radiological consequences for the protected interests shall not be unacceptable (red zone) as defined in the risks ranking chart, derived from the regulations and based on the probability/severity pairings of the scenarios considered;
- The intensity of the effects of an accident is assessed against the reference values taken from the regulations. These reference values are expressed in the form of toxic effects, the effects of over-pressure, thermal effects and effects linked to impact by a projectile on people and structures.

Moreover, the fire safety analyses take account of situations resulting from combinations of trigger events.

The selection of the combinations and the dependency links taken into account in the safety case, is mainly performed pragmatically and on the basis of experience feedback, notably to identify the plausible combinations of independent failures and hazards with fire. The events linked by cause and effect and by domino effects are also examined.

The combinations selected are justified on a case-by-case basis, taking account of the existing design provisions.

For each decommissioning operation, the fire risks are considered throughout the process, from the preliminary design studies phase up to the works performance phase.

II-2.6.2. Key assumptions and methodologies

First of all, risk control is based on generic measures taken against fire, at the worksite design studies stage, applying the principle of defence in depth. This principle is based on the following successive levels of defence:

- preventing the outbreak of fire;
- the rapid detection and extinguishing of incipient fires to prevent them from leading to an actual fire;
- limiting the intensification and spread of a fire that could not be controlled, in order to minimise its effects;
- the management of accident situations resulting from a fire which could not be brought under control, in order to mitigate the consequences for people and the environment.

All the defence in depth provisions cover the technical, organisational and human aspects.

II-2.6.3. Fire phenomena analyses: overview of models, data and consequences

The safety case is based on a set of computing tools, primarily including:

- Simplified tools based on analytical approaches commonly used in the field of industrial risk management. For example, the toxic consequences of a fire are calculated using Gaussian dispersion models. The source term released and the release conditions are evaluated by analytical correlations (Heskestad correlations for example);
- Zone or field codes. These tools are used to evaluate the spread of the fire and its impact on the targets (for example, MAGIC and FDS codes);
- Thermomechanical codes. These tools are used to evaluate the response of an equipment item subjected to thermal stress as a result of the fire. (SAFIR code for example).

These tools are qualified, ensuring that their validity range covers their utilisation range. The utilisation range is defined from the physical analysis of the calculated configuration.

II-2.6.4. Main results / dominant events (licensee´s experience)

The fire risk management case at Saint Laurent shows very slight radiological consequences as a result of the worst-case accident:

- The short-term total effective dose (over 1h), calculated at 500 m from the release point, taking account of all the radionuclides and exposure routes by irradiation from the plume and by inhalation, is estimated at a maximum of 1.1×10^{-4} Sv for an adult, or less than 0.2 mSv;
- The medium-term total effective dose (over 1 year) calculated at 2,0000 m from the release point and taking account of all the radionuclides and exposure routes by irradiation from deposition on the ground and by ingestion, is estimated at a maximum of 1.7×10^{-5} Sv for an adult, or less than 0.02 mSv.

The calculations of the radiological consequences are based on worst-case hypotheses, such as failure to take account of the thermokinetic height increase of the smoke from a fire (cold release at ground level).

The non-radiological consequences (toxic and thermal) for the protected interests are excluded for most of the fire scenarios in the safety case. For the worst-case accident, the level of risk associated with the toxic consequences is considered to be tolerable (severity of "Moderate" level and improbable fire scenario).

II-2.6.5. Periodic review and management of changes

II-2.6.5.1. Overview of actions

The latest periodic safety review concluding report for BNI 46 was submitted in December 2017. During this review, EDF took account of the changes to the regulations, notably on the subject of fire, as well as the state of the installation in 2017 and the worksites for which the preliminary design studies were available at that date. This analysis showed a certain number of provisions that need to be implemented, such as:

- as necessary, the implementation of protection for equipment performing a safety containment function or compliance with a separation distance requirement;
- updating of the operating instructions for the medium-level waste packages storage areas, to limit or prevent the use of internal combustion engine machinery in certain zones.

These actions are grouped into an action plan, which is updated as and when necessary and the progress of which is forwarded annually to ASN.

II-2.6.5.2. Implementation status of modifications/changes

The modifications mentioned in the previous paragraph will be completed by the end of 2023 except for those linked to future worksites.

II-2.6.6. Licensee's experience of fire safety analyses

II-2.6.6.1. Overview of strengths and weaknesses identified

In addition to the regulatory requirements, the prevention measures applicable on the Saint Laurent dismantling site are derived from the local implementation of the operations baseline fire requirements applicable to all sites being dismantled. These operations baseline fire requirements notably take account of experience acquired on all the dismantling sites and on all EDF sites in operation, in particular the PWRs.

Any outbreak of fire must be characterised, so that the causes can notably be analysed and the practices then adjusted accordingly.

The number of fire outbreaks on the Saint Laurent A site (none in 2021 and 2022) testifies to good management of the fire risk.

The only significant fire-related event on a nuclear site being dismantled occurred in 2015 on the Brennilis site. In the final phase of a dismantling worksite teardown, a fire broke out in a site airlock within the reactor containment. The cause of this fire was an incipient fire on rags soaked in a decontaminating/degreasing product, following cutting of a cable saw with a grinder.

The analysis of this event showed weaknesses in the prevention of fire outbreaks, which have since been corrected (see Chapter F-II-3.1.3.3).

Analysis of this event also demonstrated the robustness of the safety analyses which had predicted this type of scenario and which had evaluated the consequences as very low (far lower than the safety objectives given in II-2.6.1) with respect to the interests to be protected. This fire in fact had no consequences, whether toxic or radiological, on the interests to be protected (population and environment).

II-2.6.6.2. Lessons learned from events, reviews, fire safety related missions, etc.

The safety analyses have changed significantly to take account of the range of experience feedback and the new regulatory requirements applicable to the latest periodic safety review. As indicated in the previous paragraphs, the fire risk management case makes a deterministic postulation of the fire scenarios, without considering the generic prevention provisions for all the activities conducted in BNI 46. It demonstrates that any countermeasures needed to achieve the safety objectives set by the regulations are sufficient, whether from the viewpoint of radiological or non-radiological consequences. The consequences are systematically evaluated for the worst-case scenarios.

II-2.6.7. Regulator’s assessment and conclusions on fire safety analyses

II-2.6.7.1. Overview of strengths and weaknesses identified by the regulator

The fire prevention, detection and fighting measures implemented on BNI 46 by EDF are standard risk management provisions for the nuclear facilities, based on defence in depth in accordance with the regulations in force.

II-2.6.7.2. Lessons learned from inspection and assessment as part of the regulatory oversight

The installation decommissioning activities are at a stage where only a few elements are still to be removed around the graphite blocks. These operations fall into the category of routine fire risks. The graphite blocks will only be concerned by the decommissioning operations in a few years’ time.

II-2.6.7.3. Conclusions drawn on the adequacy of the licensee’s fire safety analyses

With regard to the work in progress, the fire risk prevention measures are appropriate. They will need to be reassessed when the operations on the reactor vessels begin. This work is not expected before 2050. EDF will need to take account of the presence of carboxide and hydrogenated carboxide deposits, which could entail a risk of fire, explosion and poisoning during thermal cutting operations.

3. FIRE PROTECTION CONCEPT AND ITS IMPLEMENTATION

3.1. Fire prevention

A- Nuclear power plants

A-I- TRICASTIN 1 - 900 MWe series – post-4th periodic safety review

A-I-3.1.1. Design considerations and prevention means

Prevention consists in a series of measures which aim to prevent the outbreak of a fire or to reduce its probability of occurrence.

The potential risk of fire and its effects is limited by:

- Using materials and fluids that contribute to the fire load as little as is reasonably possible;
- Using cables with class C1 fire reaction rating. On this account, they satisfy the verification tests of article 2.2. of standard NF C 32-070. If it is technically impossible to use C1-class electrical conductors and cables, the use of another class shall be substantiated by a specific study considering the non-C1 cable(s);
- Using, for the structures of the buildings, materials compliant with class Mo (non-combustible) or A2s1d0 (defined in accordance with the order of 21/11/2002 amended (Euroclasses defined in accordance with European standard EN 13501-1) for their reaction to fire, or at least complying with class M2 or C for the equipment items. The use of class M3 or D materials is permissible in small quantities for particular cases such as adhesively-bonded coverings, for example;
- Measures to prevent any risk of outbreak of an electrical fire, such as earthing of the electrical installations to protect them against the effects of stray currents;
- Lightning protection measures;
- Measures to limit the quantities of combustible material to the strict minimum necessary for normal functioning of the facility;
- Measures to prevent conduits transporting inflammable fluids from being routed in the vicinity of surfaces whose external temperature exceeds 100°C. It is prohibited to install electric cables at less than 1 metre from conduits transporting inflammable fluids or from hot surfaces, except for the electric cables powering and controlling the equipment items that are attached to them.

In addition, permanent storage areas are planned for at the design stage. Temporary storage places for the fire loads, and their storage capacities, are determined in advance as part of the operating procedures (comprising the baseline requirements for fire load management and sectorisation management), but were not taken into account at the design stage.

In the context of improving prevention of the fire risk, EDF conducted studies aiming to reduce the fire risk originating from paper, wood, cardboard or oil in the rooms with safety impliations. The proposed measures consist in reducing the fire load present in the risk-prone premises. The following solutions shall be applied as appropriate for the type of fire load:

- replacement of wooden furniture by metal furniture;
- installation of fire-proof cabinets for storing paper and cardboard, or transfer of this fire load outside the areas with nuclear safety risks.

EDF has also studied the additional fire load risks associated with a hydrogen leak: failure of a component on a hydrogen network in the fire zone can effectively create an ignited jet of hydrogen, likely to temporarily increase the fire load (dihydrogen fire load) and thereby affect the fire sectorisation components present in the area of the jet. A modification is proposed to eliminate the risk of introducing hydrogen into premises with a high fire load in the event of fire. The solution consists in controlling the main valve of the hydrogen networks with the fire detection system: if fire is detected in the sensitive areas, the automatic system closes the valve and thereby stops the introduction of hydrogen into the lines that run through the fire zone.

Lastly, to confirm the robustness of the facility with respect to the fire risk, EDF extends the safety studies for electrical cabinet fires by considering a fire that develops independently of the ignition conditions, and self-sustained combustion.

A-I-3.1.2. Overview of arrangements for management and control of fire load and ignition sources

In order to prevent fire outbreaks, and complementing the constructive measures presented in paragraph A-I-3.1.1, operating rules also help to prevent fire outbreaks (preventive instructions with respect to the fire risk, management of the fire load, storage plan, provisional covers on hulls containing non-encapsulated waste, storage of solvents in a room or a fire-proof cabinet for example).

The electrical installations are maintained, kept in good condition and verified periodically.

In operation, prevention of the fire risk of the EDF facilities is based on organisational measures which aim to enhance management of the fire risk. They are established in line with the design provisions and adapted from the operational aspect in each facility. They concern in particular the management of the calorific potentials, the use of inflammable products and prevention of the risks associated with hot work. These measures are also supplemented in each nuclear power plant (NPP) by measures with respect to the cleanliness of the facilities

Areas for the permanent and temporary storage of equipment and combustible materials are necessary for the functioning of the sites. The permanent storage areas have undergone a verification study as part of the Fire Risks Management Case (DMRI). It is mandatory to check their conformity every 3 months. The temporary storage areas are subject to a layout study and validation by the entity in charge of packing, assisted by the risk prevention department. In both cases the quantities of combustible materials present are limited to the strict minimum necessary.

Management of the fire loads in interim storage is governed by operating baseline requirements. The principles put in place (risk analysis, restriction of quantities, compensatory means, etc.) aim to avoid calling into question the conclusions of the fire studies associated with the reference state of each plant unit.

It is prohibited to store anything in the access fire zones, in the protected horizontal passageways, reception areas and staircases. The predetermined, occasional and worksite temporary storage areas are subject to written justification of their duration and the need, to a risk analysis and are limited in duration to three months maximum per user and per zone.

In addition, EDF has tightened the operating measures for the safety fire sectors identified as high fire risk, more importantly on account of the probabilistic safety assessments (PSAs), by prohibiting temporary storage in these areas.

With regard to the management of inflammable products, EDF puts in place measures to limit the fire risk: Inflammable liquids and aerosols, categories 1 and 2, and empty aerosol cans before waste treatment, are stored, when not in use, in a flameproof cabinet complying with standard NF EN 14470-1. The conservative inventory of products that can be stored in the fire safety cabinet matches the chemical products register at all times. The condition of the fire safety storage cabinets is inspected annually and traced.

Sources of ignition, heat and fire load are kept away from storage cabinets containing inflammable products.

Inflammable gas cylinders present on a worksite are signalled clearly and visibly.

EDF always issues "hot work permits" for all hot work operations that could cause an incipient fire.

These hot work permits are applicable throughout hot work execution and are subject to prior preparation, notably through a specific risk analysis which is systematically checked and recorded by the service in charge of risk prevention and validated by the licensee.

The works supervisor, whose presence is mandatory during the execution phase, does not authorise hot work to start until a hold point has been lifted by authorised personnel, as close as possible to the start of work. The lifting of this hold point serves to ensure that the conditions set out in the risk analysis concerning the environment and the conditions of activity performance are satisfied and that the planned protective measures are effectively in place.

All hot work is conditional upon obtaining a hot work permit, which is valid when the validation circuit and the prior verifications have been performed correctly. The hot work permit is specific to a given activity and place and its validity cannot exceed 5 days.

A-I-3.1.3. Licensee's experience of the implementation of the fire prevention

A-I-3.1.3.1. Overview of strengths and weaknesses

To guarantee the operational implementation of the prevention measures, each NPP has a fire organisation, with a department in charge of risk prevention which ensures a particular role in the control of the fire risk. It provides support and advice to the different professional trades during worksite preparation and it carries out field inspections.

EDF considers that the organisation in place for the preparation and tracking of hot work permits is robust.

The prohibition on storing fire loads in the fire safety sectors identified as representing a "major fire risk" helps to reinforce the fire culture by prioritising the measures to take in the different locations according to their risk for safety.

Weaknesses subsist in the management of the temporary and permanent storage areas, some of which do not meet all the requirements concerning fire loads, particularly during plant unit outages. Awareness-raising actions have been carried out with those concerned.

A-I-3.1.3.2. Lessons learned from events, reviews fire safety related missions, etc.

Each fire that occurs on the sites undergoes a detailed analysis which is recorded in a Findings Sheet. In these sheets the fires are analysed from two aspects:

- the cause aspect, which enables lessons to be learned about its occurrence and to propose improvements in prevention of the risk of fires occurring;
- the treatment aspect, which serves to adjust the fire-fighting baseline requirements and propose the necessary improvements in the treatment.

EDF qualifies as a "fire" and analyses any situation causing the slightest emission of smoke or the slightest rise in temperature, whether detected automatically or by a witness. Fires are analysed for LFE[12] purposes as from smouldering fire level, with the intention of memorising and addressing even the slightest low-level events.

In 2022, of the 148 "fires" that occurred and were analysed on EDF's reactor fleet, none developed into a full fire (full development and propagation). 72% concerned an equipment issue, essentially of electrical origin, occurring on equipment with emission of smoke without development or propagation. These fires are analysed as part of equipment LFE. No predominant family or cause was detected.

In his review of 2022, the EDF Inspector General for Nuclear Safety and Radiation Protection (IGSNR) notes that management of the fire loads is improving but still remains a subject of concern. The personnel do not have sufficient knowledge of the real constraints associated with the fire loads. The sectorisation analysis notes enable the duration of a fire to be estimated according to the fire loads present. But the sites find it difficult to use these analysis notes in their present state (no room-by-room picture of the authorised fire loads).

The peer reviews conducted by WANO jointly with the EDF Nuclear Inspectorate enable the Control of the Fire Risks to be assessed for each NPP every 4 years. Their assessments are reported in an annual review. It confirms EDF's diagnosis of its strengths and weaknesses, particularly the robustness of the organisation for preparing and tracking the hot work permits. It also highlights the quality of the cooperation between the NPPs and the Departmental Fire and Rescue Services

[12] LFE: Learning From Experience

(SDIS), facilitated in particular by the permanent presence of a Professional Fire Brigade Officer on each site, which also help to develop the fire control culture.

A-I-3.1.3.3. Overview of actions and implementation status

Fire-proof boxes shall be installed in the buildings of the nuclear and conventional island to complement the existing on-site fire load storage solutions (CPY plant series). By design they will allow the storage of large quantities of inflammable products without affecting the DMRI in terms of fire load management.

The boxes shall be classified IPS-NC (Safety-Important - Not Classified) and shall maintain their integrity under the design-basis earthquake (DBE) conditions. They shall also maintain their fire-resistance capacity of 1h30. The first box will be installed in 2025.

With regard to the management of temporarily stored fire loads, EDF is currently looking into ways of improving this topic, based on the principle of bringing the conditions of application of the temporary fire load storage rules into line with the DMRI, according to the reference state of each plant unit. The approach is based on using the available fire studies to identify the possibilities of temporary storage of fire loads in premises that do not call into question the conclusions of these studies. These temporary storage possibilities shall be interlinked with the recurrent needs identified by the licensee and implemented by sharing the best practices available and/or already applied by the sites. They shall be defined with the aim of adapting the means used to the risks (temporary storage prohibited in certain sensitive places, restriction of the quantities or nature of the fire loads stored, setting up appropriate compensatory means, etc.).

In this context, EDF is developing a methodology which aims to use the fire studies to identify temporary storage possibilities within the premises for all the plant units.

A-I-3.1.4. Regulator's assessment of the fire prevention

A-I-3.1.4.1. Overview of strengths and weaknesses in the fire prevention

ASN shares EDF's opinion on the identified weakness in the management of temporary and permanent storage areas. However, with regard to the strengths of the NPPs, although the presence of a fire advisor on each site (and having support at national level) is effectively a positive factor for the organisation, ASN's assessment does not find hot work permit tracking to be robust. In effect, as described in the following paragraph, regular findings are made during inspections and significant events are notified on this subject.

A-I-3.1.4.2. Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

In terms of prevention measures, the last fire inspections at the Tricastin NPP focused on the management of combustible materials and of hot work permits. Concerning the first point, fire load management was considered to meet expectations on the whole, with the exception of some premises presenting the greatest risk of a serious accident in the event of fire (premises included in the "major fire risk fire sectors"), in which the introduction of temporary combustible materials is prohibited, except for certain particular worksites. Unnecessary combustible materials were found in several of these premises. With regard to the hot work permits, the NPP was asked to be particularly attentive in conducting patrol rounds shortly after the closing of worksites involving a hot work permit in order to detect any smouldering fires.

ASN has recently been notified of several significant safety events (ESS) relating to hot work permits. At the end of 2022, ASN received three ESS notifications concerning failure to return fire detector disabling permits after hot work. Indeed, the fire detectors remained disabled even after closure of the worksites, when nobody was still present in the room.

As a general rule for the 900 MWe plant series, the management of temporary combustible materials requires particular attention, as regular breaches are observed. This is because the location of these temporary storage areas (made necessary by the worksites or the activities) was not sufficiently taken into account in the design of the facilities and the quantities of combustible materials sometimes required on the worksites (such as those associated with the fourth ten-yearly outage) lead to significant cluttering of areas which were not intended for this purpose. These temporary storage areas have a limited duration and must comply with inventories planned in advance in order to comply with the thresholds defined in the design-basis notes guaranteeing that the sectorisation requirements are met. Their in-service monitoring and the addressing of deviations are sometimes inadequate.

With regard to the hot work permits, it is noteworthy that the percentage of fire outbreaks linked to hot work has been decreasing over the last few years. The deployment of a digital hot work permit management tool in place of the paper permits, according to the initial feedback from the field, is improving tracking. The "omissions" observed at the Tricastin NPP regarding the returning of detector disabling permits after worksite completion or when nobody is present in the room are also found on other sites of this plant series.

A-II- 1300 MWe & N4 series Fire Prevention Concept and Its Implementation

A-II-3.1.1. Differences of the fire prevention concept and its implementation of the 1300 MWe & N4 series

The above prevention measures are also implemented on the N4 sites at RP2 state (2nd periodic safety review) and on the 1300 MWe installations in RP3 (3rd ten-yearly outage) status.

A-II-3.1.2. EDF' assessment and conclusions on fire prevention of the 1300MWe & N4 series

The strengths and weaknesses identified on the 900 MWe plant series (Tricastin) RP4 (4th ten-yearly outage) can also be transposed to the *RP3 1300* and *RP2 N4 plant series.*

With regard to the management of temporarily stored fire loads, the examination of ways to bring the conditions of application of transient fire load storage rules into line with the fire risk management case, shall include the 1300 MWe and N4 plant series.

A-II-3.1.3. Regulator's assessment and conclusions on fire prevention of the 1300MWe & N4 series

The strengths and weaknesses found on the 900 MWe plant series are essentially the same on the 1300 MWe and N4 plant series. In effect, it is essentially a question of operating measures, for which the doctrine is determined by the EDF head office departments and applied locally at each NPP. Some variability can be observed from one site to another.

It should nevertheless be noted that the N4 series does not have notices identifying the maximum permissible fire load per room, and that ASN has asked EDF to produce notices defining this so that the temporary combustible materials can be managed more efficiently and ensure that the fire load considered for fire sectorisation is observed. As part of the ongoing periodic safety reviews, and starting with the fourth periodic review of the 1300 MWe NPPs, ASN has also asked that notices identifying the temporary storage possibilities in the premises be drawn up in line with the fire risks management case, and subsequently kept up to date (as the facilities evolve with the modifications which can have an impact on the "fixed" fire load present in the premises or on the sectorisation elements).

A-III- EPR Fire Prevention Concept and Its Implementation

The Flamanville 3 EPR reactor comprises a pressurised water nuclear reactor with 4 loops, an electrical energy production facility and the necessary auxiliary systems designed for operation in normal and accident situations. Its design is mainly based on quadruple redundancy, with each train being situated in physically separate divisions.

The Flamanville 3 EPR design is based on requirements concerning protection against a fire in the technical buildings of a nuclear power plant and which are defined in a document called ETC-F (EPR Technical Code for Fire protection – a code that is similar to the RCC-F of AFCEN, the French Association for NSSS Equipment Construction Rules).

The ETC-F is intended for the bodies responsible for the design, construction and installation of pressurised water reactor nuclear power plants and can be used in contractual relations between customers and manufacturers, and relations with the nuclear regulators.

In its present state, it constitutes the basis of the design, construction and installation rules applied in France to the EPR Flamanville 3 plant unit.

A-III-3.1.1. Differences of the Fire Prevention Concept and Its Implementation on the EPR

The general fire prevention principles are similar to those set out in §A-I-3.1.1. The main differences lie in the use of halogen-free cables and that the fire reaction classification of the materials meets the requirements specified in the Order of 21 November 2002.

A-III-3.1.2. EDF' assessment and conclusions on fire prevention of the EPR

The Flamanville 3 EPR has been established on a frame of reference and a more recent normative basis demonstrating that the prevention approach adopted with regard to the fire risks at the Flamanville 3 BNI as a whole is appropriate.

A-III-3.1.3. Regulator's assessment and conclusions on fire prevention of the EPR

The EPR has seen changes in terms of fire prevention. Although the management of hot work permits remains as is across the fleet (the majority of the operating baseline requirements are valid for all the plant series), there are tangible design improvements, with the use of a more modern baseline.

B- Research reactors RHF – BNI 67

B-3.1.1. Design considerations and prevention means

The design of the RHF (High Flux Reactor) dates from the 1960's; in the design of the facility, fire prevention consisted firstly in isolating the wastes in according to their radiological characteristics in separate buildings (and situated at a distance) from reactor buildings ILL5 and ILL4 (housing the reactor instrumentation and control and the reactor control room).

- Activated concrete and metal wastes are stored in isolated and open buildings (ILL36 and 51), where there are no ignition sources;
- Low-level radioactive waste is treated in building ILL21, with temporary storage of incinerable low-level waste in metal drums in building ILL21B;
- Closed waste packages that present no risk of contamination are permanently stored in an isolated building, ILL 27, in a part of it that is surrounded by concrete walls, with no significant ignition source other than the waste package gamma spectrometry measurement system and the mobile handling crane.

With regard to the reactor building, as the main fire / explosion risk would come from a leak of deuterium from the horizontal and vertical cold neutrons sources, the deuterium systems have been designed with a double (or triple) jacket with a protective nitrogen enveloppe (or vacuum plus nitrogen envelope) and the inter-jacket pressures are constantly monitored (measurements transmitted to the control room).

At the RHF design stage, the detritiation facility (shut down in 2007, and now emptied) was located in a dedicated building (ILL6), situated far from the reactor, and the pressurised cylinders containing the gaseous tritiated deuterium were stored in a building that was open and permanently ventilated by a system connected to the chimney (therefore monitored through radiological measurements).

In addition to the building location measures, given the original absence of fire sectorisation provisions, control of the fire risks was based essentially on early detection in order to take action.

It was later on during the post-Fukushima works that enhanced sectorisation was integrated when the "hardened safety core" equipment was put in place with, for example, duplication and separation of the "hardened safety core" channels to meet the single failure criterion (including damage by fire).

On this account, an additional passive protection (see §2.2.5.1) was introduced on the "hardened safety core" channels in 2022 (a few linear metres of cables were insufficiently separated in the event of fire propagation in the reactor containment annulus and in building ILL5D).

The other fire-prevention design measures introduced after construction of the reactor also include the use of cables with fire reaction classification C1[13]; this principle has been extended to all new modifications affecting a P-SIC (protection-safety important component).

Means of prevention

The first level of defence is depth for controlling the fire risk is based on implementing technical and organisational measures designed to ensure that conditions that could foster the outbreak of fire are kept at a level that is as low as reasonably achievable.

Controlling the risk of a fire outbreak is therefore based on:

- reducing the quantity of combustible products to the strictly minimum necessary;
- the fire reaction of the materials;
- reducing sources of ignition.

Detailed Fire Risk Management Sheets (FGRI) are drawn up room by room in accordance with the risk rating methodology set out in §2.2.2. These sheets enable a conclusion to be drawn on the fire risk alone of the room taking into account the three parameters mentioned above, along with the means of protection available and the ease of intervention. If a room presents a significant fire risk, improvement actions can be defined to reduce this risk, either by taking steps to reduce the risk of occurrence (reducing the quantity of inflammable products, combustible materials or sources of ignition), or by increasing the means of protection or, if necessary, taking measures to facilitate intervention in the area in question.

With regard to prevention, the personnel of the facility and the ILL more generally are informed of the fire risk (safety culture, use of hand-held fire extinguishers, prevention plan for outside contractors, hot work permits for hot work, etc.) and participate regularly in fire drills. These factors help to control the risks of fires occurring.

B-3.1.2. Overview of arrangements for management and control of fire load and ignition sources

The procedure "Operational management of the fire risk in ILL premises" describes the provisions to establish the fire risk rating by means of the FGRIs mentioned above, to manage the fire loads, to guarantee conformity of the premises with the rating defined in the Fire Risk Analysis (FRA) and to define the authorisations associated with the management of the fire risk in the event of temporary or permanent modifications.

[13] Flame-retarding

Fire loads – Ignition sources

Awareness on this subject is promoted during the safety training dispensed to new employees and during the refresher training in use of the fire extinguishers.

Since 2022, room managers have been appointed and trained in ASN Resolution 2014-DC-0417 "Rules applicable to BNIs for controlling fire risks" and the "Operational management of the fire risk on ILL premises". The Room Managers are tasked with ensuring compliance with the fire risk management instructions specified in the FGRIs of the rooms under their responsibility, particularly regarding the data linked to the fire load and the presence of ignition sources. Any new authorisation need must follow the modifications management or Work Orders management processes.

A specific measure for the management of movable fire loads consists in organising an inspection round of the rooms of the ILL4 buildings (reactor instrumentation and control), ILL5 (reactor building), ILL7 and ILL22 (neutron guide halls and experimental zones) before each start of cycle. This inspection serves to verify that the facilities are in a configuration compatible with reactor startup. During this pre-starting inspection round, the safety engineer shall be attentive to the presence of any unnecessary movable fire loads. These unwanted movable fire loads are always removed before starting the reactor.

Lastly, the fire loads are checked exhaustively every 5 years in the rooms of the buildings housing S-PICs. The calorific potential (fire load) per unit surface area of each room is then compared with the permissible limit defined in the FGRIs. The fire loads of the experimental halls in buildings ILL7 and 22, and all the areas regulated for radiation protection purposes are also checked every 5 years even though no S-PICs are present there.

Management of inflammable products

The safety engineers recommend keeping at the most the quantity of inflammable products necessary for one week's use, without exceeding the quantity of one litre on the worksite. These recommendations are made during the safety training dispensed to new employees and during the refresher training in use of the fire extinguishers. These recommendations are formalised in the FGRIs for the premises containing inflammable products.

90-minute fire resistant cabinets are at the disposal of the personnel in buildings ILL5, ILL7 and ILL22.

Management of inflammable gases

The use of inflammable gases is prohibited in the rooms of the buildings housing S-PICs in which specific conditions have not been established in the FRA.

The occasional use of inflammable gases is governed by putting in place a provisional instruction circulated in the control room and/or the establishing of a hot work permit, while at the same time limiting the quantity of inflammable gas to the strict minimum.

Hot work – Prevention plans

All work on the site of BNI No. 67 requires a work authorisation procedure and the establishing of prevention plans if contractors external to ILL are involved and/or hot work permits when hot work is involved.

Hot work is governed by the issuing of a hot work permit which requires a risk analysis if S-PICs are present nearby.

For work carried out at ILL by outside contractors, a prevention plan is drawn up and validated jointly by the contractor's personnel, a safety engineer of the licensee and the Head of the Radiation Protection, Safety and Environment Department (SRSE). Work is authorised after an analysis by representatives of the "safety", "radiation protection", "coordination" and "service engineer" sectors.

B-3.1.3. Licensee's experience of the implementation of the fire prevention

B-3.1.3.1. Overview of strengths and weaknesses

Since the "Modifications management" process was revised in 2018, the risk analysis prior to facility modifications examines the impact of the modification on the fire load or the ignition sources present and any compensatory measures necessary to ensure compliance with the Fire Risk Management Sheet (FGRI).

Among the measures taken over the last few years to reinforce risk prevention, the FGRIs of the experimental areas now include quantitative limits for the use of inflammable gas cylinders (volume limited to 1 Nm3), or the use of inflammable liquids (volume limited to 1 L in use, mandatory storage of larger quantities in 90-minute fire-resistant cabinets)

Management of the movable fire load necessary for the operation of the reactor or of an experimental zone remains a sensitive issue. Due to the large number rooms present in BNI No. 67, about one hundred Room Managers were trained in the Fire Risk Operational Management procedure in 2022 (see §B-3.1.2) to ensure compliance with the limits defined in the FGRIs. This process was well received, required simple rules to maintain ease of operation but was long to set up.

B-3.1.3.2. Lessons learned from events, reviews fire safety related missions, etc.

The lessons learned from reactor restarts after inter-cycle breaks or long outages for work have enabled the principle of pre-starting patrols to be rendered systematic, with one of the focal points being the presence of unnecessary fire loads (such as those associated with the work that has just been finished). These fire loads are removed before the reactor is restarted.

During the last periodic safety review, a particular risk of potential harm to the S-PICs on the three levels of the reactor building in the event of fire was identified: it concerns the behaviour of the gas cylinders should a cylinder be present in a developed fire (rupture of the valve, missile effect, explosion of the cylinder). ILL has undertaken to develop a solution to address this risk (see B-3.1.3.3).

B-3.1.3.3. Overview of actions and implementation status

Gas cylinders (**reactor building**): At the end of 2022 a project was launched to meet the commitment made after the last periodic safety review to render safe the cylinders of gas (inflammable or inert) present on the three levels of the reactor building:

- The few cylinders containing inflammable or oxidising gases that are permanently present shall be placed inside 90-minute fire-resistant cabinets;
- For the inert gas cylinders, work has started on the development of a safety device intended to avoid the potential damage to the facility that could result from the rupture of a cylinder caught in a large-scale fire. This device, intended to equip each inert gas cylinder, aims to cause rapid release of the gas as soon as an abnormally high temperature is detected, before the cylinder can reach its bursting pressure due to its proximity to the fire (gradual entry into service targeted for 2023-2024).

Containment of chemical substances: monitoring of the chemical products inventory was tightened in 2023 with the scientific personnel responsible for the various chemistry laboratories present in BNI No. 67. The monitoring is accompanied by new measures in order to add a line of defence in depth against the risk of toxic substance discharges, a potential consequence of an uncontrolled widespread fire.

B-3.1.4. Regulator's assessment of the fire prevention

B-3.1.4.1. Overview of strengths and weaknesses in the fire prevention

The diversity of the experimental activities combined with the absence of fire sectorisation from the design stage constitutes a weak spot of the facility, particularly in the experimental halls which represent large open spaces that are highly exposed to the risk of concomitant activities. The ILL has put in place good practices, particularly with regard to the room-based fire load management and the management of hot work permits.

B-3.1.4.2. Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

The management of permanent storage of inflammable and hazardous materials has been the subject of ASN inspections which have revealed weak points in the control of certain aspects: product labelling, knowledge and signalling of the permanent storage areas, and control of the inventory of products present, particularly in the secondary buildings of the facility and auxiliary areas of the BNI such as the laboratories, which are less familiar with fire risk prevention than the buildings directly related to the reactor and the experimental areas.

C- Fuel cycle facilities

C-I- Fuel enrichment facility - George Besse II – BNI 168

C-I-3.1.1. Design considerations and prevention means

The design of the enrichment plants of BNI No. 168 with regard to fire is based on the principle of minimising the conditions of occurrence, development and propagation of a fire, and on separating equipment items containing uranium-bearing material (that is to say UF_6 of natural origin with an enrichment of less than 6%) from the equipment that could cause a fire.

The fire load in the rooms containing safety targets (radiological material, safety important equipment) to be maintained in the event of fire is minimised by design: The combustible materials (electric cables, control room consoles, local instrumentation, etc.) are limited to the strict minimum necessary for the functioning of the facility in these rooms.

The electrical equipment (electrical distribution cabinets, instrumentation & control systems, etc.) is grouped insofar as possible in sectorised premises (fire-proof volumes, see § C-I-3.3.1.2) which do not contain safety targets to be maintained in the event of fire.

Compensatory measures are implemented if necessary (for example: thermal protection, distancing).

C-I-3.1.2. Overview of arrangements for management and control of fire load and ignition sources

The construction materials used are of fire reaction class A2 S1 D0 or B S1 D1, when technically possible.

Thus, the suppliers' specifications require that the materials constituting the interior fittings of the constructions and the equipment of the facilities be chosen and implemented such as to minimise the fire loads (limiting of the calorific value), the risks of fire outbreak (compliance with the equipment safety standards), fire development and propagation (choice of the lowest level of reaction to fire for the equivalent performance) (see C-I-3.3.1). The fire loads and the fire behaviour criteria of the materials were provided and taken into consideration in the initial design data.

The electric cables that could be a threat to the safety targets in the event of fire have a flame-spread resistance rating of class C1 in accordance with French standard NFC 32-070.

The fire load in the rooms containing safety targets to the maintained in case of fire is limited by design to the functioning of the process. When conducting works, the fire load is limited to the strict minimum with only the equipment necessary for the work present.

The licensee regularly monitors the operating fire load present in the rooms through monthly patrols intended to detect any anomaly (storage of unauthorised material, presence of waste, leaks of liquid, etc.). The modifications management process includes an analysis of the potential changes of fire load.

The fluids present in the enrichment units are preferably uninflammable or, failing this, have high flashpoints, higher than the process operating conditions. The only inflammable liquids are those necessary for the functioning of the process, i.e. oils for the pumps, diesel for the generator sets, acetone and ethanol. There are no pyrophoric materials.

The tanks of diesel fuel for the travelling gantry cranes for handling the cylinders are located at a distance from the stored containers to avoid compromising the integrity of the containers in the event of a diesel fire. Moreover, the gantry crane diesel generator sets are stopped when the operator leaves the work station.

The small number of movable containers containing combustible liquids are non-combustible, unbreakable, sealed and of limited volume (e.g.: 750 mL of acetone). The inflammable products are temporarily stored in fire-proof cabinets equipped with a suitable retention structure with the quantity limited to 70 litres.

The workers are trained and informed of the risks linked to the implementation of a process that uses inflammable liquids. Furthermore, these products are transferred from the commercial containers into smaller-volume movable operating containers. These transfer operations are carried out in a dedicated room.

Solid combustible radioactive waste produced during operation and maintenance is stored temporarily in limited quantities in non-combustible, unbreakable and closed packagings in dedicated rooms classified as "sheltered" rooms which are fire-resistant (see. C-I-3.3.1), equipped with a fire detection system.

The conventional operational waste is also sorted at source and transferred, according to the place of production and type of waste, to conventional waste rooms classified as "sheltered" rooms situated near each unit where they are stored pending removal.

Lastly, the potentially radioactive liquid effluents are collected in a storage tank situated in a room equipped with an automatic fire detection (AFD) system. After obtaining the effluent analysis results, the effluents are transferred to the contaminated effluents treatment facilities.

The following measures are taken to control the sources of fire, which are essentially of electrical origin, in the enrichment plants:

- electrical continuity and earthing;
- utilisation of electrical equipment that complies with the standards, designed to be protected against the overvoltage risk in accordance with standard NFC 15-100;
- utilisation, if possible, of equipment that does not generate hot spots or sparks;
- protection of the facilities against lightning, in accordance with the regulations and standards.

If fire does break out, the electrical cabinet power supply can be cut off from the electrical rooms (general power cut-off).

Seismic vibration detectors are installed in the plants. In the event of an earthquake, they automatically cut off the facility's electrical power supply (2 out of 3 logic) in order to limit the possibility of a fire outbreak.

Hot work (welding, grinding, cutting, etc.) must be authorised by a hot work permit issued by the licensee. It includes a prior analysis of the fire risk created by the type of work and the work environment and prescribes the measures to take to control this risk when performing the work (setting up protective screens, fire extinguishers suitable for the class of fire, etc.).

A surveillance patrol is carried out 2 hours after finishing the hot work to check there is not a smouldering fire.

C-I-3.1.3. Licensee's experience of the implementation of the fire prevention

Refer to point C-I-3.4.

C-I-3.1.3.1. Overview of strengths and weaknesses

The general design and maintenance measures and the operating procedures to limit the sources of ignition (electrical installations, hot work) are satisfactory, as are the prevention measures to limit the risks associated with inflammable liquids.

C-I-3.1.3.2. Lessons learned from events, reviews fire safety related missions, etc.

The learning from experience is detailed in chapter C-I-3.4. It concerns more specifically the thermal degradation of a cardan joint bellows of a cylinder opening needle valve due to the incorrect positioning of the hot air blowing device.

C-I-3.1.3.3. Overview of actions and implementation status

The actions carried out further to experience feedback are detailed in chapter C-I-3.4.

C-I-3.1.4. Regulator's assessment of the fire prevention

C-I-3.1.4.1. Overview of strengths and weaknesses in the fire prevention

The prevention of any outbreak of fire in BNI No. 168 was taken into consideration from the design stage. Consequently, flame-retardant materials are preferred, particularly in the electrical rooms, and different sectors are partitioned in order to prevent any propagation of a fire. Furthermore, the fire loads are kept to a minimum in the premises.

Alongside this, the lessons learned from experience, particularly events having occurred in BNI No. 168 and other facilities, have led the licensee to make additional modifications to the facility to prevent incipient fires:

- smoke emission linked to the degradation of a cardan joint bellows caused by the incorrect positioning of the hot air blowing system at a cylinder needle valve. This led to the replacement of all the bellows by a more suitable material;
- following the heating of electrical devices, thermographic measurements were carried out on the electrical installations and all equipment items that were defective or did not comply with the standards in effect were replaced;
- some active charcoal filters were replaced in the light of feedback from the company Urenco concerning a chemical reaction between the active charcoal substrate and fluorine.

Lastly, the licensee takes care to maintain its facility in good working order and replace the fire door seals.

C-I-3.1.4.2. Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

No deviations were detected during the inspections conducted in BNI No. 168 on the themes relating to fire risk prevention measures. Particular attention must nevertheless be paid at all times to keep the fire loads present in the facility to the minimum possible.

C-II- Fuel fabrication facility - Romans Sur Isère / Framatome Romans – BNI 63-U

The prevention measures implemented are defined in conformity with the regulations and standards in effect. They also take into account the non-statutory baseline requirements in terms of good practices, such as the rules of APSAD (*Assemblée Plénière des Sociétés d'Assurances Dommages* – Plenary Assembly of Damage Insurance Companies). The provisions are set out in the safety report and broken down in the operating procedures and the procedures governing the creation or modification of facilities.

C-II-3.1.1. Design considerations and prevention means

The provisions are broken down along the following lines:

- construction or fitting out materials;
- limiting of fire loads;
- control of ignition sources;
- analysis of risks via the prevention plan and hot work permit.

The construction and fitting out materials are chosen taking into account their reaction to fire, favouring non-combustible, flame retardant or low flammability materials. The preferred classifications are A1, A2 or B (in accordance with the Order of 21 November 2002).

The electric conductors or cables used are chosen from flame-retardant classes.

The planned fire loads or those actually present in the rooms are inventoried according to their nature (including the transient fire loads) and quantified. Whenever possible, the fire load is limited so as to maintain the calorific potential per unit area below 400 MJ/m^2 in the rooms, without exceeding 600 MJ/m^2 in any particular place. Maximum fire load values, particularly for the transient loads, are defined for each room in the Fire Risks Control Case (DMRI). This process is currently being deployed on the site for the buildings housing uranium-bearing materials.

The equipment items with a high calorific potential per unit area are separated from the rooms containing large quantities of radioactive materials (temporary storage areas) by systems ensuring a minimum of 2 hours fire separation. These rooms include, for example, those housing electrical or computing installations or a large quantity of inflammable liquids (see paragraph C-II-3.3.1.1).

The temporary storage areas for radioactive materials are arranged so as to preclude the internal fire risk by limiting the materials present to those strictly necessary for the storage and the ignition sources to only the electrical equipment necessary for operation and safety (lighting, fire detection visual and audio alarms, evacuation signalling, ventilation).

Any waiver to these provisions is analysed (in the DMRI in particular) to assess the acceptability of the situation and to define any compensatory measures, such as:

- optimisation of the layout of the rooms in order to keep identified targets away from ignition sources or rooms with a high calorific potential per unit surface area;
- fire sectorisation;

- adaptation of the fire monitoring system so that fire outbreak in an area of high calorific potential can be detected as early as possible;
- reinforcement of the extinguishing means.

The following ignition sources are taken into account:

- the electrical installations and equipment;
- the equipment generating hot spots, including heat engines;
- the equipment items or rooms in which are used inflammable or perhaps even pyrophoric substances (liquids, gases, powders) which could possibly create an explosive atmosphere;
- lightning.

Whenever possible, the significant electrical installations are grouped in specific rooms, if necessary sectorised and with no direct link with the areas housing safety targets. The electrical installations comply with the applicable regulations and the standards in effect. They are kept in good order and ventilated, if necessary, equipped with protection systems, protected against stray currents and kept closed (except during maintenance work). Since 2021, newly installed or modified electrical cabinets and boxes which are not located in specific rooms are systematically analysed to determine whether it is necessary to equip them with an automatic extinguishing system.

Insofar as possible, equipment items that create hot spots are protected or isolated so as not to reach neighbouring fire loads, and the generator sets are housed in specific buildings.

The quantities of inflammable liquids are limited in the workshops and subject to rules governing procurement, use and storage, designed to limit the fire risk. Rules are also established for chemical substances, particularly nitric acid, in order to prevent the occurrence of a violent exothermic reaction which can lead to fire or perhaps even an explosion.

The cylinders containing inflammable gases are located outside the buildings or in a fire-proof cabinet, and appropriate gas detectors are present in the rooms supplied with gas. These detectors are connected to the site's fire safety system (see C-II-3.2.1.2).

The rooms with a potentially explosive atmosphere or in which inflammable materials are used comply with the regulations in force. The following are put in place for this purpose: zoning relative to the risk of creating an explosive atmosphere, conformity of the design or installation of equipment that could cause an explosion, and organisational measures relative to the training of the personnel concerned.

Equipment using readily inflammable or perhaps even pyrophoric pure or alloyed finely-divided uranium powders. Specific prevention measures are implemented according to the work station concerned, the level of risk and past experience: personnel training, inerting with argon (in the enclosure or temporary storage area), control of heating by permanent spraying or holding under water, limitation of the quantities used, frequent cleaning of the work station, control of agitation during transfers, metal containers in storage areas and in operation.

The installations are protected against the effects of lightning in accordance with the Order of 31 December 1999 and the Order of 31 January 2006 and standards NFC 17-100 and NFC 17-102.

The works or maintenance operations undergo a prior risk analysis, at least in compliance with the Labour Code, and for which the level of detail is proportionate to the safety/security risks. A safety analysis may be carried out, depending on these risks. The fire risks are taken into account.

Hot work is always covered by a hot work permit. The analysis information and the planned compensatory measures comply with good national practices. For the permanent work stations on which hot work is performed, the associated risks are controlled through instructions at the work station and operator training.

C-II-3.1.2. Overview of arrangements for management and control of fire load and ignition sources

The fire loads present in the rooms are subject to periodic monitoring (defined requirements). This monitoring concerns the transient fire loads and the inflammable liquids. It is currently being deployed on the site for the buildings housing uranium-bearing materials. Pending completion of deployment, the compensatory measure adopted is an inspection by the firemen of the local safety team of the rooms in the buildings not yet covered.

As part of activity monitoring by the independent safety organisation, about 120 independent safety verifications are carried out each year, of which about 20 concern the Protection Important Activity (PIA) No. 16 (fire) and about 10 focus specifically on the monitoring of fire loads in the facilities.

For the management of deviations, any person working on the site, whether a Framatome employee or an outside contractor, who thinks they have detected a deviation, a situation that is abnormal or could lead to an abnormal situation, can register the situation in order to inform management for analysis, classification according to criteria, and corrective action. This process more specifically enables low level events linked to the fire risk to be reported.

All the Framatome Romans personnel perform participative quality safety visits. These visits, which take place as discussions at the work station, also enable low level events linked to the fire risk to be reported.

The outside workers performing services involving safety risks are subject to monitoring. The monitoring focuses on compliance with the requirements communicated to them, such as compliance with the measures planned in the work phase (cleanliness of the work area, minimising and controlling the fire loads and ignition sources present).

Because of the risks that the following equipment items can present in direct or indirect relation to the fire risks, they are subject to periodic statutory verifications: the pressure equipment, the lifting and handling equipment, the work machines the electrical installations, the thermal installations, the generator sets and the lightning protection devices. In addition, periodic thermographic inspections are conducted on the electrical cabinets and boxes.

For the work stations on which pure or alloyed uranium powders or other finely divided and readily inflammable or perhaps even pyrophoric metals or alloys are manipulated, the maintaining of prevention measures over time is ensured by defined operating requirements and in-service monitoring (periodic inspections and tests).

C-II-3.1.3. Licensee's experience of the implementation of the fire prevention

C-II-3.1.3.1. Overview of strengths and weaknesses

The strengths and weaknesses currently identified for the site are listed below.

Strengths

- The processes linked to control of the fire risks, whether in the design, production, operation and in-service monitoring phase, are robust and tried and tested.
- The independent safety organisation maintains an effective surveillance over the risks as a whole. More generally, the site deploys the appropriate resources to conduct all the necessary surveillance actions.
- The site is a partner of the inter-licensee working group on the fire theme. This group shares experience on topical subjects, such as singular events. It would however be beneficial for this group to meet up more often. Moreover, a community on the fire risks theme was recently created within Framatome.

Weaknesses

- The culture with respect to fire risks, especially their prevention, must be further developed at all hierarchical and activity levels.
- Actions are still required regarding the site's conformity with the Order of 20 March 2014, particularly concerning defining the maximum fire loads in the rooms, the deployment of fire load monitoring and the implementation of fire load exclusion zones.
- There are difficulties in freeing up resources to acquire knowledge on the new or emerging risks associated with new battery technologies (lithium-ion, etc.), to establish robust and shared recommendations and to implement them.

The site's fire standard must be updated with regard to the applicable regulations and good practices.

C-II-3.1.3.2. Lessons learned from events, reviews fire safety related missions, etc.

The database listing the abnormal events on the site indicates, since 2012, six outbreaks of fire in the facilities and three occurrences of abnormal heating, two concerning an electrical cabinet and one due to the short-circuiting of a battery during packaging for disposal as waste.

Three older fire outbreaks (in 2006 and 2008) occurred during lathe turning operations in the Triga shop in building F2. That shop was subsequently shut down, and recently restarted operations. This restart came with a complete reassessment of the safety requirements, for which the lessons learned from past operating experience have been taken into account.

For the purpose of this report, the following are considered to be marking events:

- On 30 June 2015, a fire broke out in a canister containing UAlx powder undergoing transfer in the Uranium Zone of building F2.
  In terms of prevention, this event led to a process modification, with all the temporarily stored powder canisters being enclosed in heat-sealed vinyl envelopes in which the air was replaced by argon, changes in the handling instructions (no overturning of canisters) and operator training in these instructions.
- On 17 July 2020 in building C1, then on 25 August 2020 in building F2, a fire started during a welding operation when installing an instrumented fire door. These incipient fires were caused by the presence of combustible materials in the door frame which were not identified during the hot work permit analysis. Complementary measures defined further to the event of 17 July in preparation for the operation of 25 August did not prevent the second fire from starting.
  With regard to prevention, these events led to awareness-raising in the personnel responsible for supervising the hot work permits and the reinforcing of the procurement requirements concerning the reaction to fire of the internal materials of fire doors whose installation requires welding operations.
- On 4 May 2022, in the Duct Zone of building F2, a fire started during the milling of a plate from the R&D shop containing a core of U_{app}Mo surrounded by a sheet of ZrN.
  With regard to prevention, the event led to occasional machining operations of this type being incorporated in the list of "sensitive activities". This classification allows a specific activities reliability enhancement process to be implemented, inspired by the "maintenance and operation quality control" procedure put in place in all the NPPs in France.
- On 21 September 2022, a fire outbreak was detected in cubicle SE9 of the Uranium Zone of building F2. It developed into a fire inside the cubicle. The local response teams (LRTs) and the site's trained respondents were mobilised, then the outside emergency services were called and the on-site emergency plan was activated (for the first time in the site's history). After performing two successive extinguishing actions with extinguishing powder, the fire was declared extinguished about 1h30 after detection. The fire was caused by an electrical failure inside a laser printer situated on a computer console in the centre of the cubicle. The fire remained localised on these elements. With the exception of the strong coupling between the computing console and the waste bins, the defence in depth measures in place functioned, namely: limitation of the fire load in the room, automatic fire detection and transmission of alarm, intervention of the emergency teams, sectorisation and associated slaving elements, ventilation management, management of the accident situation.

  In terms of prevention, this event led to the following actions:

  - Production of a file for restarting the cubicle, including a rearrangement with separation of the waste bins from ignition sources, a verification of all the electrical installations by means including thermographic checks.

- Reactive verification of possible strong couplings between fire loads and ignition sources, computing hardware included, with immediate corrective action for building F2 as a whole and all the other buildings on the site, and the utilisation of small electrical equipment (wiring, multiple socket outlets, visual inspection of condition, etc.).
- Measures to raise awareness and train the personnel in the fires risk are planned in the medium term, through focuses on fire in the "Safety culture" training dispensed to all the personnel, workshops during the "Safety day" organised each year, and skills enhancement for the safety engineers. The reactive post-fire actions will be made standard practice. Fire load monitoring will be tightened.

C-II-3.1.3.3. Overview of actions and implementation status

The main ongoing and planned actions with regard to fire risk prevention in view of the identified weaknesses and experience feedback are as follows:

Actions in progress:

- Integrate in the periodic "Safety culture" training a part devoted specifically to the prevention of fire risks.
- Deploy the monitoring of transient fire loads in the buildings housing uranium-bearing materials.

Actions to be initiated:

- Enhance the site safety engineers' skills in taking fire load measurements.
- Incorporate in the fire load control documentation the notion of decoupling between ignition source and fire load.
- Supplement the safety engineers' patrol rounds by adding fire risk verification points

C-II-3.1.4. Regulator's assessment of the fire prevention

C-II-3.1.4.1. Overview of strengths and weaknesses in the fire prevention

With regard to the fire risk prevention measures, BNI No. 63-U was designed and is operated to minimise insofar as possible the quantities of combustible materials. Consequently, and as an example, the waste is packaged and removed as early as possible and the sensitive materials in terms of fire risks are temporarily stored in appropriate places that prevent any interaction between materials that are incompatible from the fire or explosion risk aspect. Nevertheless, particular attention must be paid to minimising the fire loads present in the facility.

C-II-3.1.4.2. Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

During inspections carried out within BNI No. 63-U on themes relating to the fire risk prevention measures, it has been noted that particular attention must continue to be focused on minimising as much as possible the fire loads present in the facility and complying with good practices for the temporary storage of sensitive materials with regard to the fire risks.

C-III- Fuel reprocessing facility - UP3A – T2- BNI 116

C-III-3.1.1. Design considerations and prevention means

The design stage provisions for management and monitoring of the fire load and ignition sources of the T2 unit are as follows:

- The structures and materials consist in priority of materials classified A1 or A2 s1 d0, otherwise B s1 d1. The facades have few openings in order to limit risks from external hazards. The openings on the facade of premises containing equipment necessary for maintaining a safe state are isolated by a zone of at least 8 metres void of any combustible materials;
- The electric cables are of fire propagation resistance class C1 (classification of standard NF-C-32070). Conductive components are earthed and their electrical continuity is ensured. The use of insulating materials liable to accumulate electrostatic charges is restricted. The T2 unit is protected against lightning by a meshed cage system. This protection circuit is connected to the main earthing system;
- The quantity of combustible materials, inflammable materials in particular, is kept to the strict minimum necessary for the process, operation, and maintenance operations. The process is designed to function below the flammability range of the products present in the unit;
- The main ignition sources in the unit are electrical. The electrical cabinets are grouped whenever possible in dedicated rooms classified as fire sector (see C-III-3.3.1.1);
- The unit is heated by a hot water circuit. The extracted heat is diffused by ventilation. Only a few rooms have electric radiators. These radiators are installed and maintained in accordance with the standards in effect. The ventilation units maintain ambient temperatures compatible with operation of the equipment.

C-III-3.1.2. Overview of arrangements for management and control of fire load and ignition sources

During operation, maintenance or intervention operations, the provisions for management and monitoring of the fire load and ignition sources of the T2 unit are as follows:

- The quantities of combustible materials are limited to the strict minimum necessary for normal operation. The combustible materials situated near equipment items necessary for maintaining the unit in a safe state and which could be harmed by a fire are physically separated from these equipment items. For the buildings containing the process, the fire load values of the rooms (cubicles excluded) are counted in a dedicated computer application. Procedures are provided for managing, monitoring and tracking the combustible materials during interventions and changes in the organisation of the rooms during the transient phases. This enables these intermediate transient phases to be supervised. In this context, the waste is always removed to the collection zones when the worksite is demobilised. In addition, the combustible materials introduced and used are always put into a safe place when the worksite is demobilised. These combustible materials are positioned at least 1.50 metres from ignition sources. If not, they are placed under thermal protection or stowed in closed metal containers. The 5S[14] approach also contributes to this objective. It enables the work conditions to be constantly optimised by ensuring organisation, cleanliness and safety.

- In rooms containing solvents:
  - Electrical equipment is of the increased safety type in order to be usable in explosive atmospheres;
  - The transfer rates of the solvent (solvents are poorly conductive liquids) are limited;
  - All metal parts are earthed;
  - Retention trays are provided to contain any leaks;
  - Instructions indicate the measures to take if:
    - The set temperatures for heated equipment are exceeded,
    - Liquid is present in the retention trays.
- They are also checked regularly by the licensee.
- All the personnel working in the facilities have received training in the risks associated with their job. A risk prevention plan is drawn up prior to any work in the facilities. When hot work is involved, a hot work permit analyses the fire risks linked to the nature of the operations and the work environment and defines the measures to take to control this risk:
  - The measures to take before and during the work (prevention of outbreaks of fire and mitigation of consequences) as well as the monitoring and extinguishing procedures;
  - The compensatory measures if the systems for controlling the fire risks are out of service and the measures to put them back into service.
- The various process temperatures are constantly monitored to detect any drift.

The management of changes to premises and activities forms the subject of a special assessment in order to take into account risks, and fire risks in particular.

C-III-3.1.3. Licensee's experience of the implementation of the fire prevention

C-III-3.1.3.1. Overview of strengths and weaknesses

Strengths

- The existence of a documentation baseline governing the management of transient combustible materials.
- The presence of solvent in the unit process was taken into account from the design stage. Consequently, the principles for controlling the process fire risks, whether in the design, production, operation and in-service monitoring phases, are robust and tried and tested.

[14] **Seiri** (Sort): sort, throw away, recycle, archive, place work tools according to their frequency of use;
Seiton (Set in order): stow, classify so as to limit physical movements or the carrying of heavy objects, optimise the use of space;
Seiso (Shine): clean, repair;
Seiketsu (Standardise): organise the documents or work station so that another person can find things easily;
Shitsuke (Sustain/self-discipline): be rigorous, apply the preceding 4 operations and maintain them over time.

Weaknesses

The T2 unit is made up of about 750 rooms and cubicles. This means that several worksites and contractors can therefore be present simultaneously in the T2 unit. Faced with this situation, a prevention plan is drawn up prior to all work in the unit. The aim of the plan is to analyse, identify and prevent the risks inherent to concomitant activities, to define the necessary or compensatory measures to sustain the safety case. A prior visit with the licensee and the contractor companies involved enables all these measures to be taken into account in the facility.

C-III-3.1.3.2. Lessons learned from events, reviews fire safety related missions, etc.

The safety provisions of the T2 unit are reviewed at the statutory 10-yearly frequency. The DMRI carried out as part of these periodic safety reviews is based on:

- the design documents;
- the study documents relating to changes in the regulations.

In this context, the significant fire loads necessary for operation (consumables) or resulting from operation (combustible waste) have been grouped together in dedicated and identified rooms (e.g. consumables storerooms, rooms for interim storage of waste).

Several fire-related events have formed the subject of operating experience feedback sheets from the last safety review of the BNI 116 units, but none of these events concerned the T2 unit (see C-III-3.4).

C-III-3.1.3.3. Overview of actions and implementation status

A system of operational management of transient fire loads is in place in the T2 unit.

It is based on the logic of keeping transient combustible materials away from ignition sources. Protecting them or packaging them in a metal container is a way of ruling out or delaying and minimising a thermal hazard if applicable. Furthermore, the principles applied aim to:

- Remove the unnecessary waste and materials;
- Minimise the quantities of combustible materials to the strict minimum needed per day or per shift, for example) in order to define the maximum reasonable quantities of such materials.

It takes into account any constraints in terms, for example, of:

- distances;
- or calorific potential which would be predetermined and applied locally by a means of signalling (yellow and black barrier tape, posting of restrictions in terms of number of drums, etc.).

In such cases, these constraints are applied, save with duly justified notice and applying a compensatory measure if necessary. With transient situations, it is essentially a question of adopting a 5S-type logic and thus:

- taking care to define the location of these materials as clearly as possible (distancing from any ignition sources);
- and limiting their quantities to the strict minimum per room (shelves of consumables, linen, aerosols, bags of waste, etc.).

The constant presence of workers on a worksite (for maintenance or modifications) contributes to the monitoring of the places. Worksite demobilisation is including:

- transferring the waste to the collection zone;
- rendering safe the site, and notably putting the combustible materials introduced and used into a safe place. Positioning them at a distance of at least 1.50 metres from an ignition source is one measure for mitigating consequences. Otherwise the combustible materials are:
  - Covered with thermal protections (tarpaulins or heat shields),
  - Stowed in closed metal containers, for example.

The prevention plans and the "Safety minute" during the visual management meeting provide the opportunity:

- To reiterate the procedures specific to the T2 unit. In particular, the 10 fundamental rules[15] defined by the site are regularly spelled out. These rules set out the fire risk prevention measures to be applied in the immediate vicinity of all the workers in the unit;
- To indicate the places of temporary storage of equipment and materials, waste and garments and the measures adopted.

The surveillance patrol rounds, the worksite installation safety inspections (VSI), the field observations sheets (called GEMBA) or 5S audit also allow the detection of any deviations and their correction as early as possible.

To conclude, the main ongoing and planned actions with regard to fire risk prevention in view of the current state of the T2 unit are as follows:

Actions	Status	Deadline
Deployment and application of the combustible materials management guide in the Orano site units	Done	2019
Updating of the fire load in "fire sector" rooms	In progress	2023

[15] List of the 10 fundamental rules:

Keep fire doors closed at all times

Règle 1. Fire doors must be kept closed

Règle 2. Make sure that the electrical cabinet doors are kept closed

Règle 3. Make sure that emergency exits are always accessible

Règle 4. Make sure that the fire-fighting equipment and the ventilation management controls are always accessible

Règle 5. Do not clutter or do not use prohibited areas and never park in front of or on the accesses to fire-fighting water standpipes or dry risers

Règle 6. Help to control the fire load in the premises (5S approach)

Règle 7. Take particular care to ensure that no combustible material can come into contact with an ignition source (hot spot, electrical, chemical, etc.)

Règle 8. Evacuate the premises rapidly as soon as the fire alarm sounds or if asked to do so by the public address system broadcast

Règle 9. Warn PSM (Site and Material Protection service) (dial 18 from a fixed telephone) of any outbreak of fire. After giving the alert, if the fire can be controlled, attack it with an extinguisher without putting yourself in danger

Règle 10. Keep in practice to preserve and maintain your knowledge and skills

C-III-3.1.4. Regulator's assessment of the fire prevention

C-III-3.1.4.1. Overview of strengths and weaknesses in the fire prevention

The fire risk prevention means are satisfactory. The licensee must nevertheless demonstrate greater rigour with the prevention means specific to the worksites.

C-III-3.1.4.2. Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

ASN underlines the amount of work put in by the licensee to produce the fire risks analyses for the entire facility. During the last periodic safety review the licensee was asked to supplement its fire risks management case in line with the last updates to the regulations, and the work is well under way. Further efforts are expected regarding the frequency and speed of reaction in the inspection and maintenance of the fire risks management systems.

C-IV- Fuel fabrication facility - MELOX – BNI 151

The Orano Mélox recycling plant fabricates Mox fuel assemblies from mixtures of uranium oxide and plutonium oxide taken from spent fuels. These fuel assemblies are intended for the light water nuclear power reactors (PWRs and BWRs).

The fabrication process comprises the following steps:

- reception and storage of the uranium and plutonium oxides;
- preparation of the mixes of the oxide powders in the required proportions;
- production of the MOX pellets by compressing the powder mixes;
- sintering of the pellets by heat treatment in furnaces in a reducing atmosphere (consisting of a gaseous mix of argon and hydrogen);
- shaping of the pellets using grinding wheels;
- fabrication of fuel rods consisting of pellets in zirconium alloy tubes;
- fabrication of fuel assemblies by inserting the rods into a skeleton;
- interim storage and shipping of the fuel assemblies;
- performance of physical and chemical analyses in the laboratory.

The main structures and facilities on the BNI site are:

- a nuclear fuel fabrication building;
- a nuclear building for packaging and treating waste and discards;
- a building dedicated to the supply of electricity;
- a building controlling access to the nuclear buildings;
- a temporary storage platform for gases;
- a building dedicated to emergency situation management;
- several support and administrative buildings.

C-IV-3.1.1. Design considerations and prevention means

Prevention of fire outbreaks is the first level of defence in depth for fire risk management applied at Mélox.

The prevention measures in the design of the facility aim to avoid or limit the simultaneous presence of combustible materials, oxidising agents and ignition sources. The main design and operating rules are detailed below.

Rules limiting combustible materials

Liquid and gaseous combustible materials

The hydrogen and diesel fuel storage areas are situated outside the nuclear buildings.

Inflammable chemical products are stored in fire-resistant safety cabinets ventilated by the extraction network of their installation room's ventilation system.

The combustible liquid products present in large quantities (oil in presses, etc.) in equipment are collected in a retention structure equipped with a detection system in the event of accidental loss of equipment sealing.

The batteries supplying electrical power to equipment are sealed gas recombination batteries, which avoids the formation of gaseous hydrogen.

Solid combustible materials

The fitting out materials used in the facility are preferably non-combustible or non-flammable materials (fire class A2 S1 D0 or B S1 D1, when technically possible).

The solid combustible materials present are essentially limited to the electric cables, electrical cabinets and boxes, measuring and control equipment, glove box panels (Lexan, Kyowaglass, etc.) and their equipment (glove ports, etc.), and to the operating equipment (plastic products, storage cupboards, furniture, etc.).

The electric cables in the nuclear buildings are qualified C1 (flame retardant) in accordance with the provisions of standard NFC 32-070 (or equivalent European standards).

Oxidising agent limiting rules

The production operations from unloading through to cladding are carried out in an inert atmosphere (nitrogen, argon) in order to preserve the quality of the uranium powder used. This measure, linked to the risk of UO_2 oxidation, effectively limits the risk of a fire occurring in the glove boxes.

Ignition source limiting rules

Electrical initiators

Lighting sources and motorisations that could induce hot spots are kept at a distance from any combustible material.

Pipes and containers are earthed to avoid the generation of static electricity.

The electrical installations comply with the applicable standards; the electrical equipment items are compatible with the atmosphere in which they are installed; motors, lighting systems and electrical boxes are protected against electrical faults by fuses and circuit breakers.

Thermal initiators

The unit producing the argon-hydrogen mix, situated outside the buildings, is sufficiently far away (at a distance of about 10 metres) for a fire in the unit not to affect the buildings.

The sintering and calcining furnaces are cooled by water or air circuits and welding of the fuel rod plugs is carried out in a neutral atmosphere.

Chemical initiators

In the laboratory, products that could cause exothermic reactions are separated from the heat sources and incompatible products; more specifically, the cellulose-based cleaning wipes are separated from the strong oxidising agents.

Effects of lightning

All the nuclear buildings and their associated facilities are covered by a lightning protection system. It is designed in accordance with the standards in effect.

C-IV-3.1.2. Overview of arrangements for management and control of fire load and ignition sources

The main operating provision for preventing fire outbreaks are:

Rules limiting combustible materials

The quantities of inflammable chemical products used in the rooms containing nuclear material are limited to the strict minimum necessary, in particular to control the criticality risk and to allow the future management of waste.

The quantities of combustible materials used in the facility are limited to what is necessary for normal operation and the upkeep of the installations.

The proportion of hydrogen in the gaseous argon / hydrogen mix is limited to less than 10%.

The processes used for the fabrication and inspection of the fuel rods and assemblies (cutting cladding, fuel rod insertion, etc.) can generate zirconium alloy chips and dust. Regular manual cleaning of the workstations with a fine brush limits the build-up of zirconium alloy chips and dust. The vacuum cleaner used to remove the chips is qualified against the risk of igniting the dust. The finely divided zirconium alloy waste (chips and dust) are packaged in bags placed inside a metal drum and covered with a plastic bag of extinguishing powder.

Note: control of the fire loads is presented in chapter C-IV-3.3.

Oxidising agent limiting rules

During containment chamber maintenance operations in that imply introducing air to replace the inert atmosphere reigning in the chambers in normal operation, specific measures are taken: reduction of equipment operation (stopping of production), limiting of the quantity of nuclear material present in the glove boxes, prohibition of hot work and work requiring disabling of the fire detection system.

The oxidising chemical laboratory products (concentrated nitric acid, nitrate salts, etc.) are stored in a dedicated room and used in quantities restricted to what is necessary for daily operation in the laboratory rooms.

Ignition source limiting rules

In application of the regulatory provisions, the electrical installations are verified annually by a specialised organisation.

Work that could lead to a fire outbreak is covered by a hot work permit, the work authorisation is issued by the service responsible for the work sites after:

- prior analysis, with the competent fire service, of the potential fire risk created by the nature of the work and the work environment;
- defining the measures to take during execution of the work (distancing of combustible materials, installing protective screens, making available dedicated and appropriate fire extinguishers, etc.).

At the end of the hot work, the workers monitor the worksite to ensure there is no smouldering fire.

Manual heat-welding machines for closing and sealing the vinyl bags are used under the supervision of the operator who ensures early detection of any malfunction.

C-IV-3.1.3. Licensee's experience of the implementation of the fire prevention

C-IV-3.1.3.1. Overview of strengths and weaknesses

The general design and maintenance measures and the operating procedures to limit the sources of ignition (electrical installations, processes creating hot spots and hot work) are considered satisfactory, as are the prevention measures to limit the risks of pyrophoricity, exothermic reactions and the risks associated with inflammable liquids.

Control of the proportion of hydrogen in the argon - hydrogen gas mix used in the fabrication process (control of the content analysed by a regulation system and checked by an independent safety system).

The inerting of a portion of the fabrication process glove boxes contributes to the prevention of fire outbreaks.

C-IV-3.1.3.2. Lessons learned from events, reviews fire safety related missions, etc.

The learning from experience is set out in chapter C-IV-3.4. It concerns an event that caused the release of fumes in a glove box.

C-IV-3.1.3.3. Overview of actions and implementation status

The actions carried out further to experience feedback are detailed in chapter C-IV-3.4.

C-IV-3.1.4. Regulator's assessment of the fire prevention

C-IV-3.1.4.1. Overview of strengths and weaknesses in the fire prevention

The fire risks management measures taken within BNI No. 152, defined in line with the principle of defence in depth, were taken into account from the facility design stage.

The measures to prevent any outbreak of fire are all the more important given that the use of water in numerous rooms is prohibited on account of the induced criticality risk.

The requirements concerning limiting the fire load in sensitive rooms are satisfactory.

C-IV-3.1.4.2. Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

The last three inspections focusing specifically on the fire theme raised no comments regarding the adequacy of the fire prevention measures. The licensee must nevertheless maintain its vigilance regarding fire load management, particularly on the facility modification worksites.

D- Dedicated spent fuel storage facility La Hague – SFP D (T0) BNI 116

D-3.1.1. Design considerations and prevention means

The design stage provisions for management and monitoring of the pool D fire load and ignition sources are as follows:

- The pool D building has no openings in order to limit the risk of external hazards;
- The structure and materials are primarily made of materials classified A1, A2 s1 d0 or B s1 d1;
- The quantity of combustible materials, inflammable materials in particular, is kept to the strict minimum necessary for the process;
- The main ignition sources in the unit are electrical;
- The extracted heat is diffused by ventilation;
- The electric cables are classified C1 for their reaction to fire (classification of standard NF-C-32070);
- Conductive components are earthed and their electrical continuity is ensured. The use of insulating materials liable to accumulate electrostatic charges is restricted;
- A meshed cage-type system protects the pool D building against lightning. This protection circuit is connected to the main earthing system.

D-3.1.2. Overview of arrangements for management and control of fire load and ignition sources

During operation, maintenance or intervention operations, the provisions for management and monitoring of the fire load and ignition sources of the pool D building are as follows:

- The quantities of combustible materials are limited to the strict minimum necessary for normal operation;
- The use and temporary storage in the building of combustible materials near equipment items necessary for maintaining the unit in a safe state and which could be harmed by a fire are physically separated from these equipment items;
- The fire load values of the rooms (cubicles excluded) are counted in a dedicated application;
- The Japanese 5S approach enables the work conditions to be constantly optimised by ensuring organisation, cleanliness and safety. This approach is presented in paragraph C-III-3.1.2;
- The management of changes to premises and activities is specially assessed in order to take into account risks, and fire risks in particular;
- Procedures are provided for managing, monitoring and tracking the combustible materials during interventions and changes in the organisation of the rooms during the transient phases. In this context, the waste is always transferred to the collection zones when the worksite is demobilised. In addition, the combustible materials introduced and used are always put into a safe place when the worksite is demobilised. These combustible materials are positioned at least 1.50 metres from ignition sources. If not, they must be placed under a fire-retardant tarpaulin or stowed in closed metal containers;
- The electrical network and its equipment undergo planned statutory inspections. They are also checked regularly;
- All the personnel working in the facilities have received training in the risks associated with their job;
- A risk prevention plan is drawn up prior to any work in the facilities;
- When hot work is involved, a hot work permit analyses the fire risks linked to the nature of the operations and the work environment and defines the measures to take to control this risk:
    - The measures to take before and during the work (prevention of outbreak of fire and mitigation of consequences) as well as the monitoring and extinguishing procedures,
    - The compensatory measures if the systems for controlling the fire risks are out of service and the measures to put them back into service.

D-3.1.3. Licensee's experience of the implementation of the fire prevention

D-3.1.3.1. Overview of strengths and weaknesses

The pool D building does not have rooms with significant fire loads necessary for operation (consumables) or resulting from operation (combustible waste) because they have been grouped together in dedicated and identified rooms in the T0 unit (e.g. consumables storerooms, rooms for interim storage of waste). However, the pool-side passageways are narrow, which can complicate the positioning of the equipment used during maintenance and operation.

Several operations and workers can be present simultaneously in the pool D building, therefore a prevention plan is drawn up before conducting any work in the unit. The plan serves to analyse, identify and prevent the inherent risks in order to define the necessary or compensatory measures to sustain the safety case. A prior visit with the licensee and the contractor companies involved enables all these measures to be taken into account in the facility.

D-3.1.3.2. Lessons learned from events, reviews fire safety related missions, etc.

No fire has ever occurred in the pool D building.

As the ignition sources located in the pool hall cannot be moved to a dedicated room, the adequacy of the level of fire protection with respect to these sources is currently undergoing a confirmation study as part of the lessons learned from the periodic safety review.

D-3.1.3.3. Overview of actions and implementation status

Any improvements resulting from the period safety review lessons shall be put in place taking the constraints and technical possibilities into consideration.

D-3.1.4. Regulator's assessment of the fire prevention

D-3.1.4.1. Overview of strengths and weaknesses in the fire prevention

The fire prevention measures are satisfactory. ASN notes the extent of the work performed since the last safety review to put these measures in place over the BNI as a whole. The particular points observed on the T0 unit - pool D are also satisfactory.

D-3.1.4.2. Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

ASN notes the substantial amount of work carried out by the licensee to produce the fire risk studies for the facility as a whole. The licensee had however been asked to supplement its fire risks management case in accordance with the latest changes in the regulations. ASN also asked the licensee to implement the risks management provisions decided upon after completing the periodic safety review examination. The last inspections conducted on the T0 unit concluded that its standard of fire risks management is satisfactory. The provisions mentioned at the end of the safety review have been put in place and the required procedures were known to the personnel.

E- On-site storage radioactive waste storage La Hague - Silo 130 - BNI 38

E-3.1.1. Design considerations and prevention means

The provisions for management and monitoring of the fire load and ignition sources of Silo 130 unit are as follows:

- At initial design of the Silo 130 unit:
    - Silo 130 is a buried concrete structure of which only its upper surface is accessible;

- At the Silo 130 unit waste retrieval and packaging (WRP) design stage:
  - The structure and materials consist essentially of materials classified A1, A2 s1 d0 or B s1 d1,
  - The main ignition sources in the unit are electrical. The electrical cabinets are grouped whenever possible in dedicated rooms classified as fire sector (see E-3.3.1),
  - Only a few rooms have electric radiators. These radiators are installed and maintained in accordance with the standards in effect,
  - The ventilation units maintain ambient conditions compatible with operation of the equipment,
  - The electric cables of the installations are of fire reaction class C1 (classification of standard NF-C-32070),
  - Conductive components are earthed and their electrical continuity is ensured. The use of insulating materials liable to accumulate electrostatic charges is restricted. The Silo 130 unit is protected against lightning by a lightning arrester system.

E-3.1.2. Overview of arrangements for management and control of fire load and ignition sources

During operation, maintenance or WRP intervention operations in the Silo 130 unit, the provisions for management and monitoring of the fire load and ignition sources of Silo 130 are as follows:

- The quantities of combustible materials are limited to the strict minimum necessary for normal operation;
- The use and temporary storage in the unit of combustible materials near equipment items necessary for maintaining the unit in a safe state and which could be harmed by a fire are physically separated from these equipment items;
- For the buildings containing the process, the fire load values of the rooms (cubicles excluded) are counted in a dedicated application;
- The management of changes to premises and activities is specially assessed in order to take into account the fire-related risks in particular;
- Procedures are provided for managing, monitoring and tracking the combustible materials during interventions and changes in the organisation of the rooms during the transient phases. In this context, the waste is always transferred to the collection zones when the worksite is demobilised. In addition, the combustible materials present are always put into a safe place when the worksite is demobilised. The 5S approach also contributes to this objective. This approach is presented in paragraph C-III-3.1.2;
- The electrical network and its equipment undergo scheduled statutory inspections and are also regularly checked by the licensee;
- All the personnel working in the facilities have received training in the risks associated with their job. When hot work is involved, a hot work permit analyses the fire risks linked to the nature of the operations and the work environment and defines the measures to take to control this risk:

- ○ The measures to take before and during the work (prevention of outbreak of fire and mitigation of consequences) as well as the monitoring and extinguishing procedures,
- ○ The compensatory measures if the systems for controlling the fire risks are out of service and the measures to put them back into service.

E-3.1.3. Licensee's experience of the implementation of the fire prevention

E-3.1.3.1. Overview of strengths and weaknesses

Strengths

The WRP facilities of pit 43 were designed in accordance with the most recent fire protection principles.

Furthermore, tests have revealed the factors limiting the risks of an outbreak of fire in the pit during the retrieval operations (see 2.5.4).

Weaknesses

The initial design of the silo did not take into account the fire risk associated with the types of waste stored.

The waste stored in pit 43 contains graphite, magnesium and uranium. Combustion of the magnesium and graphite can be initiated in the event of impact (such as during retrieval) by uranium hydride (UH_3) which forms in the presence of humidity.

E-3.1.3.2. Lessons learned from events, reviews fire safety related missions, etc.

In 1981 a fire broke out in pit 43 without its origin being identified. The most likely cause is waste incompatibility, because pit 43 received different types of waste. The lesson learned is that waste management requires the implementation of a process and procedures for countering the hazards and the risks the wastes can cause.

E-3.1.3.3. Overview of actions and implementation status

Tests of the reactivity of uranium hydride and the possibility of ignition of the waste containing magnesium, uranium and graphite were carried out prior to WRP. They show that:

- the impacts caused by the mechanical grab, rearrangements, falls, etc. are not strong enough to initiate a fire due to the uranium hydride;
- the presence of humidity prevents the ignition of the mixtures of uranium and uranium hydride when impacts arise (particularly when using the mechanical grab).

Consequently, the risk of fire linked to the process in the retrieval unit is limited by the prevention of impacts that could create the ignition energy.

Moreover, prevention of the fire risk in the connecting gallery is based on checking that no fire has broken out in the retrieval unit.

E-3.1.4. Regulator's assessment of the fire prevention

E-3.1.4.1. Overview of strengths and weaknesses in the fire prevention

Since the January 1981 fire in the silo pit 43, the licensee has reinforced the prevention means with the design of a new waste retrieval and packaging (WRP) unit and the setting up of a system for automatic argon inerting of the pit containing the immersed waste. This new design combined with the management and monitoring of the fire load and ignition sources limit fire outbreaks in this facility.

The electrical cabinets are grouped whenever possible in dedicated rooms and classified as fire sector, the electric cables of the installations are of fire reaction class C1 (classification of standard NF-C-32070), and a lightning arrester system also protects the Silo 130 unit against lightning.

The initiator of the 1981 fire has not been identified, which constitutes a weak point. Knowing that the waste in temporary storage in pit 43 contains graphite, magnesium and uranium, that this waste has been partially immersed since the fire and that combustion of the magnesium and graphite may, in the event of impact, be initiated by uranium hydride (UH_3) which forms in the presence of humidity, it was necessary, before starting the WRP operations, to perform tests concerning the reactivity of uranium hydride and the possibility of ignition of this waste. The tests performed showed that the envisaged retrieval process using a mechanical grab did not cause sufficiently hard impacts to initiate a fire, and that the presence of sufficient humidity (waste under water) prevented ignition of the uranium and uranium hydride mixes during impacts (particular during operations using the mechanical grab). The risk of fire linked to the WRP process is therefore found to be limited in the retrieval unit.

E-3.1.4.2. Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

The various field inspections conducted by ASN enabled the prevention measures implemented by the licensee to be verified. ASN has noted an improvement in the fire prevention measures, but the licensee must nevertheless be more rigorous in the drafting of hot work permits and the management of fire loads.

F- Installations under decommissioning

F-I- Research reactor OSIRIS – BNI 40

F-I-3.1.1. Design considerations and prevention means

The design of BNI 40 dates back to the early 1960's and therefore corresponds to the knowledge available at that time in terms of constructional measures concerning protection against the fire risk. One of the main constructional measures adopted concerns the geographical and physical separation between the nuclear area (the Osiris and Isis reactors hall, the hotshop halls containing the hot cells) and the areas housing the electrical rooms and the nuclear ventilation equipment. The construction and fitting out materials used for the modifications introduced since the initial design are chosen paying attention to their fire reaction class (class M1 minimum for solid materials and C1 or C1SH for electric cables).

With regard to the nuclear waste interim storage areas, the following measures have been or shall be put in place:

- to limit the risk of waste packages being harmed in the event of fire, these areas are situated some distance from the ignition sources and are physically demarcated (marking on ground);
- The following provisions are adopted so as to ensure control of the mobilisation of the waste in the event of fire:
  - authorised types of wastes and packaging (metal walls, etc.),
  - maximum volume stored and storage conditions (stacking, types of pallets, etc.)

With regard to the design and operation of the nuclear worksite air locks, the measures described below are adopted:

- the fire reaction class of the materials used limits the risk of a fire outbreak and propagation (preference given to class M0 and M1 materials);
- the fire load and the in-process waste are limited to the strict minimum;
- with respect to the risk associated with electrical accessories/equipment, these are switched off outside work phases and protective screens or an exclusion distance are put in place between the air lock and the external initiators (moveable fan, breathing air system).

Hot cutting operations are limited insofar as possible. If they have to be carried out, the special measures presented in paragraph F-I-3.1.2 are deployed.

F-I-3.1.2. Overview of arrangements for management and control of fire load and ignition sources

Fire loads

The fire loads are limited to the strict minimum necessary for operation. They are subject to a geographical assessment to define, with margins, a maximum authorised fire load in operation, substantiated by the fire risks management case. A periodic check of the fire loads is therefore carried out to make sure that the authorised values are not exceeded for the different areas of the facility (annually for sensitive rooms and every three years for all the rooms). This approach is supplemented by a systematic assessment in the context of the different work sites.

Furthermore, as part of the preparatory work for decommissioning, the fire loads that are not necessary for operation of the facility in the decommissioning phase are removed. For example, the two old generator sets and large reserves of diesel fuel have been removed. These two generator sets have been replaced by a new fixed generator set of appropriate power rating, installed outdoors at a distance from the buildings. It has its own diesel fuel retention system.

The new equipment items installed as part of the decommissioning preparation work are chosen, whenever possible, such that the added fire load is limited (for example, selecting cutting shears that use high-performance fire-resistant hydraulic oil, a retention structure and a safety system in the event of leakage).

Inflammable liquids are stored in safety cabinets and their use is limited to the strict minimum necessary. Attention is paid to the volume and nature of the containers used. Inflammable gaseous substances are limited to the strict minimum necessary and are stored outside the buildings.

Concerning the risk of H2 production at the fork-lift truck loading stations, and the battery rooms, measures are taken to avoid the creation of an inflammable atmosphere (ventilation, recharging conditions, etc.).

Ignition sources

Electrical and electromechanical sources

The conformity of the electrical installations with the standards in effect, the presence of various emergency stop devices for switching off the electrical equipment and the performances of inspections, periodic tests and maintenance serve to prevent electrical and electrostatic risks. Specific operations can be carried out, such as checking the tightness of terminal lugs in the power cabinets or taking infrared thermographs of the sensitive equipment of the electrical installations.

The electromechanical equipment (motor-driven fans, travelling cranes, etc.) undergo inspections, tests and maintenance operations (e.g.: retightening or replacement of belts, checking for oil leaks, etc.).

Thermal sources (heating, hot work, heat engines)

The facility is heated by the Centre's hot water heating system; it does not use combustible materials.

The performance of hot work in rooms where this is not provided for in the safety baseline requirements is authorised subject to a hot work permit application. The hot work permit is drawn up by a person who is specially trained and authorised to do this. The hot work permits must be transmitted to the site fire-fighting service (FLS) 48 hours before the start of the hot work. The hot work permits allow compensatory measures to be defined as appropriate for the nature of the risk induced by the work. Patrol rounds are carried out and recorded in daily tracking sheets.

If hot cutting work is carried out in nuclear worksite airlocks, special measures are taken:

- the walls are made using materials of fire reaction class M1 at least;
- reinforced and qualified thermal protection is put in place in the most exposed cutting zone (fire-retardant tarpaulins, fire-retardant cardboard boxes or other equivalent protections);
- all the combustible materials present in the air lock and the elements necessary for placing and maintaining in a safe state that are present in or near the cutting zone, are protected by screens (fire-retardant tarpaulins, fire-retardant cardboard boxes, stainless steel sheets. etc.);
- the openings and cable paths in the walls of flexible or rigid air locks are blanked off and protected against combustion (aluminised adhesive tape for example);

- the high efficiency particulate air (HEPA) filtration system is protected (spark-arrester device, ducts of fire reaction class M1 at least, up to the first HEPA filtration stage);
- a system for collecting sparks and smoke at source can be used.

The entry of heat engine trucks into the OSIRIS pile hall or the ISIS pile hall is limited as much as possible. If a truck does have to enter a hall, the following measures are taken:

- the area is tidied up and cleaned in order to limit the fire load in the vicinity of the operation;
- the FLS is informed that a truck will shortly be entering the hall;
- the complete vehicle (tractor + trailer) is parked outside the hall for at least 30 minutes to allow the mechanical components to cool (engine, brakes, axles) if it has come from outside the Saclay site;
- the FLS goes to BNI No. 40 with the appropriate fire extinguishing means and checks the entire vehicle for hot spots or excessively high temperatures and the mechanical components in particular, using a thermal means;
- once the truck has entered the hall, the engine is stopped and a retention tray is placed under the tractor below its engine oil tanks;
- the FLS again checks there are no hot spots or excessive temperatures;
- the duration of the truck's presence in the building is kept to the strict minimum.

<u>Exothermic origin</u>

In the course of the decommissioning preparation operations, the reserve of non-irradiated NaK (sodium-potassium) has been removed. The very large majority of the irradiated NaK that was contained in the experimental devices has been neutralised in the hot cell. The active NaK still present wil l also be neutralised in the hot cell. This operation is carried out by pouring small quantities of NaK into a neutralisation tank in which an argon blanket is maintained to avoid contact with air (inerting). The thin layer of NaK in the bottom of the tank is destroyed by pouring a few drops of demineralised water over it. This operation is carried out as many times as necessary until the NaK has been completely destroyed (in which case no further reaction is observed). Demineralised water is poured over all the residues in the bottom of the tank to complete neutralisation.

With regard to the use of chemical products, rules of good practice are applied (take regular inventories of the products, limit the quantities in stock, ensure the mutual compatibility of the products, keep track of purchases and disposal of obsolete products, return the products to the protected cabinets after use, etc.).

<u>Climatic source (lightning)</u>

The facility has undergone a lightning risk analysis and a technical study of the means of protection against the effects of lightning. New means of protection and prevention have been defined, more particularly the installation of lightning arresters as close as possible to the terminals or at the last electrical cabinet supplying components important for the protection of interests.

F-I-3.1.3. Licensee's experience of the implementation of the fire prevention

F-I-3.1.3.1. Overview of strengths and weaknesses

Since BNI No. 40 came into operation, a very small number of fire outbreaks have been recorded, and each time they were easily brought under control (without necessitating major fire-fighting means).

The study of the management of fire-related risks carried out as part of the last periodic safety review highlighted actions to be taken to:

- supplement the existing prevention measures (management of fire loads, formalising instructions);
- improve the integration of the needs associated with preparation for decommission of the facility (equipment dismantling worksites with the installation of a containment air lock if necessary, increase in the temporary storage capacities for nuclear waste).

F-I-3.1.3.2. Lessons learned from events, reviews fire safety related missions, etc.

Lessons learned from the main events related to fire outbreaks

Event	Causes	Corrective action
1991 Exothermic reaction of NaK in hot cell (outside working hours)	Increase in the relative humidity of the air in the cell, combined with a drop in the effectiveness of the argon inerting (due to the ventilation) causing the restarting of the exothermic reaction in the absence of personnel and triggering of the automatic fire detection alarm	Changes in the operating procedure (operation to be completed during working hours) Raising personnel awareness of the problems associated with the handling of NaK Change in the neutralisation process (butyl alcohol replaced by water which is less reactive)
2002-2003 Fire outbreaks on the frames associated with the control rod motors of the Osiris reactor	Heating of an electrical component	Replacement of the incriminated component by one with more recent technology
2006 Emission of smoke on a heater upstream of the ventilation system extraction filters	During a periodic test with the ventilation system stopped, unintentional disabling of slaving of the heaters to the operation of the ventilation system, leading to excessive heating of the air in the duct (and triggering of the detection system) causing melting of the sheaths of the relative humidity probes	Replacement of the damaged equipment, requalification tests and inspections after making corrections to the slaving control systems

More recently, other electromechanical equipment items have caused smoke emissions. They were caused by the motors of small hand-held equipment (angle grinder, vacuum cleaner) which were used in the worksite air lock. Their replacement by new, more robust equipment that is better suited to the conditions of use is under way.

Feedback from the ASN inspections on the fire theme (prevention measures)

Further to the ASN inspections on the fire theme, the main prevention measures for which action has been requested concern:

- the management of the fire loads (occasional increase in the fire loads in certain rooms having necessitated equipment stowage and removal operations) and more particularly the need to improve fire load monitoring and traceability;
- the management of chemical products and more particularly inflammable products (stowage in the safety cabinets, personnel awareness-raising and the drafting of a management procedure).

F-I-3.1.3.3. Overview of actions and implementation status

The fire risk management study carried out during the last periodic safety review led to recommendations concerning the prevention measures such as:

- limiting of the fire load in certain rooms (particularly near penetrations that are sensitive to the fire propagation risk) and/or the removal of combustible equipment;
- identification of fire load exclusion zones and rules for the temporary storage areas;
- the deployment of measures specific to the use of motorised machines (for example, prohibiting the use of electric trolleys in certain rooms);
- the deployment of specific measures when setting up worksite air locks.

These measures are deployed in the context of a safety improvement action plan.

F-I-3.1.4. Regulator's assessment of the fire prevention

F-I-3.1.4.1. Overview of strengths and weaknesses in the fire prevention

The Fire Risks Management Study (EMRI) carried out in 2018 as part of the facility's periodic safety review led to several fire risk prevention measures being put in place. The insulation of the penetrations in walls identified by the study has been correctly carried out and identified in the field.

The electrical installations are regularly maintained and inspected, but nonconformities still remain to be settled following the statutory inspection of August 2022.

The calorific potential (fire load) per unit surface area is checked annually in the sensitive rooms and every three years in the non-sensitive rooms. However, there has not been an exhaustive check of the fire load per unit surface area of the rooms for several years. The fire loads of the various rooms must therefore be monitored with greater regularity.

Furthermore, a regularly updated internal memo provides a precise list of the fire-related training courses the operators must follow according to their qualifications, with the dates of the next refresher training sessions. The refresher training for the members of the local initial response team (LIRT) in the use of fire extinguishers has fallen behind schedule.

The management of the hot work permits for the facility's worksites is clear and duly traced.

F-I-3.1.4.2. Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

The ASN inspections have shown that control of the fire risk is characterised by good fire permit management and constructive improvement measures in view. However, the CEA is expected to take measures to store the non-hazardous waste separately from the hazardous waste and specify the actions to eliminate the infiltrations observed at the last ASN inspection on the fire theme.

F-II- UNGG Saint-Laurent des Eaux - BNI 46

F-II-3.1.1. Design considerations and prevention means

The "fire" theme rules applied on the Saint Laurent des Eaux site stem from the regulatory requirements, from the safety case and from the good practices stemming from acquired experience. These rules concern all the levels of defence in depth. They apply to the design of the decommissioning worksites (minimum fire resistance of electric cables, for example) to the operation of the facility (on-site management of fire loads for example).

F-II-3.1.2. Overview of arrangements for management and control of fire load and ignition sources

Measures concerning management of the movable fire loads are taken according to the duration of their presence on the site. For each temporary storage request, the organisation in place provides for an estimation of the fire load of the zone, a risk analysis according to zone's risk level and defining of the corresponding countermeasures, various inspections and the responsibilities associated with the zone. A particular organisation is planned for inflammable chemical products, with more specifically the obligation to store them in a fire-proof cabinet, limitations on the quantities and a risk analysis according the product category.

The analysis of the events on sites undergoing dismantling shows that hot work is the leading cause of fire outbreaks. Such work requires preventive measures which are defined when the "hot work permit" is drafted. For each "hot work permit", the organisation in place provides for a risk analysis, defining of the associated countermeasures, various inspections and the responsibilities associated with the hot work.

F-II-3.1.3. Licensee's experience of the implementation of the fire prevention

F-II-3.1.3.1. Overview of strengths and weaknesses

As indicated in paragraph II-2.6.6.1, the strength of EDF is that it can use first and foremost the experience feedback and lessons learned from these BNIs, as well as from other external sources, whether French or international.

The number of fire outbreaks on the Saint Laurent A site (none in 2021 and 2022) testifies to good management of the fire risk.

The single significant event on a nuclear site undergoing dismantling concerns a fire that occurred in 2015 on the Brennilis site; the event is described in paragraph II-2.6.6.1. The analysis of this event showed weaknesses in the prevention of fire outbreaks, which were addressed as described below.

This fire had no consequences on the interests to protect (population and environment) against toxic and radiological releases alike.

F-II-3.1.3.2. Lessons learned from events, reviews fire safety related missions, etc.

The analysis of the Brennilis fire of 2015 highlighted:

- That the risk associated with the use of the decontaminating/degreasing product has not been properly grasped in a hot spot cutting environment;
- The lack of robustness in the facility's chemical products utilisation procedure.

Failure to draw up a hot work permit and the inadequacy of the protection measures when cutting with an angle grinder.

F-II-3.1.3.3. Overview of actions and implementation status

This feedback from the Brennilis fire led to the following main actions:

- revising of the worksite demobilisation procedure in order to take into account all the activities, including the demobilisation phase itself (specific risk analysis to be carried out);
- tightening of the checking of workers' authorisations;
- reminder of the compliance with the requirements specified in the general monitoring and maintenance rules applicable to the site facilities;
- a detailed risk analysis of the liquid wastes from the worksites shall be provided in the production file;
- improvement in the robustness of the procedure for applying to use chemical products in the facilities;
- vigilance and raising awareness concerning the hot work permit risks analysis (identification of the risks and putting in place the associated prevention measures in particular).

These factors have been integrated in the fire operating baseline requirements of the EDF sites undergoing dismantling.

F-II-3.1.4. Regulator’s assessment of the fire prevention

F-II-3.1.4.1. Overview of strengths and weaknesses in the fire prevention

ASN's last assessments of fire risk management at the facility showed that the prevention measures were suitably defined and implemented. The improvements concerning the hot work permits must be continued, more specifically in the lifting of the hold points on the decommissioning worksites.

F-II-3.1.4.2. Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

ASN has identified a number of deficiencies whose causes are mainly linked to the interfaces with operation of the two in-service reactors of the Saint-Laurent NPP, with which BNI No. 46 shares some of the fire risk management means. In 2022, unauthorised temporary storages of fire loads from maintenance work on the in-service reactors were thus observed on BNI No. 46.

3.2. Active fire protection

A- Nuclear Power Plants

A-I- TRICASTIN 1 - 900 MWe series – post-4th periodic safety review

A-I-3.2.1. Fire detection and alarm provisions

A-I-3.2.1.1. Design approach

The premises are permanently monitored by a general fire detection network which ensures:

- Rapid detection of an incipient fire;
- Activation of the fire alarm;
- Locating of the fire outbreak;
- Memorisation of the first fire;
- Control of the isolation components slaved to the fire detection:
    - Closure of certain fire dampers,
    - Starting of certain fire protection systems installed at fixed stations (spraying of the diesel generator sets for example),
    - Closure of certain fire doors that were kept open for ventilation purposes.
- Monitoring of progression of the fire.

As part of the "Fire Risk Management" project, which concerned the industrial and tertiary buildings, EDF carried out an overall renovation of the fleet's fire detection systems and improved the reliability of fire detection in certain damp areas (space between containments). This work aimed to overcome the confirmed obsolescence of the equipment, to take into account the regulatory requirement to eliminate ionisation chamber smoke detectors (ICSDs) by 03/12/2021 (deadline set by the Order of 18/11/2011) and also to improve the utilisation of the fire detection system by giving the control room operators the means to supervise and effectively process the alarms.

A-I-3.2.1.2. Types, main characteristics and performance expectations

The fire detection system is safety classified (IPS-NC – Safety-Important – Not Classified) in all the buildings containing Safety Important Components (SICs): nuclear island buildings, the pumphouse, SEC (essential service water system) Galleries and the Ultimate Backup Diesel Generator Set Building.

For its participation in safety sectorisation, the fire detection system instrumentation and control (I&C) meets the requirements of the fire directives in effect. As such, it remains functional after an earthquake of OBE[16] intensity. It is also designed, from the robustness aspect, not to send untimely commands to other elementary PIC systems during an earthquake of DBE[17] intensity. (Example: untimely closure of fire dampers when earthquake resistant ventilation is required).

[16] OBE: Operating-Basis Earthquake
[17] DBE: Design-Basis Earthquake

The design of the fire detection systems complies with the EDF in-house baseline requirements, with backed-up power supply, fire-resistant cables (the power supply of the detectors uses fire-qualified cables; C1 or C1-CR1 when necessary), etc.

The detectors in the buildings containing PICs have a battery-backed standalone power supply in accordance with the regulations in effect.

Different types of fire detectors are installed in the site buildings. The fire detectors are addressable (identifiable), they are distributed in the rooms to monitor and grouped in detection zones covering geographically defined areas. The fire detection zones are consistent with the fire volumes. The fire detection line is designed such that a fire in one fire volume does not cause loss of detection in the other fire volumes concerned.

The type of detector installed in each case is appropriate firstly for the significant phenomena generated by the fire of the monitored equipment or room (temperature, flame, smoke, combustion gases, etc.) and secondly its installation conditions (accessibility – ambient environment: relative humidity, temperature, ionising radiation, etc.).

These detectors are interconnected electrically by a network of detection loops connected to fire control panels, which give access to the status of each detector (standby, alarm status, fault condition). Two-way polling enables fire detection to be maintained in the event of a break in the loop.

The fire control panels process the information delivered by the detection loops to identify which detector is in fire alarm status. They are interconnected by a communication bus. The fire control panels also transmit the fire detection information to the synoptic boxes via a network of programmable logic controllers.

These mimic diagram boxes are installed at the access points or on the different landings of the main buildings to enable the responders to visually identify the room in which the fire is detected (memorisation of first fire), to follow the progression of the fire and rapidly guide the response personnel to it, and they group the manual controls and/or the fire sectorisation automatic interlocks.

The fire alarm information is available on the fire terminals situated locally on the front of the fire cabinets and remotely in the control room. These fire terminals allow routine operation of the fire system: identification of the detectors in alarm status, detectors in fault condition, running tests, putting zones into or out of service, viewing of alarms (building/fire volume/room/detector) or the system fault.

Fire terminals connected to each fire control panel allow the fire detection information to be read. Fire terminals are also installed in the control room for transmitting the fire detection information to the licensee.

For each fire control panel, two visual warnings are displayed on the alarm summary panel in the control room: a "fire alarm" warning and a detector "unavailable" warning, which are accompanied by an audio signal.

An alarm summary panel is installed in the control room and enables the licensee to be warned of a fire detection, including in the event of failure of the fire terminals.

As part of the technical requirement associated with the lessons learned from Fukushima and the stress tests, EDF has verified the robustness of the fire detection system and its resistance to the revised safe shutdown earthquake (SSE). This robustness is confirmed for all the detection equipment after integrating the modifications resulting from the "Fire Risk Management" project mentioned in the previous paragraph.

A-I-3.2.1.3. Alternative/temporary provisions

Following the renovation of the fire detection system, if a detector is out of service or has to be disabled due to a risk of untimely activation, only the zone covered by that detector is no longer monitored. This represents a real improvement, by avoiding unavailabilities or the disabling of the loop systems of entire zones.

The unplanned unavailability of the fire detection system is covered by operating technical specifications which require a systematic analysis of the reasons for this unavailability and its impact in terms of monitoring.

In the event of partial or total unavailability of the fire detection system, repair times are set and licensee is required to ensure permanent monitoring by personnel or to organise patrol rounds at an appropriate frequency with respect to the risks. The prevention measures (elimination of additional fire loads, prohibition of hot work, absence of simultaneous sectorisation fault) can also be stepped up.

When carrying out operations that could trigger unwanted fire detection, and in order not to generate an excessive number of alarms or trigger interlocked automatic systems, the detectors monitoring the potentially impacted zone can be disabled.

The disabling phase is limited to the strict necessary and only during the period when the risk of excessive triggering is identified.

These operations can only be carried out with personnel permanently present in the disabled zone. Permanent monitoring by people effectively replaces the disabled detectors. Contact with the licensee is obligatory before each detector disabling action, whatever its duration, in order to put the detection system back into service.

In addition, with regard to worker safety, an audio fire alert system allows evacuation of the personnel in the event of a fire in the facility.

A-I-3.2.2. Fire suppression provisions

A-I-3.2.2.1. Design approach

A series of provisions are made for extinguishing fires, depending on the case.

As an initial response, any worker located near a fire outbreak can use the appropriate hand-held fire-fighting means (water, powder or carbon dioxide extinguishers, etc.) provided in the facility to put it out.

When a fire is detected, the first recon team and the response team are sent to the place to check it is not a false alarm and to initiate the emergency actions indicated on the reflex sheet of the room concerned (acknowledgement of the fire with extinguishing attempt, emergency cut-off, checking correct operation of the automatically triggered components, check of sectorisation, etc.). If the alarm is confirmed, the external emergency services are called. They can use the following complementary means:

- mobile fire-fighting means (fire-fighter turnout bags, fire-fighting trailers or trucks for on-site intervention, etc.);
- water hose connected to a firefighting network (fire hose cabinet). To this end, all the levels of the nuclear island buildings are equipped with a sufficient number of fire hose cabinets connected to the fire-fighting water system. The fire hose cabinets are positioned such that the fire hose can reach any equipment item in a room, even if this room is equipped with fixed fire-extinguishing devices such as sprinklers;
- water hose connected to a fire hydrant.

The road network within the sites, the access points and the access openings are designed to enable the rescue and fire-fighting appliances of the external emergency services, including aerial ladder trucks, to get as close as possible to the buildings. Specific means are also available to the external emergency services (dry risers, fire-fighting water standpipes, etc., distributed across the site).

In addition, fixed extinguishing means are planned for in relation to the safety case (in this case they are usually automatic) or protection of the equipment.

Fixed extinguishing systems are installed in certain rooms when necessary on account of safety sectorisation:

- in the rooms with fire duration exceeding 1 hour and 30 minutes forming part of a safety fire volume;
- when they are necessary for the justification of certain safety fire zones;
- when they are necessary for addressing common modes.

The systems supplying water for the fire-fighting means are protected against freezing.

The fixed extinguishing systems installed on account of the safety case in the fuel buildings (BK), the operations building (BW) and the electrical building (BL) do not have active equipment. Only the nuclear auxiliary buildings (BAN), the reactor building (BR) and the diesel generator set buildings have fixed sprinkler systems - whose pipes are maintained in air under normal operating conditions - comprising active equipment. The failure of these equipment items is postulated.

The local accessibility and operability of these items (valves) have been verified. The existence of functional redundancies combined with manual activation of the extinguishing systems (applying the defined operator delays) guarantees the availability of the functions to protect against the effects of the fire if fire breaks out in the rooms concerned.

Thus, the sensitivity studies conducted to assess the impact of the consequences of the fire, considering an aggravating factor applied to the active equipment of the fixed automatic fire extinguishing system, conclude that the existing provisions are sufficiently robust.

A-I-3.2.2.2. Types, main characteristics and performance expectations

There are several types of fixed extinguishing system depending on the risk and the equipment to protect: Water sprinkler systems, pre-action sprinkler systems, total flooding systems.

The sizing of the fire protection systems is based on controlling the development of a fire and guarantees the spray densities required by the standards.

Spraying in case of fire is ensured by different means depending on the equipment in the rooms and the possibilities of access to said rooms.

On account of the technical requirement associated with the lessons learned from Fukushima, EDF has assessed the Safe Shutdown Earthquake (SSE) resistance of the structures and equipment items that are subject to a requirement for resistance to the Operating Basis Earthquake (OBE) and contribute to the extinguishing of a fire (fixed extinguishing systems). On completion of these studies, the fixed extinguishing systems of:

- the conventional island and the nuclear island (inside the reactor building) are robust to the SSE without any modifications;
- the nuclear island (outside the reactor building) is reinforced in lot B to the SSE by deploying modifications in the robustness of the fire extinguishing network outside the reactor building.

The fire-fighting water production system pressurises and supplies the water to the general fire-fighting distribution systems (fixed extinguishing systems and fire-fighting means).

It comprises two pumps per plant unit, each driven by an electric motor supplied with power via trains A and B, backed up by the generator sets of the plant unit concerned.

For "riverside" sites (such as Tricastin), these pumps are supplied with raw filtered water from the pumping stations. For "seashore" sites, these pumps draw from one fire-fighting water reserve per plant unit of about 1500 m^3, supplied with decarbonated and filtered water. Water make-up with sea water can be carried out if necessary.

The pumping systems of a given pair of plant units are interconnected. The water production system is designed so that three out of the four pumps of the pair of reactors suffice to supply simultaneously:

- the fixed means intended to the fight the fire whose extinction requires the greatest volume of water;
- several fire hoses.

A mobile pump with a heat engine can be connected to the fire network to supply - as an ultimate backup - the general distribution system with water from the SER (demineralised water reserves) tanks, from water sources near the site or from the cooling tower ponds (on sites that have them).

Consequently, the consideration of an aggravating factor on a fire pump does not call into question the capacity of the system to supply the quantity of water required for the reference fire of the nuclear island. No modification was necessary for the *RP4 900* (4^{th} periodic safety review of the 900 MWe plant units).

The general fire water distribution system is supplied by the production network. It includes a fire water supply line serving the fire water networks of the nuclear island and the conventional island.

To guarantee the distribution of fire water in the nuclear island buildings in the event of an earthquake (system designed to seismic standards), the distribution system of the conventional island (not designed to seismic standards) can be isolated by paraseismic valves.

The general fire water distribution system of the nuclear island is supplied by the production and distribution network. It serves the fixed extinguishing systems of the nuclear island comprising the reactor building and its peripheral rooms, the nuclear auxiliary building, the fuel storage building and the RRI (component cooling system) rooms.

The fire water distribution system in the buildings of the conventional part is a looped system inside the turbine hall. It supplies:

- the protection branches of the normal areas of the turbine halls;
- the fire protection of the transformers;
- the fire protection of the oil tanks of the main turbogenerator set and its lifting circuit, and the turbine-driven feedwater pumps (main water supply to the steam generators);
- the site fire water distribution network.

Additional fire-fighting means deployable by the internal or external response teams were also defined at the design stage:

- the network outside the buildings is meshed and features one fire hydrant every 50 metres;
- the internal fire network is designed to protect the safety fire volumes and not to cover the totality of the plant unit premises.

The network of fire hose cabinets or other water-based extinguishing devices is present in the non-sectorised premises (e.g. laundry, waste packaging auxiliaries buildings, etc.). Some of these rooms which do not contain fire loads or which are not contiguous with fire sectors might not be covered by the fire network.

A preventive maintenance programme prescribes the fire network maintenance work (piping, sprinkler system, nozzle system, fire-fighting water standpipes, etc.). To give an example, it requires the verification of the condition of the sprinklers every 2 cycles ± 1 (signs of impact, corrosion, leakage, etc.) and the replacement of the sprinkler if any damage is found.

A-I-3.2.2.3. Management of harmful effects and consequential hazards

When the fire-fighting means are planned to fight a fire within the fire volumes (fixed means or fire hose cabinet), their design must take into consideration the common mode risks due to water. Thus:

- a sill (or change in level) is provided at the walls or boundaries separating trains A and B, unless specific studies showed that these sills were unnecessary;
- floor drains, when present, are suitably dimensioned for the spray delivery rate and the drainage possibilities.

Penetrations in walls or boundaries separating different fire volumes are made watertight if their location makes their immersion possible.

The extinguishing agents are collected and treated to ensure the containment of radioactive materials.

EDF has undertaken the renovation of the means of retention of fire-extinguishing effluents. In this context, the preferred strategy is containment at source inside the facilities, particularly when radioactive substances are involved.

If this is technically impossible, external retention means are provided. They shall be sufficiently dimensioned to retain the fire-extinguishing effluents and the other effluents such as rainwater.

The extinguishing effluent volumes and the associated retention structures are dimensioned using the CALVIN method which is based on methods used in other sectors of activity or rules taken from the regulatory texts.

A-I-3.2.2.4. Alternative/temporary provisions

If the fire protection system is partially or totally unavailable, an analysis is always carried out to put in place appropriate compensatory or supplementary measures and means in the facility. These usually aim to reinforce another line of defence than the one affected by the unavailability. Thus, when an extinguishing means is out of service, the measures will aim at reducing the risk of starting a fire (by prohibiting hot work), the risk of development (by guaranteeing the availability of detection means) and by stepping up the monitoring (patrol rounds or permanent human presence).

There are 2 types of means:

- Compensatory: When the means permit an action that compensates for the loss of effect of the protection; for example: Action of 2 water hoses each covering 200 m^2 for loss of a network (fixed water extinguishing system covering a surface area of 260 m^2);
- Complementary: When the unavailability cannot be fully compensated for; Examples: Additional extinguishing means, overdimensioning of the water resources, presence of a response team on site or use of the public fire brigade.

Repair is carried out as soon as possible, and whatever the case in compliance with the Operating Technical Specifications, which set repair time frames and response actions proportionate to the risks.

A-I-3.2.3. Administrative and organizational fire protection issues

A-I-3.2.3.1. Overview of firefighting strategies, administrative arrangements and assurance

The facilities are designed such that, in the event of fire, safety is maintained by a series of material provisions that suffice even without the intervention of the fire brigade. The development of a fire must nevertheless be controlled to limit the consequences for safety as well as for security, the environment and the assets.

Fire fighting is organised on the basis of Article 3.2.2-2 – Operational organisation of the appendix to Resolution 2014-DC- 0417 (Fire Resolution) and the identification of the different phases of fire-fighting organisation in line with the expected levels of defence.

Fire fighting in the NPPs is based on the seamless complementarity of action between the internal fire-fighting organisation (described in the following paragraph) and the Departmental Fire and Emergency Services (SDIS – *Services Départementaux d'Incendie et Secours*),

As part of operational forecasting, the major possible fires led to the identification of 20 design-critical scenarios, which were examined jointly by all the SDIS's concerned. They cover all the major risks to which NPPs are exposed.

For each risk, the operational means necessary for fighting it have been defined. This generally concerns developed fires that are assumed to spread, necessitating the engagement of one or more levels of means (hydraulic means, fire engines, foam trailers, etc.).

These scenarios are regularly tested when preparing joint EDF/SDIS exercises.

For common events, the basis of organisation by phase remains identical, the licensee's means are always fully deployed, and the minimum first projection means to be deployed by the SDIS's are defined under their responsibility.

A-I-3.2.3.2. Firefighting capabilities, responsibilities, organization and documentation onsite and offsite

The effectiveness of the line of defence relies on an organisation that enables the necessary fire-fighting actions to be accomplished pending deployment of the means of the external emergency services.

The fire-fighting organisation is described in a reference document "organisation of fire-fighting and assistance to persons". Its main instructions are taken up below:

<u>Detection</u>

Any person who notices an incipient or developing fire is obliged to give the alert by calling the internal number 18, and to use the extinguishing means at their disposal (fire extinguishers, etc.), as long as their own safety is not jeopardised. The call is directed to the main control room for the industrial premises or to the site's main protection station for the administrative buildings or outdoor areas.

Reception and acknowledgement of alert

Any call reporting a fire or any fire alarm is immediately and seamlessly acknowledged.

Identification and verification

Following a fire alarm or call reporting a fire, two verification officers (first recon team) are immediately sent to the location. In the case of an alarm, they check that it is not a false alarm, and they call 18 to report their findings. If there is a fire or emission of smoke, they check the completeness of the fire sectorisation within 20 minutes at the most after the alarm or fire/smoke reporting call. The first recon team is not meant to fight a developing fire, but they can fight an incipient fire with extinguishing means if it does not jeopardise their own safety.

Mobilising the emergency services

In the case of a fire/smoke reporting call or after confirmation that the alarm is not a false alarm due to untimely alarm triggering, the operator who took the 18 call mobilises the internal response team which is available 24h/24. He also alerts the external emergency services.

Fire-fighting actions

The response team shall be ready for action in front of the door of the stricken room 25 minutes at the most after the alarm or reporting call. The team comprises a Response team leader and 4 team members, one of whom can assume the role of first-aid coordinator if there are any injured persons.

The response team deploys the internal fire-fighting means to limit the impact of the fire, provides assistance to persons and prepares for the arrival of the external emergency services. The priority of the NPP response teams is to assist persons and fight the fire. They are always supplemented by the operational means of the SDIS in the event of a confirmed fire.

As soon as the fire is confirmed, the emergency organisation is activated.

Intervention of the external emergency services:

Within the framework of the emergency organisation, an Emergency Operations Director interfaces with site Senior Management, the external Emergency Operations Commander (COS), the Response team leader and the control room personnel. The Emergency Operations Director coordinates the all the mobilised players on the ground.

The public fire and emergency services take action with the teams in place in a complementary and concerted manner.

All the personnel concerned by the fire response receive initial training which is regularly refreshed. These training courses are supplemented by exercises and periodic training sessions covered by formalised reports and debriefings.

A-I-3.2.3.3. Specific provisions, e.g. loss of access

If there are on-site routing difficulties, the Emergency Operations Director coordinates the players to identify the most appropriate route for the external emergency services to gain access to the place of the fire with the equipment they deploy.

A-I-3.2.3.4. Managing the functional consequences of a fire

EDF has drawn up incidental or accidental rules of conduct, known as "FAIop" (for *Fiche action incendie opérateur* – operator fire action sheet), which define the actions and guidelines to be followed in the event of a confirmed fire in certain electrical rooms supplying safety equipment, in order to return to a safe state using only equipment not likely to be affected by the fire. They are implemented on notification of a confirmed fire in one of the Safety Fire Volumes concerned, in all reactor operating states except when the reactor is completely unloaded. They apply even when the reactor is operated according to incidental or accidental instructions.

A fire in a fire volume can generate false measurements as well as protection signals and false alarms, which can have an impact on the operation of the reactor (misalignment, switching to hard line, etc.).

These "FAIop" operating rules provide for an electrical shutdown plan for equipment affected by the fire, in order to limit the risk of unexpected equipment manoeuvres and to clarify operation, by voluntarily making equipment likely to be affected by the fire unavailable.

For example, when the damage caused by the fire entails a risk of untimely safety injection (SI), the SI order is inhibited in the anticipated actions. The permanent monitoring provided by the state-based approach means that the SI can be started later if necessary.

A-I-3.2.4. Licensee's experience of the implementation of the active fire protection

A-I-3.2.4.1. Overview of strengths and weaknesses

No noteworthy or major fire having resulted in safety consequences has occurred in the last ten years. Low-level events (smoke emissions or incipient fires) are analysed and lessons learned from them if necessary.

Following the renovation of the fire detection system on the fleet, if a detector is out of service or has to be disabled due to a risk of untimely activation, only the zone covered by that detector is no longer monitored.

The reliability of the detectors installed in the pumping station (resistance to saline environment; state of corrosion of equipment and supports) and in the BR (radiation resistance of the detectors) was improved as part of the Fire Risk Management (MRI) project.

The fire detection equipment and the fixed fire extinguishing systems of the nuclear island (BR exterior excluded) and the conventional island are robust to the revised SSE.

The nuclear island protection system (reactor building exterior) shall be robust to the SSE after deployment of the modifications scheduled as part of phase B of the periodic safety review.

Complementing this, EDF is integrating the insurers' recommendations for the nuclear and conventional parts of its facilities. These recommendations have led it to make improvements to its fire protection systems. For example, moving an isolation valve allowing rapid emptying of the hydrogen from the main alternator in the turbine hall.

The analysis conducted by EDF's services identified several sites on which the on-site fire-fighting personnel must work more closely with the external fire services in order to improve fire-fighting effectiveness. Since 2020, EDF has launched a fire-fighting enhancement project which aims to improve the efficiency of the organisation as a whole and to reinforce the operational coverage, including when the emergency services centre is not in the immediate vicinity of the site.

A-I-3.2.4.2. Lessons learned from events, reviews fire safety related missions, etc.

In order to guard against anomalies in the calibre of the sprinklers installed on the fixed extinguishing systems, the sprinkler replacement procedure is being updated to integrate a specific verification of the calibre of the heat-sensitive system.

EDF has moreover put in place a monthly indicator on the number of requests for work on the fixed fire protection systems. Sites with a large number of ongoing requests have put in place action plans to reduce them by the end of 2023.

The EDF response teams have made significant progress thanks to the training session and exercises.

EDF's Inspector General's Report on Nuclear Safety (IGSNR) considers the recent commitments to improve the fire-fighting organisation to be satisfactory:

- avoid needlessly mobilising the SDIS's by making verifications within the maximum deadline for calling the external emergency services;
- have teams of EDF voluntary firemen on site during working hours who can supplement the SDIS teams.

Conversely, apart from the problem of fire load management mentioned earlier, it notes that the number of anomalies concerning the emergency assistance and fire-fighting means of certain reactors is too high.

A-I-3.2.4.3. Overview of actions and implementation status

In the context of the Fire Risk Management project, measurement stations have been installed on the fire network to ensure that the flow rate/pressure combination required by the design-critical manifolds can be provided and to check this during the periodic tests.

A-I-3.2.5. Regulator’s assessment of the active fire protection

A-I-3.2.5.1. Overview of strengths and weaknesses in the active fire protection

With respect to the strong points identified by EDF, ASN concedes that there have been no fire events with real safety consequences, but nevertheless wishes to underline that across the nuclear fleet there is a significant number of fire outbreaks each year, some of which are considered "notable") (on the EDF scale), such as the recent (fully developed) fire on the main transformer of Paluel reactor 1, which led to the tripping of 2 of the NPP reactors.

The renovation of the fire detection systems is also a point deemed positive by ASN.

However, ASN considers the condition of the fire-fighting means and the heavy reliance on the external emergency services to be a weakness in the fire-fighting strategy.

A-I-3.2.5.2. Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

As far as fire detection is concerned, the renovation of the fire detection systems over the last few years represents a safety improvement. This being said, the period of deployment of this new detection system has been the cause of several significant events on many reactors of the in-service fleet, and the Tricastin NPP suffered partial unavailabilities of the fire detection system that sometimes lasted several days. Furthermore, as specified in chapter 3.1 (A-I-3.1.4), cases of failure to lift disabling permits once hot work worksites are completed arise regularly.

During the last fire inspection on the Tricastin NPP, the maintenance of the fire-fighting means was judged particularly unsatisfactory, and more particularly the condition of the site's fire-fighting water standpipes.

Furthermore, given that the fire-fighting strategy at EDF relies primarily on the intervention of the public emergency services, ASN made requests in 2019 for EDF to ensure the permanent presence on its sites of competent fire-fighting personnel, with appropriate equipment for their missions and trained to cope with developed fires. In response, as of 2024 EDF will deploy a new organisation integrating the supply of complete fire-fighting outfits for the EDF response team members and the presence of a posted operational guard of six firemen on a number of NPPs, including Tricastin, which should allow fire outbreaks to be dealt with more rapidly. This new organisation will have to be assessed.

A-II- 1300 MWe & N4 series active fire protection concept and its implementation

There are two types of fixed extinguishing systems on the 1300 MWe plant series, depending on the risk and the equipment to protect: Water sprinkler systems and total flooding systems.

On the 1300 MWe and N4 plant series, the pumping system for the production of fire water is provided for each plant unit.

At the design of the N4 and 1300 MWe plant series, the fire detection of the nuclear island buildings and those of equivalent status is functional after an SSE for the IPS-NC equipment of the detection system of the N4 series and functional after an OBE for the 1300 MWe series respectively.

As part of the technical requirement associated with the lessons learned from Fukushima and the stress tests, EDF has verified the robustness of the fire detection system and its resistance to the SSE for the 1300 MWe plant series. The fire detection system is robust to the SSE revised after the renovation of all the detection equipment on the 1300 MWe series.

EDF will verify the robustness of the fixed extinguishing systems and their resistance to the revised SMS during *RP4 1300* and *RP3 N4* (the 4th and 3rd periodic safety reviews of the 1300 MWe and N4 series respectively).

Lastly, a modification under the Fire Risk Management project aims to slave the sprinkler manifolds of the RCV (chemical and volume control system) pump rooms to the fire detection system (elimination of the "PFG" [Potential for Generalised Fire] by automatic triggering of spraying in less than 3 minutes). A fire protection sprinkler system is currently being deployed on the TEG (gaseous waste treatment system) compressors. These compressors constitute a PFG with fast kinetics in a room containing an H_2 pipe.

A-III- EPR active fire protection concept and its implementation

Fire detection and alarms

The fire detection system is classified as being designed specifically to monitor the Fire in accordance with the design code RCC-E (AFCEN).

Like the Tricastin NPP, the system comprises fire detectors connected to automatic detection and alarm control panels. They are permanently self-monitored and any unavailability is signalled on the fire detection control panel. The system design is similar to that of the fleet. The main difference lies in the fact that the control functions of the fire-related equipment are carried out via the plant unit instrumentation and control (I&C).

Extinguishing systems

The fire-fighting systems are equivalent to those of the fleet. The presence of an inter-containment space through which numerous cable raceways are routed necessitates fire protection which is ensured by four fixed water sprinkler networks, one per fire safety zone, and by a ring equipped with fire hose cabinets. Each network can be isolated by a manual valve situated outside the reactor building.

On the EPR, the production and supply of fire water is ensured by 4 main pumps and network pressure is maintained by one dedicated pump. The system supplies the systems that ensure more specifically the fire protection of the safety-classified buildings.

The systems supplying water to the fire-fighting equipment and systems are classified under the protection of the facility against internal hazards, excluding the total flooding systems of the Reactor Coolant Pumpset which are not considered in the safety analyses.

Site's organisation for maintaining the fire protection and fire-fighting systems in good condition

The baseline operating requirements and the personnel skills are identical (managerial and regulatory). However, the deadlines for bringing the sectorisation into conformity are different and based on the applicable operating requirements defined in the General Operating Rules (RGE).

The baseline safety requirements of the EPR require the facility design to take into account all the internal and external hazards that could affect the nuclear safety of the reactor through the common mode effects on the systems and equipment necessary to bring the plant unit to and maintain it in a safe shutdown state and to avoid and limit radioactive releases. The hazards chapters of the safety report define the nuclear safety objectives to be met in hazard situations and the design provision to guarantee this. Chapter II "Hazards" of the RGEs defines the general specifications for guaranteeing that the abovementioned safety objectives are met in service. In particular, the Fire sub-chapter of chapter II of the RGEs defines the specifications for guaranteeing in-service compliance with the safety objectives defined in section 3.4.7 of the Safety Analysis Report (SAR).

The fire-fighting organisation is identical to that presented in §A-I-3.2.3.2.

B- Research reactors RHF – BNI 67

B-3.2.1. Fire detection and alarm provisions

The second level of defence in depth for fire risk management is based on putting in place fire outbreak detection systems adapted to the different types of risk and the different rooms of the facility.

The sensitive rooms of BNI No. 67 (rooms ensuring the reactor safety and availability, rooms featuring regulated areas in terms of radiation protection) are monitored by a Fire Detection System (FDS).

A second FDS monitors and protects the other rooms of the Laue-Langevin Institute (ILL).

These FDS's transmit the restricted fire alarms to places where personnel are constantly present (control room, security command post, hardened safety core command post). The general evacuation order is triggered after confirming the fire (verification) by means of the evacuation systems (Fire Protection Control Panels, Public Address System, evacuation system specific to reactor building ILL5).

B-3.2.1.1. Design approach

The installation of the fire detection system started with the equipping of a few key places such as the reactor building ILL5, building ILL5D (emergency command post), the control room of building ILL4 containing the reactor's entire I&C system.

In the following years the Fire Detection System (FDS) was progressively installed in the other sensitive rooms of the ILL (in accordance with rule APSAD R7).

The detector network (more than 2000 detectors on the site) comprises point detectors which can be optical, thermal, UV/IR or linear, and multipoint detectors which have been chosen according to the risk and the environment of the monitored room.

B-3.2.1.2. Types, main characteristics and performance expectations

All the installed detectors are addressable, allowing fast, easy and precise locating of any fire outbreak. The fire alarm signal is different from any other alarm that might sound in the BNI.

The detection lines are looped back, which ensures that the availability of all the detection points is maintained if there is a break in one detection line, and only one detection point is lost if a detector fails. Furthermore, any failure is precisely indicated on the fire control panels and on the fire supervision console enabling the licensee to put in place the necessary compensatory measures until the failure is repaired.

The FDS is designed to the "hardened safety core" earthquake standards; it is backed up by battery with a 12-hour operating autonomy. Moreover, the fire control panels are energised by an electrical network backed up by diesel generator sets (or by the ultimate backup diesel-generator sets stemming from the stress tests).

The FDS also exchanges fire detection information with the Electrical Automatic Control and Delay Devices (EACDD) which equip the Automatic Gas Extinguishing Systems (AGES) of the control room and of the emergency command post ensuring the robustness of the detection part of these devices.

B-3.2.1.3. Alternative/temporary provisions

The unavailability of one or more detectors following a failure leads to the implementation of compensatory measures:

- at least one patrol round every twelve hours and banning the issuing hot work permits for the zone in question;
- drawing up and circulation of a provisional instruction indicating the zone concerned and the compensatory measures taken.

Maintenance operations on the fire systems are scheduled outside the activity phases of the rooms (for example, reactor shut down).

If an operation requires disabling of the Automatic Fire Detection (AFD) system in a room (operation under a hot work permit for example), it is the works manager who is responsible for monitoring the room during the operation and putting the AFD system back into service afterwards.

A complementary measure has been put in place in the sensitive rooms to return the AFD system to service automatically (following its disabling for work operations): return to service takes place within 12 hours in the reactor building ILL5, the emergency command post ILL5D and the control room ILL4, and within 24 hours for the experimental halls ILL7 and ILL 22.

B-3.2.2. Fire suppression provisions

Three types of fire extinguishing means are deployed on BNI No. 67:

- gas extinguishing systems (automatic or manual);
- sprinkler extinguishing systems;
- hand-held and wheeled extinguishers.

Furthermore, the dry risers in the reactor building ILL5 and building II4, and the hydrants provided on the site enable the external fire-fighting services to connect an extinguishing means directly.

B-3.2.2.1. Design approach

The gas or sprinkler automatic extinguishing systems have been installed in the rooms where there is a high risk of fire propagation (electrical power, presence of fuel or other significant fire loads).

Automatic Gas Extinguishing Systems (AGES)

They protect:

- the ultimate backup diesel generator sets (DUS) of the emergency command post, by application of CO_2 gas;
- the control room of building ILL4 housing the I&C and the reactor low voltage power circuits, by total flooding with nitrogen (N_2);
- the C compressor of the cold neutrons sources in building ILL6 (detritiation) by application of CO_2 gas, in manual mode only.

These systems have been installed in conformity with the APSAD reference base R13 which details the choice of extinguishing agent, the safety measures to put in place, the sizing of the pipes and overpressure vents, the volume of extinguishing agent to install, and the functional, operating and preventive maintenance requirements.

These systems are checked twice a year by an accredited organisation in accordance with APSAD rules R13. The fire detectors used in an AGES are checked twice a year. The correct functioning of the weight indicators of CO_2 cylinders and the pressure of the nitrogen cylinders are checked monthly.

Sprinkler extinguishing system: It ensures the fire protection of the diesel generator set room in building ILL3, and of the technical and cable galleries situated in the immediate vicinity of building ILL4.

A total flooding spray system equips the room that routes the cables up from ILL4 to the reactor building.

In 2022, a manual spray system equipped with sprinkler heads was installed in the bunkers of the heat exchangers and the reactor coolant pumps on level B of the reactor building, which are prohibited areas (red) when the reactor is in operation.

These systems are checked and maintained by an accredited organisation in conformity with APSAD rule R1.

Hand-held or wheeled extinguishers: The number, type and location of the extinguishers have been defined in application of APSAD rule R4. All the ILL personnel are trained in the use of fire extinguishers. Refresher training is provided every 3 years at least. During this training, the action to take in the event of fire is reiterated.

The hand-held extinguishers undergo annual maintenance and verifications in application of APSAD rule R4 and standard NFS 61-919.

Dry riser and hydrants

Dry riser in reactor building ILL5: It serves levels B, C and D of the reactor and gives the fire-fighting services direct access to an extinguishing means inside the building without calling into question its static containment.

Conformity of the dry riser with standard NFS 61-751 is verified annually.

This dry riser is supplied with water from two different sources: normal supply via the public water supply and emergency supply by pump tender in two different places, provided by the external fire-fighting services and supplied by a fire-fighting water standpipe.

The emergency network up to the level B outlet is designed to SSE design standards. When the public water supply is unavailable, a compensatory measure enables the reactor dry riser to be supplied with water from an intake point on the River Drac.

A second dry riser is currently being installed in the reactor building; it will supply the future sprinkler system that will equip reactor level C.

Dry riser in building ILL4: It serves all the levels and gives the fire-fighting services direct access to an extinguishing means inside the building. Conformity of the dry riser with standard NFS 61-751 is verified annually.

Hydrants: nine fire hydrants are installed on the ILL site so as to allow a fire-fighting intervention over the entire perimeter of the site and ensure a delivery rate of 60 m^3/h when three water standpipes are open, in accordance with standard NFS 62-200.

Fire water network: The public water supply network that supplies the fire network (fire hydrants and dry risers) is meshed and protected against freezing.

B-3.2.2.2. Types, main characteristics and performance expectations

The following paragraph details the performance expectations for the automatic gas -extinguishing system sand for the sprinkler systems (see §B-3.2.2.1 for hand-held fire extinguishers).

Automatic Gas Extinguishing Systems (AGES): The extinguishing process is controlled by the Electrical Automatic Control and Delay Device (EACDD) of each sector. and the "gas flow" alarm report is transmitted to the FDS.

When in standby mode: the quantity of extinguishing agent is monitored permanently.

Any fault affecting an AGES component is transmitted to the FDS.

Sprinkler extinguishing system: the performance levels have been determined on the basis of APSAD rule R1 for the installation of the sprinkler heads, the reference surface area and the required flow rate to guarantee the function.

For the level B bunker sprinklers, the water supply is activated manually from outside the bunkers.

These extinguishing systems are not designed to seismic standards due to the fact that all the site's electrical power supplies (apart from the "hardened safety core" emergency diesel generator sets) are cut off as soon as an earthquake precursor threshold is reached (0.06 g measured in the level B basement of the reactor).

Case of experimental areas: The level of fire risk on these areas did not necessitate deploying any particular extinguishing system of the AGES or sprinkler type. They are therefore protected by hand-held fire extinguishers (distribution and type defined in application of the APSAD rule R4). Access paths for a fire-fighting intervention have thus been demarcated on the ground in the experimental halls and on the different levels of the reactor.

The projects to install ambient and bunker sprinklers on level C of the reactor building (see B-3.2.2.1 and B-3.2.4.3) will reduce the risks of a fire spreading from one experimental area to the other.

B-3.2.2.3. Management of harmful effects and consequential hazards

The automatic gas and sprinkler extinguishing systems will limit the damage caused by a fire outbreak by preventing it from spreading.

The choice of these systems was based on the possible origin of a fire outbreak and the types of rooms to protect. For example, the choice of an AGES for the control room housing the reactor I&C enables a fire outbreak to be circumscribed without risking harming the part of the facility that is still functional.

If the sprinkler systems of the HV room or the cable chases should be activated, the HV branches are cut off. Access to the HV room is prohibited to avoid any risk of inductive discharge of the HV transformers due to the runoff water.

In 2021 the ILL launched a project to recover the fire extinguishing water (except from a fire in the reactor building which is a water containment sector). A flexible tank of about 1000 m^3 volume will collect the fire extinguishing water further to a fire in one of the ILL site buildings.

B-3.2.2.4. Alternative/temporary provisions

These gas or sprinkler extinguishing systems are reliable systems that undergo regular verifications as indicated in §B-3.2.2.1. The only alternative in the event of equipment failure is human action. In such a case it is probable that the damage to the facility would be more extensive, but in any event this would not affect the safety of the facility, only its availability in the short term.

These systems are also monitored permanently and any untimely degradation of the system would cause transmission of an alarm in the control room (water pressure below the minimum threshold for the sprinkler system, weight of gas cylinders below the minimum threshold for the AGES's).

B-3.2.3. Administrative and organizational fire protection issues

The third level of defence in depth for fire risk management is based on the means of limiting fire propagation and the response and fire-fighting means. This paragraph describes the organisational fire-fighting measures.

B-3.2.3.1. Overview of firefighting strategies, administrative arrangements and assurance

The response strategy (verification, first extinguishing actions, evacuation) is based on the response of the internal brigades, i.e. the Local Initial Response Teams (LIRTs). The external brigades i.e. the Local Security Force of the CEA, whose site is next to the ILL, and the Grenoble fire brigade (Departmental Fire and Emergency Service - SDIS) have signed agreements with the ILL; they intervene to fight confirmed and developed fires.

The procedure "Setting up a Local Initial Response Team" describes the duties of the ILL internal brigade, the training and exercise frequencies and procedures, the interactions with the external fire-fighting forces. It is supplemented by several Operational Security Procedures intended for the ILL security officers, describing the way to receive the external fire-fighting forces, get them into controlled access areas and guide them on the site to minimise the time taken to get to the fire.

The LIRTs, who are attached to the Security Protection Service, also ensure the operability of the fire provisions by being responsible for the periodic inspection and maintenance of all the fire-fighting devices, equipment and systems.

B-3.2.3.2. "Firefighting capabilities, responsibilities, organization and documentation onsite and offsite"

Local Initial Response Teams: The procedure "Setting up a Local Initial Response Team describes the organisation for responding to a fire outbreak, in coordination with the CEA's Local Safety & Security Force (FLS) and the SDIS. There is always at least one LIRT comprising three members present on the site, the composition, role and training of which are governed by this procedure.

The role of the LIRT, comprising personnel from the Reactor Operations Service and the Security Protection Service, is to carry out the first response actions which are described in the Particular Operating Instruction "Response in the event of fire or explosion".

Furthermore, in the event of a confirmed fire, the external professional fire-fighting teams are always called out by the security command post (or directly by the control room); their action is covered by agreements established with the ILL:

- the Local Safety & Security Force (FLS) of CEA Grenoble, neighbouring the ILL site;
- the Grenoble fire brigade (SDIS), situated near the ILL.

The operational response instructions for the LIRTs in the various building or particular rooms of the ILL are described in the Particular Operating Instruction "Response in the event of fire or explosion". Precise instructions are given concerning the various actions to carry out according to the types of risks considered for each building.

This Particular Operating Instruction is updated after each modification to the facility or organisation that impacts fire fighting.

The SDIS for its part has documented the intervention particularities specific to the ILL (means of access, identification of the radiological and chemical hazards, fire hydrants, etc.) in an internal document entitled "PLAN ETARE", on the basis of information that is regularly updated then transmitted by ILL.

The ILL building access plans are given to the teams of the external forces at the site entry post before their intervention, at the same time as they are given their active dosimeter.

In the event of a confirmed fire (or during joint exercises), coordination between the LIRT and SDIS is ensured by two liaison officers from SDIS, one placed in the licensee's Emergency Technical Team, the other in the ILL Strategic Management Command Post. The SDIS Emergency Operations Commander also ensures the coordination between the teams on the ground and these two emergency structures.

Training courses and exercises: Each LIRT member participates in an initial training course (reminder of the fire safety fundamentals, utilisation of self-contained breathing apparatus (SCBA), verification with SCBA, emergency evacuation from a room with an unbreathable atmosphere, training in the use of extinguishing equipment).

In addition, once a year the LIRTs follow an in-house course given by ILL instructors and focusing on multi-skills acquisition and maintenance, not only relating to fire (use of extinguishers, SCBA, explosimeters) but also technical knowledge (lifts/elevators, radiation protection, etc.). The typical content of this training is based on the study and implementation of the specific Particular Operating Instructions and Operational Security Procedures relating to the fire theme.

Each ILL in-house training course is supplemented by exercises on themes relating to the different situations set out in the Particular Operating Instruction "Response in the event of fire or explosion".

The ILL carries out at an exercise in collaboration with the FLS and the SDIS at least once per year. Over and beyond the operational lessons learned from these exercises, they enable the members of the SDIS to acquire a safety culture and knowledge of the radiological risks that helps them in their interventions in the ILL.

These exercises have also allowed the creation of Operational Security Procedures formalising the instructions to be applied by the site security officers to optimise the speed of access into the ILL's controlled access areas.

Access and circulation routes: The external access and circulation routes are materialised by roads that are kept clear. The site security officer who conducts the patrol rounds makes sure that no vehicles are parked outside the parking spaces which are identified by markings on the ground.

The circulation routes inside the buildings are prepared and kept clear. During their patrol round, the watch personnel make sure that nothing will obstruct traffic movements.

B-3.2.3.3. Specific provisions, e.g. loss of access

At least two access routes are available to gain access to any of the buildings on the ILL site.

If it is impossible for the fire brigade to gain access to the ILL via the main entrance to the EPN Campus, they can access the ILL site directly by taking a road that comes from the CEA site and crosses that of ST Microelectronics.

In the reactor building and in the experimental halls, there are also two possible routes for accessing the intervention site.

Particular case of gaining access to the level B bunkers of the reactor building (heat exchangers, reactor coolant pumps, etc.): these bunkers are prohibited (red) radiological areas which are inaccessible when the reactor is operating. Because of this, sprinkler systems were installed in them in 2022. If a confirmed fire is detected, connection of the building dry riser and opening of the system water supply are done manually from outside the bunkers.

B-3.2.4. Licensee's experience of the implementation of the active fire protection

B-3.2.4.1. Overview of strengths and weaknesses

Regarding the use of hand-held fire extinguishers: all the ILL personnel are trained in the use of fire extinguishers, which are placed in locations guaranteeing a fast speed of reaction. The weak point is that these extinguishers are only suitable for fighting incipient or small-scale fires

The automatic gas-type extinguishing systems are well suited to sectors which may be confined and they adequately protect the other equipment items present in them.

Sprinkler systems detect and participate in extinguishing a fire; a negative aspect nevertheless concerns the potential damage caused by the water and its run-off, which makes it necessary to cut off electrical power in the area rapidly.

Given that the weak point common to these active systems is their potential unavailability or sudden failure (see B-3.2.4.2), they must be rigorously monitored by periodic testing.

As far as the interventions are concerned, it has been observed that good coordination between the internal fire-fighting teams and the external forces (FLS, SDIS) can only be maintained through regular exercises with joint debriefing.

B-3.2.4.2. Lessons learned from events, reviews fire safety related missions, etc.

No learning from experience has yet been acquired on the effectiveness of the automatic gas or sprinkler extinguishing systems, as they have never yet been activated under real fire conditions, or accidentally, at ILL.

However, on one occasion an automatic gas extinguishing system came very close to being unavailable due to the failure of a gas cylinder, which led to corrective action being implemented (see B-3.2.4.3).

The few actual fire outbreak events having required the use of hand-held fire extinguishers by the ILL personnel have shown that these means, and the way of using them, were effective for smothering or rapidly putting out an incipient fire or a combustion phenomenon in its early stages.

The joint exercises with the SDIS have consolidated the intervention times and improved coordination between ILL's Local Initial Response Team members and the professional firemen. A sensitive point remains that the complexity of some of the ILL buildings requires the SDIS firemen to be accompanied by the ILL LIRTs in order to identify certain specific risks or particular topographies of the sites (e.g. inside the reactor building).

B-3.2.4.3. Overview of actions and implementation status implementation

AGES[18] : further to the lessons learned concerning this system, it was decided to procure a second gas cylinder for these systems as a safeguard against possible failure of the first cylinder.

Sprinkler extinguishing system: a project for a new sprinkler system for experimental level C of the reactor building ILL5 is currently being examined (in 2023) by ASN. Intended to limit the spread of a fire outbreak, it will also guarantee additional margins for the fire resistance of the level D supporting structure and level C travelling crane.

B-3.2.5. Regulator's assessment of the active fire protection

B-3.2.5.1. Overview of strengths and weaknesses in the active fire protection

The ILL does not have its own fire-fighting force beyond the first aid team members and many areas are not equipped with automatic fire-extinguishing systems due to the initial design of the facility.

B-3.2.5.2. Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

ASN has been able to test the ILL's systems through exercises during inspections dedicated to the fire risk. Management of the fire-fighting water, which can lead to discharges, has also undergone improvements and been the subject of exercises during inspections.

ASN has often observed a good standard of training of the LIRT team members, who have demonstrated the ability to respond rapidly and effectively. A recent fire outbreak confirmed the effectiveness of the LIRTs and the good coordination with the secondary response teams of the CEA Grenoble.

C- Fuel Cycle Facilities

C-I- Fuel enrichment facility - George Besse II – BNI 168

C-I-3.2.1. Fire detection and alarm provisions

C-I-3.2.1.1. Design approach

The earlier a fire outbreak is detected, the better it can be brought under control. Consequently, the fire detection system installed in the GBII plants is designed to:

- detect, signal and locate any fire outbreak as early as possible, particularly in the rooms in which there is an identified fire risk;

[18] Automatic Gas Extinguishing Systems

- memorise the location of the first detector activated;
- transmit and translate the signal in a clear and reliable manner in order to allow a rapid response;
- activate, if necessary, the interlocked safety devices such as doors, automatic extinguishing systems if present, cutting off certain electrical power supplies, etc.

The detectors are appropriate for the risk encountered in the room in which they are installed, for example:

- smoke detectors are installed in rooms containing electrical equipment;
- flame detectors are installed in the rooms containing diesel fuel;
- temperature detectors are installed in the handling gantries and transfer conveyors.

The rooms equipped with fire detectors are those housing:

- equipment classified SIC (safety important components), uranium-bearing materials including equipment items that are safe by design, and the waste interim storage rooms;
- fire sources (e.g.: presence of electrical equipment).

In practice, all the rooms of the enrichment units are equipped with an AFD system except those whose movable fire load is limited to paint, lighting devices and safety equipment.

Furthermore, the storage of fire loads in rooms without an AFD system is prohibited.

C-I-3.2.1.2. Types, main characteristics and performance expectations

The AFD system is made up of addressable automatic fire detectors connected to fire control panels.

This detection system is permanently energised. The backup electrical power supply for these fire control panels is provided by batteries with about 12 hours of autonomy, supplied by the backed-up electrical distribution network.

Each detector corresponds to a specific address. The addressable detection loop is a loop in which the detectors are connected to a BUS looped back to the fire control panel (the bus starts at the FCP and returns to it). The functioning of the detection points in the rooms adjacent to a fire sector in which a fire would destroy its detectors is ensured thanks to the possibility of energising and polling the loop from both sides: if an incident affects the cable, the undamaged detectors continue to function while being polled by the fire control panels from the 2 sides of the detection line.

The fire control panel monitors the availability of the detectors and manages the detector activation information and the position information from the fire dampers and fire doors when they are slaved to the fire detection system. In the event of an operating fault and degraded operation, the fire control panel delivers the information on the presence and nature of the fault.

The information delivered by the fire control panels, associated with the audio and visual alarms, is transmitted to the operational control room and acknowledged by the personnel who is present in the operational control room at all times.

The detailed information and a summary are sent to the Security Command Post of the UPMS (Material and Site Protection Unit, see C-I-3.2.3.1).

C-I-3.2.1.3. Alternative/temporary provisions

In the event of unavailability of the fire detection system, the General Operating Rules provide for:

- checking that the fire doors are properly closed;
- conducting patrol rounds at each shift and prohibiting hot work until the system has been repaired.

If work necessitates disabling of the AFD system, the licensee disables the system and informs the UPMS which records the changes of status of the AFD system in a register.

Whenever the personnel leave the worksite, irrespective of the duration of their absence, the AFD system is put back into service. The worksite shall never be left without surveillance.

When the AFD system is put back into service, the UPMS is informed and registers this.

Moreover, at each change of shift, the status of the inhibited detectors is registered on the shift change file.

C-I-3.2.2. Fire suppression provisions

C-I-3.2.2.1. Design approach

The site has a meshed fire water distribution network supplied by 2 water towers located on the site. They supply the fire-fighting water standpipes which protect the plants. Each one can deliver 400 m^3 of water per hour.

The buildings are designed to ensure stability in the event of an earthquake. The equipment installed inside the buildings, such as the dry risers, will be accessible to the emergency response teams after an earthquake.

The dry risers are located in the protected stairways of the plants and can be connected to the fire water network.

The buildings are equipped with fixed or mobile extinguishing systems. They are designed and installed in accordance with the standards and rules of good practice (APSAD recommendations, etc.). All these systems are subject to periodic functional checks

The chosen extinguishing agent is appropriate for the risk and the utilisation constraints.

The design of the fixed systems takes account of the consequences of untimely activation. If an automatic extinguishing system is interlocked with the AFD system, the detection signal is subject to a confirmation process to limit untimely activations (dual detection by detectors using different technologies, separate detection loops). This is the case with the centralised control rooms and for extinguishing actions in the room cabinets.

C-I-3.2.2.2. Types, main characteristics and performance expectations

Hand-held extinguishers using CO_2, sprayed water or powder are provided throughout the facility, distributed according to the type of fire to put out (electrical, solids, etc.).

Automatic extinguishing means are installed on the main electrical cabinets of the gantries of the North and South units, and at the diesel generator sets of South unit gantries.

The control rooms are equipped with an automatic gas extinguishing system (FM-200 gas).

In addition, fixed extinguishing systems are installed in the inaccessible or poorly accessible fire risk areas, such as the cable galleries. A time delay is applied between fire detection and release of the gases to allow the evacuation of the personnel present in the room. In the event of fire in these rooms, an audio and visual alarm ("immediate evacuation") above the doors signals the forthcoming activation of the automatic extinguishing system, and this information is transferred to the security cabinet managing the AFD system.

The fire-fighting water standpipes meet the following requirements:

- they are readily accessible and situated 5 metres at the most from the edge of the road or the fire engine parking areas, on which the parking of other vehicles is prohibited;
- they are distributed according to the risks to be protected against;
- the distance between two water standpipes is less than 300 m.

The supply port of each dry riser is situated at a distance not exceeding approximately 60 metres from a water standpipe.

C-I-3.2.2.3. Management of harmful effects and consequential hazards

For reasons of criticality, it is prohibited to use fire extinguishing water in the rooms of the enrichment unit stations. This information is present in particular in the UPMS response plans (see C-I-3.2.3.1).

Sills are installed to retain the extinguishing water in the room in which extinguishing took place. When necessary, mobile pumps can be used to recover the extinguishing liquids, thereby avoiding any discharge into the environment.

The automatic extinguishing system in the control rooms use FM-200 fire suppressant. Its use can lead to anoxia in the personnel present. It is therefore necessary to evacuate the rooms before use. Regular evacuation exercises are conducted to train the personnel.

C-I-3.2.2.4. Alternative/temporary provisions

In the event of unavailability of the automatic fire extinguishing system, the General Operating Rules provide for patrol rounds to be carried out at each shift and prohibit hot work until the equipment has been returned to service.

C-I-3.2.3. Administrative and organizational fire protection issues

C-I-3.2.3.1. Overview of firefighting strategies, administrative arrangements and assurance

The pre-established fire-fighting organisation put in place in the plants comprises four distinct operational levels:

- The first level of the organisation comprises all the personnel working on the site. Their mission is to give the alarm, evacuate and use the available initial response means to put out an incipient fire;
- The second level of the organisation comprises the Local Initial Response Teams (LIRTs) who are permanently present in the plants and who know the safety-important SSCs (systems, structures and components. They have in-depth knowledge of the prevention and fire-fighting means of their assigned building;
- The third level of the organisation comprises the Material and Site Protection Unit (UPMS) to respond to the risks and requirements of the platform.

The site's organisation can be backed up by the public emergency services if necessary.

C-I-3.2.3.2. "Firefighting capabilities, responsibilities, organization and documentation onsite and offsite"

Main missions of the LIRT:

- reconnaissance of the sites and of the fire, without taking risks, giving the alarm, alert;
- deploying the mobile or fixed fire-fighting means;
- receiving, informing and guiding the first responders of the UPMS;
- if necessary, when the fire concerns a fire sector, it participates in the compartmentalisation actions (checking effective closure of the fire dampers, etc.) and management of the nuclear ventilation (checking opening of the smoke vents in the upper sections of the rooms).

The UPMS can intervene rapidly with heavy fire-fighting equipment to fight to two simultaneous incipient fires or one developed fire.

The UPMS personnel have received firefighter training. It ensures the fire-fighting call duty 24h/24 for all the plants. The UPMS has intervention equipment, some of which is stored in dedicated rooms designed to withstand an extreme earthquake.

The UPMS intervenes in the plants with emergency response plans indicating the location of the fire-fighting and emergency equipment (extinguishers, dry risers, etc.), of the detection equipment, the sectorisation, the radiological and electrical risks and lastly the alerting devices.

These plans also indicate the supply points for the fire-fighting appliances, the access routes to the buildings and their rooms, and the fluid cut-off components. They specify any prohibitions on the use of extinguishing agents and the harmful effects that their use would cause (e.g. use of water prohibited, loss of containment, flooding, etc.).

The teams participate regularly in exercises (about 80 per year, of which a third concern fire).

An assistance agreement with the fire brigade provides for:

- preparation of the conditions of intervention of the fire brigade to back up the means engaged by the UPMS;
- training of the fire brigade firemen in the risks inherent to the facility, supplemented by exercises and visits.

At each level the responders are trained in the safe use of the intervention, fire-fighting and emergency means at their disposal, and in the action to take during interventions.

C-I-3.2.3.3. Specific provisions, e.g. loss of access

There are several access routes that can be taken by the response vehicles.

C-I-3.2.4. Licensee's experience of the implementation of the active fire protection

C-I-3.2.4.1. Overview of strengths and weaknesses

The main strengths of the BNI lie in:

- broad coverage by the automatic fire detection network fostering early detection and enabling the personnel involved in fighting the fire to be mobilised rapidly and to place and maintain the facility in a safe state in a fire situation;
- the on-site presence of a service specialised in fire fighting with personnel and technical means equivalent to those of the fire brigade.

No weak points needing improvement have been identified since the plants were commissioned.

C-I-3.2.4.2. Lessons learned from events, reviews fire safety related missions, etc.

The lessons learned are set out in detail in chapter C-I-3.4. They concern more specifically the disabling of a fire interlocking system by a shunt installed for a test.

C-I-3.2.4.3. Overview of actions and implementation status

The actions carried out further to experience feedback are detailed in chapter C-I-3.4.

C-I-3.2.5. Regulator's assessment of the active fire protection

C-I-3.2.5.1. Overview of strengths and weaknesses in the active fire protection

Active fire risk control measures were defined from the BNI No. 168 design stage.

More precisely, the active measures correspond to:

- appropriate detection devices located specifically in the rooms where there is a fire risk;
- appropriate fire-fighting and extinguishing means (extinguishing water supply hydrants, dry riser, carbon dioxide gas injection systems in rooms where the presence of water is prohibited, etc.);
- a robust initial response organisation including specifically trained personnel.

It must be pointed out that active fire risk management systems require special attention with regard to keeping them operational. Consequently, the functioning of the detection systems must be verified periodically and any organisation based on the intervention of specific personnel members in the event of fire necessitates the maintaining of a high level of skill and organisation, particularly through training courses. Safety events relating to human factors have been recorded in this respect:

- in 2015, during the inspection of a fire detection system, it was discovered it had not been re-enabled after its previous disablement;
- in 2021, a problem of alignment of several fire-fighting water standpipes was discovered on the facility's South unit.

C-I-3.2.5.2. Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

No major deviations were detected during the inspections conducted in BNI No. 168 on the themes relating to active fire risk control devices. Nevertheless, particular attention must be maintained regarding keeping the response personnel's training and the emergency response plans up to date.

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The protection measures implemented are defined in conformity with the regulations and standards in effect. They also take into account the non-statutory baseline requirements in terms of good practice, such as the rules of APSAD (*Assemblée Plénière des Sociétés d'Assurances Dommages* – Plenary Assembly of Damage Insurance Companies). The provisions are set out in the safety report and broken down in the operating procedures and the procedures governing the creation or modification of facilities.

C-II-3.2.1. Fire detection and alarm provisions

C-II-3.2.1.1. Design approach

The site's fire safety system (FSS) is category A. It covers all the buildings. It complies with standard NF S 61-931 (taken up by APSAD rule R7). The requirements concerning its design, production, tests, operation, maintenance (preventive and corrective), its periodic verifications and its modifications are specified in procedures.

The FSS comprises:

- a fire detection system (FDS) consisting of automatic fire detectors (AFDs), manual call points (MCPs), fire racks (monitoring and signalling equipment – MSE, each individual MSE being of the addressable looped-back type);
- a fire safety control system (SMSI) for the controls command post (PCC) building, including a fire safety control panel (CMSI);
- an on-site centralised fire supervision station at the central security station (PCS) in the "emergency command post" (PCC) building, manned 24 hours a day and 7 days a week by specialised personnel, to which the essential information is transmitted;
- a secured communication network allowing communication between the FDS, the CMSI and the supervision stations;
- a backup system on an independent loop allowing transmission to the PCS, on a dedicated signalling cabinet, of information summaries for each MSE (alarm, including the alarms from the

explosive gas detection racks, fault condition, out of service), without precise information on the activated detector(s) or sensor(s).

The FSS undergoes periodic preventive maintenance provided for in APSAD R7 and the Labour Code, and corrective maintenance where necessary. The periodic verifications are covered by procedures.

If an alarm is transmitted, the PCS informs the local response team (LRT) which verifies on site that it is not a false alarm. If the fire is confirmed, the evacuation alarm is activated locally using an MCP. If a fire outbreak is detected by the personnel, the PCS is alerted either by an internal telephone call to 18, or by activating an MCP. All the personnel are trained in these initial response actions.

C-II-3.2.1.2. Types, main characteristics and performance expectations

Fire detection on the site is automatic, with alarms centralised at the PCS.

The rooms of the buildings housing uranium-bearing materials are monitored by the fire detection system. There can be exceptions for certain rooms, on condition that the Fire Risks Management Case (DMRI) enables the risk of a fire outbreak to be excluded in them (no source of ignition or fire load). Additional detectors are installed in the false ceilings and false floors as well as, if considered necessary, in the electrical cabinets and boxes.

The FDS ensures early detection with locating of the fire. As the system is addressable, each detector is identified by a unique address. In the event of activation, the detector concerned can be located geographically via the following logic structure: site (building) / section (level or storey) / area (room or zone) / element (detector). Each detector is thus identified:

- on the fire supervision station in the PCS (visual and audio signalling);
- on the building monitoring and signalling equipment;
- at the entrance to the room (visual signalling) on some rooms;
- on the detector itself (visual signalling).

The choice of the type, number and location of the fire detectors depends on the analysis carried out for the DMRI and is done in conformity with the Labour Code and APSAD R7. Different types of detectors are thus installed on the site: point optical, linear and multipoint aspirating detectors for smoke; heat detectors; flame detectors; multiple criteria smoke-heat, etc. The site also relies on the competence of the supplier (certified APSAD I7).

The FDS enables, through programmed interlocks, automatic actions required by the DMRI to be taken to place the facility in safety condition if a fire breaks out, sectorisation actions in particular. For example, if a fire detector is activated, the interlocked actions are as follows: closure of the fire doors and fire dampers, cutting off the electrical equipment or process, closure of hazardous gas valves, automatic extinguishing. With the exception of the PCC building which has a CMSI, the interlocks within the buildings are managed by the FDS.

It will be noted that other technical equipment items relating to fire safety are connected to the FSS, by retrieval of information from the monitoring and signalling equipment. Examples include the hazardous gas detectors, the temperature probes, the automatic extinguishing systems, etc. These equipment items are involved in certain interlock equations.

The interlocks are subject to periodic inspections and tests provided for in the general operating rules.

If the power supply of the normal electrical distribution network is lost, the monitoring and signalling equipment has a backup electrical power supply (internal battery with an autonomy of 12 hours). If the backup power supply is lost, the auxiliary source (cell, secondary cell or capacitor) enables local alerts to be given (for at least 1 hour) associated with the loss of monitoring. Procedures, such as the General Operating Rules, describe the action to take in these situations.

The cables and buses of the FSS are classified with respect to their fire behaviour and reaction (order of 21 July 1994):

- Cca s2 dx (x=0, 1, 2) ay (y=1, 2) at least for the detections (general case);
- CR1-C1 for the connections from the rack to the first loop detector and from the last loop detector to the rack, for the connections that are not monitored by the loop associated with the cables, and for the cables necessary for the automatic sectorisation or safeguarding actions (interlocking of doors, fire dampers, electrical power cut-offs, alarms, etc.).

In practice, all the FSS connection cables on the site (buses, detection, safeguarding devices) are classified CR1-C1.

The communication-loop organisation of the FSS, the presence of the backup network and the multiplicity of the detectors, ensure redundancy of the communication channels and thereby limit the common modes with respect to possible hazards. The detection buses and the interlock buses are physically separated insofar as possible.

Any anomaly on either of the FSS communication loops send a fault signal (Unavailable) to the PCS.

The FDS is not designed to seismic standards. However, in this case the electrical power supply (normal, backed-up and permanent) of the entire site is automatically cut off, with the exception of the equipment in the PCC building, designed to the seismic event exceeding the design basis standards (of which the PCS is part), and other equipment which must be kept energised to maintain the facilities in a safe state in this situation. The supply of hazardous fluids is also cut off. These measures drastically reduce the risk of a fire outbreak. Following an earthquake, the emergency organisation is mobilised and the on-site emergency plan is activated in reflex mode to manage the situation.

If potential sources of damage to the detectors are identified (environmental, electromagnetic, chemical, radiological, etc.), the choice of system is adapted insofar as possible. Whatever the case, any failure is reported to the PCS (Unavailable) and the periodic verifications can detect any drifts or damage.

C-II-3.2.1.3. Alternative/temporary provisions

If operations or work lead to the emission of dust, smoke or light that can be likened to a flame, such as with hot work, it may be necessary to partially or fully disable the automatic fire detection system of a room or a zone. In this situation, procedures provide for compensatory measures: prior informing and agreement of the local response team, maintaining human monitoring, increasing the number of fire extinguishers, hot work permit, etc.

The loss of fire detection is identified through the supervision station in the PCS. Loss of detection leads to loss of the associated interlocks, which imposes a limit on the associated duration of unavailability, set at one week in the General Operating Rules. Several compensatory measures are defined in the General Operating Rules according to the level of unavailability (local, affecting one or more detectors, or general, affecting the monitoring and signalling equipment of a building). These include, for example, prohibiting hot work, stopping certain processes, placing equipment in safe condition, cutting off the supply of hazardous gases.

In the event of loss of the fire supervision system, detected in the PCS by an alarm on the supervision screen or the alarm centralisation panel, the backup system in the PCS ensures restricted supervision. This loss is moreover compensated for by the local monitoring possibilities in each of the monitoring and signalling components.

C-II-3.2.2. Fire suppression provisions

C-II-3.2.2.1. Design approach

The fire-fighting and response resources are as follows:

- means placed in the buildings and on the roadways:
  - hand-held and mobile fire extinguishers,
  - automatic or manual fixed gas extinguishing systems,
  - fire hose cabinets in certain buildings,
  - fires-fighting water standpipes;
- mobile response means (located in the PCC building):
  - Initial Response Vehicle (IRV) i.e. a fire-fighting pumper vehicle,
  - Response and Rescue Vehicle (RRV),
  - Command vehicle (PCOM),
  - fire trailer with motor-driven pump,
  - extinguishing powder trailers,
  - foam trailer.

The number, capacity and location of the hand-held fire extinguishers, the fire hose cabinets and the fire-fighting water standpipes are determined in conformity with the Labour Code and in accordance with the APSAD rules and the analysis performed for the DMRI. The location of the water standpipes enables the entire site and the buildings to be covered. The equipment items are positioned in signalled locations and kept readily accessible at all times.

The need for gas extinguishing systems to protect the electrical installations is analysed specifically in accordance with safety criteria. If necessary, criteria relating to the requirement for activity continuity are also taken into account.

C-II-3.2.2.2. Types, main characteristics and performance expectations

The extinguishing agents used are chosen in accordance with the APSAD rules and the analysis performed for the DMRI.

The water network is protected against freezing and is meshed insofar as possible. It is supplied by two separate channels.

The response and fire-fighting means take into account the possible types of fire, the specific risks - especially the criticality risk, and the building and room access constraints.

The hand-held fire extinguishers, the fire hose cabinets, the water standpipes and the fixed gas extinguishing systems are not designed to earthquake standards. However, in the event of an earthquake, the risk of fire outbreak is drastically reduced as described in paragraph C-II-3.2.1.2. The PCC building which accommodates the mobile response means is designed to withstand a seismic event exceeding the design basis. Following an earthquake, the emergency organisation is mobilised and the on-site emergency plan is activated in reflex mode to manage the situation.

C-II-3.2.2.3. Management of harmful effects and consequential hazards

The design, installation, maintenance and deployment of mobile extinguishers, fixed gas extinguishing systems, fire hose cabinets and water standpipes undergo a risk analysis in accordance with the APSAD rules, particularly with regard to personnel safety and, for the fixed extinguishing systems in rooms, the resistance of the room to the pressure variations.

For the buildings harbouring uranium-bearing materials, the criticality risk linked to the introduction of a moderating substance is taken into account. The use of water-based agents is regulated by a procedure. Furthermore, regarding powder fire extinguishers, only low-hydrogenated powders are authorised in these buildings.

In the event of fire extinguished with water, the extinguishing water is retained and collected insofar as possible within the building concerned or its immediate vicinity. The effluents that cannot be retained are taken up by the stormwater drainage network. The liquid effluents in this case are retained in stormwater tanks isolated from the public network; provisions specified in the general operating rules.

C-II-3.2.2.4. Alternative/temporary provisions

If operations or works lead to the partial or total unavailability of a fire-fighting means, an analysis is carried out to determine appropriate compensatory measures.

The fixed gas extinguishing systems are connected to the FSS (see paragraph C-II-3.2.1.2). In the event of anomaly, an alarm is transmitted to the supervision station.

In the event of total loss of public water supply network, the mobile means that are permanently present provide protection pending its return to service.

C-II-3.2.3. Administrative and organizational fire protection issues

C-II-3.2.3.1. Overview of firefighting strategies, administrative arrangements and assurance

The operations to conduct in the event of a fire alarm are defined in procedures (alarm, calling the LRT, verification, confirmed fire, evacuation, mobilising of the emergency management organisation, analysis and preparation for secondary response, etc.). These procedures contain flow charts that clearly set out the roles and responsibilities of those involved.

The response teams have operational documents, including:

- reflex sheets containing the information necessary for the immediate actions to take. They also indicate the major risks for each facility;
- the intervention files, which constitute, for each building, a compendium of the operational information necessary for conducting the intervention: plans, access routes, internal and external risks (criticality, chemical, etc.), location of the fire-fighting means, safety instructions, etc.

Furthermore, if the emergency organisation is mobilised, the mobilised personnel assist with analysing the situation and defining the fire-fighting strategy to deploy.

The operational documents are updated according to the lessons learned from the exercises and situations encountered.

All the fire-fighting means undergo regulatory periodic inspections as appropriate (fire extinguishers, fixed gas extinguishing systems, fire hose cabinets, water standpipes) or preventive inspections in the case of the mobile response means.

C-II-3.2.3.2. "Firefighting capabilities, responsibilities, organization and documentation onsite and offsite"

The fire-fighting equipment means are listed in paragraph C-II-3.2.2.1.

The operational organisation, described in procedures, particularly the On-Site Emergency Plan (PUI), is based on human resources:

- All the Framatome and outside contractor personnel, who receive general safety training ("safety induction") which must be successfully validated to obtain site access authorisation. Refresher training is provided annually for outside contractors and every three years for the site personnel;
- Local Response Team (LRT) members. This activity is subcontracted in whole or in part to an outside contractor. The team members are trained firemen with refresher training based on a list of courses defined in the service specifications, and which cover all the technological risks present on the site. The LRT takes part in the on-site exercises. The LRT is present 24 hours a day, 7 days a week. In the event of a call or an alarm, it checks that it is not a false alarm, and can

deploy an initial response vehicle manned by a team leader, a pump operator and a two-person response team. During daytime hours from Monday to Friday it is backed up by a site manager and a preventer. The LRT may be supplemented by complementary Framatome personnel;

- The Response Manager (RM). The RM coordinates the actions and operations of the internal and external emergency services if an event arises. As an on-call system is in place, the RM is available 24 hours a day, 7 days a week.

The Framatome response personnel receive initial theory and practical training on site and in a training centre. These training courses focus on knowledge of the risks of the site, the monitoring means, the organisation of internal and external emergency services, communication rules and the supervision of the response operations. They are supplemented by training sessions with real situation exercises. The Departmental Fire and Emergency Services of the Drôme *département* (SDIS 26) also delivers initial training to the Framatome response personnel who do not exercise a volunteer fireman function.

Relations with the external emergency services and SDIS 26 in particular are formalised through agreements. They are materialised by working group meetings, joint exercises and the dispensing of training.

C-II-3.2.3.3. Specific provisions, e.g. loss of access

Possible partial or total losses of means of access are identified in post-earthquake fire scenarios. As is indicated in paragraphs C-II-3.2.1.2 and C-II-3.2.2.2, an earthquake leads to activation of the site's On-Site Emergency Plan (PUI).

With regard to internal accesses to the site building(s) concerned, this situation is taken into account by the documented identification of the roads and access ways impacted by potential collapses further to a maximum extreme earthquake. During the situation analysis phase, this information can be used to determine the response strategy.

With regard to the risk of the emergency response team being unable to gain access to the site, the site has an emergency command post (PCC building) designed to withstand the maximum extreme earthquake. It can accommodate the necessary personnel and material resources in an emergency situation for 48 hours. Beyond this, the site can also be reinforced by the resources of the joint Orano/Framatome National Intervention Force (FINA).

C-II-3.2.4. Licensee's experience of the implementation of the active fire protection

C-II-3.2.4.1. Overview of strengths and weaknesses

The strengths and weaknesses currently identified for the site's protection measures are listed below.

Strengths

- All the Framatome and outside contractor personnel receive general safety training ("safety induction") which must be successfully validated to obtain site access authorisation. Refresher training is provided annually for outside contractors and every three years for the site personnel.

- The site is equipped with an FSS, an automatic fire detection system and automatic safeguarding systems deployed in all the buildings, and constant monitoring on a centralised site by dedicated personnel.
- The site has human resources, including firemen, who are trained and undergo periodic refresher courses, and it has emergency response equipment. These human and material resources are available and maintained on the site at all times to intervene in a fire situation.
- A robust emergency organisation is in place, with the periodic organisation of exercises, some carried out jointly with the external emergency services and the other stakeholders (ASN, IRSN, the Prefecture of the Drôme *département*, the municipal councils of the neighbouring municipalities). The interfaces with the external emergency services are taken into account.

Weaknesses

- The FDS currently in service, and its communication network, will soon be obsolete, which will create system maintenance problems (software, spare parts).
- The organisation of the site does not include the FSS coordination missions such as they are defined in standard NF S 61-931.
- Two buildings must undergo improvements in order to retain and recover the extinguishing effluents. If water runs off to the exterior of the buildings, it is taken up by the stormwater drainage network and retained in stormwater tanks.

To be in conformity with the Order of 20 March 2014, protected paths must be defined and deployed for the buildings housing uranium-bearing materials.

C-II-3.2.4.2. Lessons learned from events, reviews fire safety related missions, etc.

The periodic exercises contribute to the continuous improvement of the emergency response organisation.

The events mentioned in paragraph C-II-3.1.3.2 have also been taken into account. These events have led to the following actions with regard to protection:

- For the event of 30 June 2015, fire-proof waste bins were installed for the safe disposal of a canister suspected of heating;
- For the event of 17 July 2020, awareness-raising session for the LRT on the importance of the means of alert (telephone, etc.) to be made available to the responders;
- For the event of 21 September 2022, the functioning of the fire detection system and the associated interlocks was verified before restarting the installation. There are plans in the medium term to deploy protected routes in the building housing uranium-bearing materials, and to examine the possibility of replacing the D-powder extinguishes with BC-powder extinguishers.

C-II-3.2.4.3. Overview of actions and implementation status

The main ongoing and planned actions with regard to fire risk prevention in view of the identified weaknesses and experience feedback are as follows:

Actions in progress:

- Modernise the site's FDS and communication network.
- Deploy protected routes in the buildings housing uranium-bearing materials.

Action to be initiated:

- Replace the D-powder extinguishers with BC-powder extinguisher if the examination proves this possible.

Action under study:

- Take measures to recover the extinguishing water in buildings F2 and L1.

C-II-3.2.5. Regulator's assessment of the active fire protection

C-II-3.2.5.1. Overview of strengths and weaknesses in the active fire protection

Active fire risk control measures were defined from the BNI No. 63-U design stage.

More precisely, the active measures correspond to:

- appropriate detection devices located specifically in the rooms where there is a fire risk;
- appropriate fire-extinguishing means;
- a robust initial response organisation including specifically trained personnel.

It is to be noted that the active fire risk control measures (fire detection and extinguishing systems) have been installed specifically in the electrical cabinets further to a previous periodic safety review.

It must be pointed out that active fire risk management systems require special attention with regard to keeping them operational. Consequently, the functioning of the detection systems must be verified periodically and any organisation based on the intervention of specific personnel members in the event of fire necessitates the maintaining of a high level of skill and organisation, particularly through training courses. Exercises are regularly organised in this respect, both internally and externally, with the support of the Prefecture, the departmental emergency services, ASN and IRSN. The lessons learned from the local and national exercises contribute to the continuous improvement process.

Furthermore, the fire-fighting devices that can be used by the personnel are stowed within BNI No. 63-U in a protected building designed to earthquake standards.

C-II-3.2.5.2. Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

Further to an inspection on the theme of the control of fire-related risks, Framatome acknowledged the necessity to better prepare the fire-fighting operations. To this end, the licensee has organised numerous training sessions with specialised organisations for all its personnel. The actions of the response team have been specifically analysed in order to prioritise them and thereby achieve greater efficiency.

C-III- Fuel reprocessing facility - La Hague UP3A – T2 - BNI 116

C-III-3.2.1. Fire detection and alarm provisions

C-III-3.2.1.1. Design approach

The fire detection systems of the T2 unit serve to:

- Give the alert in good time;
- Ensure the interlocks.

The fire detection and alarm (FDA) system is designed and chosen specifically according to the type of fire that could break out in the FDA-equipped rooms. It is dimensioned and installed in accordance with the principles established in rule R7 of the APSAD (*Assemblée Plénière des Sociétés d'Assurances Dommages* – Plenary Assembly of Damage Insurance Companies), a reference base listing a set of good practices. Several identical fire detection heads can thus be installed in a given room, according to its dimensions. These identical heads situated in the same room and interconnected with one another constitute a detection loop. The information transmitted by the fire detection systems is processed in the T2 unit fire control panels. The fire control panels transmit the information to the PSM security station and to the station of the shift supervisor of the T2 operational control room. The triggering of a fire detector in the event of a fire outbreak or malfunctioning of the fire detection system causes audio and visual alarms:

- in the T2 unit operational control room;
- and/or to the operational control and monitoring station of the Site and Material Protection Service (PSM).

Personnel are present at all times in the T2 unit operational control room and in the operational control and monitoring station of the PSM.

The detection system also functions in the event of loss of the normal and backed-up electrical power supplies thanks to an ultimate power supply provided by batteries. This ultimate power supply ensures about 12 hours of autonomy.

The following volumes are equipped with automatic fire detection (AFD) systems:

- rooms with a calorific potential exceeding 600 MJ/m^2;
- the electrical rooms;
- the false floors with a calorific potential exceeding 150 MJ/m^2;
- the rooms containing equipment necessary for maintaining the facility in a safe state and whose redundancy may be lost simultaneously, are equipped with a fire detection system;
- the cells in zone 4 containing solvent are equipped with a fire detection system in the ventilation extraction duct of these cells;
- the rooms containing glove boxes;
- the rooms facing the zone 4 cells (presence of observation ports looking onto the zone 4 cells);
- the laboratories (rooms for performing analyses);

- the reagent rooms (rooms containing tanks of reagents);
- the rooms containing the "Last Filtration Barriers" (DNF);
- the extraction fan rooms;
- the machine rooms of the lifts / goods elevators;
- the storerooms and temporary storage rooms;
- the rooms classified as protected routes (routes for reaching the places from which the facility can be maintained in a safe state).

The other rooms of the T2 unit are equipped with fire detection systems according to:

- the number of ignition sources;
- the fire load density.

About half the rooms of the T2 unit are now equipped with a fire detection system.

C-III-3.2.1.2. Types, main characteristics and performance expectations

The following types of automatic fire detector are used:

- Optical smoke detector: it allows early detection of smouldering fires or flames with release of smoke. Its operating principle is based on the diffusion of light. It measures the density of the smoke;
- Multicriteria smoke detector: it allows early detection of fires with flames or smouldering fires with release of smoke;
- Infrared flame detector: it is suitable for the detection of fires of liquid or gaseous origin without smoke. It is also suitable for the detection of open fires with the emission of smoke;
- Interactive smoke detector: it detects fires that emit smoke;
- Flame detector: it is sensitive to the infrared radiation emitted by the flames of a fire and the presence of CO2 resulting from a fire;
- Thermal detector:
  - Fixed-temperature heat detector: it measures the temperature using a low-inertia thermistor,
  - Rate-of-rise (ROR) heat detector: it detects a rate of rise in temperature that exceeds a predetermined value and lasts for a certain length of time;
- Multipoint or aspirating detector: it allows early detection by detecting very low concentrations of smoke.

The maintenance of fire detection equipment in the T2 unit is applied as follows:

- Fire detection control unit:
  - Periodic inspection every 6 months: test of the indicator lights and verification of the power sources,
  - Preventive maintenance every year: overhaul of the fire detection control unit,

    - Preventive maintenance at between 4 to 8 years: replacement of the batteries,
- Fire detectors:
    - Periodic inspection every 6 months: functional test of the detection loops,
    - Preventive maintenance every year: functional test of all the detection loop detectors;
- Transmission of alarms:
    - Periodic inspection every 6 months: information transfer test.

C-III-3.2.1.3. Alternative/temporary provisions

Partial unavailability of the fire detection system in one or more rooms gives rise to a repair service request. This repair is carried out within one month at the most.

Total unavailability of the fire detection system in one or more rooms gives rise to a repair service request. This repair is carried out within one week at the most. Pending repair, specific patrol rounds are conducted in the rooms concerned at a frequency defined by an instruction, and hot work is prohibited in them.

Only the unit manager or their representative is authorised to disable a fire detection system. In this case, compensatory measures are provided for, such as:

- regular patrol rounds;
- provision of fire extinguishers;
- elimination of all ignition sources;
- removal of all combustible materials;
- hold point at end of works and checking for hot spots with thermal camera.

C-III-3.2.2. Fire suppression provisions

C-III-3.2.2.1. Design approach

The fire extinguishing design principle of the T2 unit hinges around 3 levels of response:

- the initial response means specific to the unit;
- the Site's on-site secondary response means;
- the emergency services external to the Site.

C-III-3.2.2.2. Types, main characteristics and performance expectations

The use of water as a fire-fighting agent during interventions is compatible with the safety-criticality objectives of the facility.

The following specific initial response means are present in the T2 unit:

- Fire extinguishers: the T2 unit is equipped with a sufficient number of extinguishers. The extinguishing agents are suitable for the risks to cover, ensuring that they are appropriate for the class of fire while at the same time taking into account any constraints inherent to their effects (particularly through the production of effluents, for example). Their locations are signalled and readily accessible. They can be used by all the personnel;

- Fixed fire extinguishing systems: the false floors with a calorific potential exceeding 150 MJ/m^2 are equipped with a fixed manual fire-extinguishing system using FM-200 gas.

The following specific secondary response means are present in the T2 unit:

- Fires-fighting water standpipes: the T2 unit is protected by five water standpipes connected to a meshed network. This network has a delivery capacity of 600 m^3/h and a nominal pressure of 8 bars;
- Dry risers: the T2 unit is equipped with 10 dry risers located in the stairways. They are supplied with water by the pumpers of the PSM (Site and Material Protection) service, through the supply half-couplings located outside the buildings;
- Fixed manual extinguishing systems in the cells (inaccessible rooms) containing solvent and/or HTP (hydrogenated tetrapropylene): the cells containing solvent and/or HTP are equipped with permanently installed extinguishing systems. They consist of nozzle diffusers installed in each cell concerned. They allow the delivery of water with an additive. The pipes supplying the diffusers are routed to points close to the dry risers to which they can be connected;
- Fixed manual fire extinguishing system in the rooms containing tanks of solvent: the rooms containing tanks of solvent are equipped with permanently installed extinguishing systems. These consist of spray booms located above the solvent tanks. The pipes supplying these booms are routed to points close to the dry risers to which they can be connected; they are supplied by the PSM service pumpers with the addition of 6% foaming agent by volume. The extinguishing systems have an operating instructions sheet included in the facility's fire file;
- Fixed manual fire extinguishing system in the room containing a tank of formalin (formaldehyde): the room containing a tank of formalin is equipped with a permanently installed extinguishing system. This consists of a spray boom located above the tank of formalin. This boom is supplied with water from a sectional valve;
- Accessibility of the T2 unit: the T2 unit is accessible to the fire brigade's fire appliances on two of its sides.

When in service and during maintenance or intervention operations, the general prevention principles are based on verification of the correct operation of the fire-extinguishing systems by applying maintenance/servicing procedures. The maintenance schedule for the fire-extinguishing equipment in the T2 unit as follows:

- hand-held extinguishers:
    - preventive maintenance every year: servicing maintenance;
    - hand-held water and powder extinguishers replaced every 10 years;
    - hand-held CO_2 extinguishers: renewal of hydrostatic testing every 10 years;
- fixed fire extinguishing systems using FM-200 gas:
    - periodic inspection every 6 months: functional check;
    - periodic inspection every 10 years: statutory test of pressure equipment;

- fires-fighting water standpipes:
  - periodic inspection every 6 months: verification of static pressure, dynamic pressure and flow rate;
  - preventive maintenance every 3 months: verification of operation of the manual valve at the foot of the standpipe;
- dry risers:
  - periodic inspection every year: verification of the dry riser;
  - preventive maintenance every 3 years: test of the dry riser;
- fire pipes in the PSM service and in the unit:
  - preventive maintenance at between 2 and 3 years: pressurisation of pipes and visual inspection.

C-III-3.2.2.3. Management of harmful effects and consequential hazards

The static containment (walls) and the dynamic containment (ventilation) of the rooms prevent a risk of significant contamination of the neighbouring rooms and the environment. The ventilation systems are designed such that:

- They do not contribute to the propagation of a fire;
- They limit the dissemination of radioactive substances in the unit in case of fire;
- They limit releases of radioactive substances into the environment in case of fire.

Thus, negative pressure cascades are produced from the rooms with the lowest contamination risk towards the rooms with the highest contamination risk. Furthermore, the Last Filtration Barrier filters (DNF) before discharge into the environment:

- are qualified to function at 200°C for 2 hours;
- undergo regular clogging and temperature measurements in fire situations.

The civil engineering of the T2 unit has sufficient capacity to retain the volume of extinguishing agents required to put out a worst-case fire in a controlled area. Furthermore, the extinguishing waters can be collected in the stormwater network if they spread outside the T2 unit.

C-III-3.2.2.4. Alternative/temporary provisions

The facility has a sufficient number of fire extinguishers to enable an operator to respond rapidly to an incipient fire, even in the event of unavailability or failure of an extinguisher.

Concerning the fixed fire-extinguishing systems, the Site has a stock in store.

Moreover, if an extinguishing system is unavailable, compensatory measures are put in place for the entire duration of unavailability.

Furthermore, the PSM service has secondary response extinguishing means which can supplement or compensate for the failure or possible unavailability of the fixed extinguishing means.

C-III-3.2.3. Administrative and organizational fire protection issues

C-III-3.2.3.1. Overview of firefighting strategies, administrative arrangements and assurance

The fire intervention procedure in a controlled area takes into account the objective of limiting the dissemination of contamination by radioactive materials. The defining of intervention zoning meets this objective. This zoning can potentially change during the intervention. It is defined by the PSM team and may change in relation to the work of the radiation protection team. The zoning defines three zones:

- zone A is the volume in which the fire occurs. It is postulated that this zone is contaminated;
- zone C is the zone defined and confirmed as being non-contaminated. It allows a safe exit to the exterior;
- zone B is situated between zones A and C, and acts as a radiological air lock, allowing in particular the radiological management of the entry and exit of workers.

C-III-3.2.3.2. "Firefighting capabilities, responsibilities, organization and documentation onsite and offsite"

The fire management organisation of the T2 unit is based on the following three response levels:

- The initial response means specific to the unit: a Local Response Group (LRG) can be mobilised immediately for missions:
  - of reconnaissance and safeguarding;
  - of protection;
  - fighting the fire using hand-held extinguishers if possible, pending the arrival of the site's emergency services (Site and Material Protection service - PSM). All the personnel working in the T2 unit have been trained in the use of fire extinguishers;
- The Site's on-site secondary response means; The Site has a PSM service equipped with heavy fire-fighting and fire protection means. The service can be mobilised immediately 24 hours a day. The heavy means at its disposal are equivalent to those of a town of 10,000 inhabitants;
- The emergency services external to the Site. The Site has an agreement with the SDIS (Departmental Fire and Emergency Service) of the Manche *département*).

In addition to the training sessions for the specialised secondary response teams, annual exercises are organised and conducted with the licensee in order to improve the coordination and intervention preparation of the fire-fighting teams. There are several types of exercises:

- exercises based on an "On-Site Emergency Plan" activation scenario;
- restricted command post exercises;
- fire/chemicals/transport exercises organised by the DMRE/MLR (Orano's independent safety entity);
- LRG mobilisation exercises;
- self-paced refresher training sessions for the LRGs;

- injured persons evacuation exercises, etc.

They can be broken down as follows:

- internal to the Site:
    - an annual schedule of weekly exercises is drawn up for the Site. It takes into account all the facilities concerned by the exercises.
- external to the Site:
    - an annual exercise is conducted on the Site with the fire brigade. It enables the efficiency of the organisation (procedures for reception on site, guiding, coordination between PSM and the fire brigade).

These various training courses, practical training sessions and exercises serve to test the response instructions, to improve the coordination between the various responders and ultimately to take into account the main organisational and human factors.

C-III-3.2.3.3. Specific provisions, e.g. loss of access

The T2 unit has:

- 4 main fire brigade access points;
- 5 secondary fire brigade access points.

These fire brigade access points provide access to all the T2 unit rooms in case of fire. They are sufficiently numerous to allow an intervention in the T2 unit rooms even if one of the access points cannot be used.

C-III-3.2.4. Licensee's experience of the implementation of the active fire protection

C-III-3.2.4.1. Overview of strengths and weaknesses

Strengths

The fire alarms are transmitted to the T2 unit operational control room and to the PSM's control and monitoring room. The chosen ergonomics enable the location of the fire alarm triggered in the T2 unit to be identified rapidly and with certainty.

The 24h/24 presence of the PSM service fire-fighting teams enables fire-fighting to begin immediately with heavy-duty means without waiting for the external emergency services (SDIS).

Weaknesses

The obsolescence of the fire control panels installed when the T2 unit was built combined with the growth in the number of rooms equipped with fire detection systems further to the periodic safety reviews, means that the obsolete equipment is being replaced with recent technology equipment.

C-III-3.2.4.2. Lessons learned from events, reviews fire safety related missions, etc.

The last periodic safety review of the T2 unit led to the approximate doubling of the number of T2 unit rooms equipped with automatic fire detection (AFD) systems. The ongoing periodic safety review will further increase the number of T2 unit rooms equipped with AFD systems.

C-III-3.2.4.3. Overview of actions and implementation status

All the active protection systems (fire detection systems) recommended further to the last safety review have been installed.

C-III-3.2.5. Regulator's assessment of the active fire protection

C-III-3.2.5.1. Overview of strengths and weaknesses in the active fire protection

The work carried out further to the safety review of BNI 116 on the La Hague site as a whole is substantial. More specifically, the realisation of the works to reinforce the fire detection provisions on the site are viewed positively.

C-III-3.2.5.2. Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

During the last inspections on the site, the local response groups (LRGs) demonstrated satisfactory knowledge of the procedures to follow in the event of fire.

The fire-fighting means should be reinforced, particularly by providing water fire extinguishers in numerous rooms. The controlled area of the unit has no water fire extinguishers, whilst the criticality risk has not been determined by the licensee. Improvements are expected in this respect.

With regard to the heavy fire-fighting means (PSM), for several years now it has been difficult to check their implementation during the exercises organised for the inspections. The multitude of missions assigned to these teams on this site means that they can only rarely participate in the exercises in a satisfactory manner.

C-IV- Fuel fabrication facility - MELOX – BNI 151

C-IV-3.2.1. Fire detection and alarm provisions

The fire monitoring of the equipment and rooms that contribute to the safety of the BNI is ensured by the general Automatic Fire Detection (AFD) network. It is supplemented by the presence of personnel on duty 24h/24.

C-IV-3.2.1.1. Design approach

The AFD system is designed to ensure the following under all circumstances, except in the event of an earthquake:

- monitoring of rooms or equipment that represent a fire risk;
- monitoring of the functioning of the AFD system;
- activation of an audio evacuation alarm;
- activation of the automatic systems interlocked to detection;
- transmission of the fire detection and malfunction alarms to the operational control rooms and the General Monitoring Station in order to start the actions necessary to place the facility in safe state as quickly as possible, to evacuate the personnel and to fight the fire.

C-IV-3.2.1.2. Types, main characteristics and performance expectations

The types of detectors and their location are determined according to the equipment to monitor, the plausible types of fires and the environmental conditions (ventilation, dust build-up, radiation, etc.).

Optical smoke detectors are chosen for their speed of detecting fires of electrical origin.

Optical flame detectors are installed in the areas where there is a fire risk due to inflammable liquids and other combustible flame-generating materials (metal fires in particular);

Heat detectors (fixed-temperature and rate-of-rise heat detectors) are used in the areas where the atmosphere can be smoky or dust-laden in a normal non-fire situation (in glove boxes for example); the fixed-temperature heat detectors are also used in the ventilation ducts and certain glove boxes (Laboratory area in particular);

Some of the laboratory glove boxes in which processes generating heat are carried out (ovens, hot plates and evaporators) are equipped with temperatures probes;

Multipoint detection units are used in volumes that are poorly accessible or have particular configurations (e.g.: spaces under false floors, spaces situated above cable chases in corridors). They are equipped with one aspirating path per monitored volume, and each path is equipped with a smoke detector. These units are equipped with a specific independent electrical power supply.

The fire detection system is addressable. It enables the system or detector(s) in alarm condition to be located from the general monitoring station (PSG). In addition, action indicators are installed above the access to monitored rooms.

With regard to the interlocks associated with the AFD system, the interlocked actuators are used on the following types of equipment:

- ventilation (fire dampers, stand-alone fans, recyclers, etc.);
- process (doors, hatches, valves, hydraulic units, etc.);
- extinguishing equipment (for the CO_2, FM-200 extinguishing systems.).

Their role is to protect the facility against the risks associated with a fire and in particular by restoring the sectorisation or limiting the introduction of oxidising agents or fuel into the fire zone.

The commands sent by the Fire Control Panel take priority over those from the normal operational control systems, including stop/shutdown commands (except emergency stop commands required for personnel safety).

In the approach based on maintaining negative pressure cascades, the fire dampers in certain rooms containing glove boxes ventilated with nitrogen are not manoeuvred automatically when fire is detected.

C-IV-3.2.1.3. Alternative/temporary provisions

Availability of the fire detection systems is ensured by continuous electrical self-monitoring enabling any system fault to be detected; if a detector or fire loop is faulty, an alarm is generated. The equipment items comply with the standards applicable to them.

The fire safety system has a permanent electrical power supply delivered by the normal and emergency distribution networks. If the electrical power supply fails, the fire control panels are equipped with uninterruptible power sources with an autonomy of 12 hours.

The actuators that restore sectorisation and are installed in fire sectors controlled by the Fire Control Panel are wired with fire-resistant cables.

The fire detection lines interconnecting the detection points are wired to the Fire Control Panel in a closed loop. This guarantees that information is not lost in the event of a line break or short circuit: for example if a fire breaks out in one room, the adjacent rooms are still monitored.

The fire detection alarms are transmitted to the general monitoring station which is manned 24h/24 by personnel who immediately analyse the information delivered by the alarms.

During maintenance operations or hot work, the detection system of the rooms concerned may be disabled to avoid untimely alarms and interlocks. In this case compensatory measures are taken to avoid the complete disabling of a room or the disabling of a non-inerted glove box, to ensure the constant presence of personnel on the site of the operation and to put the AFD system back into service as soon as disabling is longer justified.

It is mandatory for the fire safety system equipment and interlocks to undergo periodic operating checks.

Preventive and corrective maintenance of the fire detection systems is outsourced under a maintenance contract to a company with the appropriate professional means and skills. Fire control panel programming changes remain the exclusive responsibility of equipment designer company.

The personnel have means of alerting by telephone and internal interphone distributed around the facility and means of raising the alarm via manual call points (MCP) connected to the AFD system; the MCPs send an alarm to the PSG.

C-IV-3.2.2. Fire suppression provisions

C-IV-3.2.2.1. Design approach

The buildings are equipped with fixed or mobile extinguishing systems. These systems are designed and installed in accordance with national regulations and rules of good workmanship. These systems are subject to periodic functional checks.

C-IV-3.2.2.2. Types, main characteristics and performance expectations

Hand-held and wheeled fire extinguishers are provided in the various rooms. The extinguishing agent can be sprayed water, BC powder, ABC powder, special powder or CO_2, depending on the nature of the combustible materials and the risks specific to the room.

The glove boxes are equipped with couplings to which the fire response teams can connect CO_2 extinguishers. These extinguishers have a flow limiter to avoid creating sudden overpressure in the glove boxes.

Bags of extinguishing powder suitable for metal fires are placed in the decladding and fuel rod repair glove boxes because they can contain zirconium alloy fragments.

Fixed extinguishing systems are installed:

- in rooms in which an uncontrolled fire could present a risk of dispersion of radiological material (presence of nuclear material in powder form);
- in rooms in which a fire would be difficult to bring under control with hand-held or wheeled fire extinguishers.

The following fixed automatic fire-extinguishing systems are present at the MELOX plant:

- extinguishing by discharging CO_2 into the ambient atmosphere, for the powder and pellet process rooms and certain particular rooms (oil-equipped hydraulic units, etc.);
- extinguishing by discharging FM-200 into the false floor and the ambient atmosphere (electrical rooms, operational control room);
- extinguishing by water + AFFF (Aqueous Film Forming Foam) sprayed into the ambient atmosphere for the diesel generator set building.

15 fire-fighting water standpipes connected to the meshed industrial water network are distributed across the site. The static pressures vary from 4 to 5 bars (depending on altitude) with individual delivery rates of 63 m^3/h to 84 m^3/h.

The two nuclear buildings are equipped with dry risers (2 dry risers per building). The dry risers are situated in the opposing stairways in each building: they enable water to be supplied to the different levels.

The system is completed by high expansion foam generators.

The main supplementary fire-fighting appliances and equipment available on the Marcoule site, in addition to the means of the MELOX BNI, are equivalent to the fire station of a town of 60,000 inhabitants: 2 fire tenders, one forest fire-fighting vehicle, one foam truck, 2 motor-driven pumps on trailer, 2 motor-driven pumps x 240 m^3/h, one powder truck, 2 light intervention vehicles, one powder truck of the Microfeu brand, diesel generator sets, thermal cameras, etc.

C-IV-3.2.2.3. Management of harmful effects and consequential hazards

The criticality accident risk is taken into consideration in the choice of extinguishing agents. Water is prohibited in the rooms in which moderation is the method of controlling criticality. In this case carbon dioxide is preferred in the fixed extinguishing systems. For the so-called "water prohibited" rooms which do not have a fixed fire-extinguishing system, complementary large-capacity CO_2 extinguishing means are available nearby.

The risk of dispersion of nuclear material is taken into consideration for the use of fixed gas extinguishing systems. The discharges of extinguishing gas are made progressively to avoid excessive pressure rises in the rooms and to preserve the constituents of the fire sectors and the containment sectors.

C-IV-3.2.2.4. Alternative/temporary provisions

The possible failure of wheeled and hand-held fire extinguishers is compensated for by the large number of extinguishing units and the possibility of having additional equipment brought in by the response teams.

With the fixed carbon dioxide extinguishing system, it is possible to make several gas releases as there are two racks of gas cylinders and one external reserve.

In the event of failure of the system remotely controlling the fire dampers and the fixed CO_2 extinguishing system, they can be manoeuvred using manual controls located near the room without having to enter it.

C-IV-3.2.3. Administrative and organizational fire protection issues

C-IV-3.2.3.1. Overview of firefighting strategies, administrative arrangements and assurance

The fire-fighting organisation is defined and put in place by a specialised service. This organisation is based on two successive levels of response according to the seriousness of the situation.

<u>The first level of response is internal</u>

The operating personnel present on site constitute the first response. This response consists in:

- making a reconnaissance of the affected site in the event of an alarm to assess the situation;
- passing on the alert to the people present;
- alerting the emergency services (Secondary Response Team);
- carrying out the basic technical actions vital for the safety of persons and property;
- meeting, guiding and informing the company emergency services (Secondary Response Team).

This initial response is supplemented by the Secondary Response Team (SRT) comprising:

- a Response Operations Manager (ROM) with fireman type training in operations command;
- security staff, specially trained and prepared for fire fighting, assisted, if necessary, by the secondary response team members from the operating personnel;
- a radiation protection officer (if nuclear buildings are concerned).

On order from the ROM, the main missions of the SRT are to:

- make a reconnaissance of the site concerned and locate the fire;
- put out the fire using the fixed or mobile means;
- supervise closure of the fire dampers (in coordination the radiation protection, utilities and operation managers);
- inform, meet and guide the external emergency services, particularly the FLS of CEA Marcoule.

<u>The external emergency services constitute the second level of response</u>

The Local Safety & Security Force (FLS) of the neighbouring site of CEA Marcoule forms part of the on-site fire-fighting organisation of MELOX, under the authority of the MELOX director when it intervenes in the nuclear buildings. It intervenes when called out by the MELOX personnel under a specific agreement binding the two sites. The mobile means of the FLS correspond to those of a fire brigade fire station.

If necessary, the operational engagement of the fire brigade is carried out in accordance with the provisions of an agreement with the SDIS. This agreement includes training the firemen with respect to the risks MELOX represents, plus joint intervention exercises.

C-IV-3.2.3.2. "Firefighting capabilities, responsibilities, organization and documentation onsite and offsite"

The On-Site Emergency Plan (PUI) is established by MELOX for the management of emergency situations that require major fire-fighting means or risk leading to harmful consequences.

Deployment of the PUI organisation allows the mobilisation of all the technical and human resources available on the MELOX site as a whole, with a view to mitigating the consequences for people and the environment of accident situations resulting more specifically from a fire that could not be brought under control by the unit in which it occurred.

The on-site and off-site responders have documents such as reflex sheets and response plans. These plans also indicate the supply points for the fire-fighting appliances, the access routes to the buildings and their rooms, and the fluid cut-off components. They specify any prohibitions on the use of extinguishing agents and the harmful effects that their use would cause (e.g. use of water prohibited, loss of containment, flooding, etc.).

C-IV-3.2.3.3. Specific provisions, e.g. loss of access

There are several access routes that can be taken by the response vehicles.

C-IV-3.2.4. Licensee's experience of the implementation of the active fire protection

C-IV-3.2.4.1. Overview of strengths and weaknesses

Strength

The main strengths of the BNI lie in:

- broad coverage by the AFD network, fostering early fire detection;
- the transmission of alarms to a permanently manned station in order to rapidly mobilise the fire-fighting personnel and to place and maintain the facility in a safe state in a fire situation;
- the on-site presence of a service specialised in fire fighting with the personnel and technical means of the MELOX site.

Areas of improvement

MELOX has a project to install temperature sensors:

- In the production rooms containing nuclear material which are at the boundary of the 3rd barrier, or which contain a high fire load. The transmission of alarms when an abnormal temperature rise is detected in a room will permit a rapid response in the event of a fire outbreak following an earthquake;

- In the extraction ventilation ducts of the MOX pellet interim storage rooms. These rooms are equipped with fixed extinguishing systems but not with fire dampers. The new temperature sensors will make it possible to monitor the effectiveness of extinguishing gas release in the event of fire.

C-IV-3.2.4.2. Lessons learned from events, reviews fire safety related missions, etc.

The lessons learned are set out in detail in chapter C-IV-3.4. This concerns events relative to the loss of monitoring by the AFD system on the one hand and the untimely triggering of interlocks on the other.

C-IV-3.2.4.3. Overview of actions and implementation status

The actions carried out further to experience feedback are detailed in chapter 3.4.C-IV.

The actions resulting from the improvement points in C-IV-3.2.4.1 are currently being studied. The modification is scheduled to enter service at the end of 2023.

C-IV-3.2.5. Regulator's assessment of the active fire protection

C-IV-3.2.5.1. Overview of strengths and weaknesses in the active fire protection

Active fire risk control measures were defined from the BNI No. 151 design stage.

More precisely, the active measures correspond to:

- appropriate detection devices located specifically in the rooms where there is a fire risk;
- appropriate fire-fighting and extinguishing means (extinguishing water supply hydrants, dry riser, carbon dioxide gas injection systems in rooms where the presence of water is prohibited, etc.);
- a robust initial response organisation including specifically trained personnel.

Consequently, the control of fire-related risks has been improved in the past by replacing all the detectors taking the best available technologies into consideration.

Furthermore, BNI No. 151 has its own dedicated fire-fighting team which can be backed up by the units from the CEA Marcoule site as well as the departmental fire and emergency services (SDIS).

It must be pointed out that active fire risk control systems require special attention to ensure they remain operational. Consequently, the functioning of the detection systems must be verified periodically and any organisation based on the intervention of specific personnel members in the event of fire necessitates the maintaining of a high level of skill and organisation, particularly through training courses. Exercises are regularly organised in this respect, both internally and externally, with the support of the Prefecture, the departmental fire and emergency services (SDIS), ASN and IRSN. The feedback from these local and national exercises enables any shortcomings to be identified and contributes to the continuous improvement of fire management.

C-IV-3.2.5.2. Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

The last three inspections on the fire theme at BNI No. 151 did not call into question the active fire risk control measures.

D- Dedicated spent fuel storage facility La Hague – SFP D (T0) - BNI 116

D-3.2.1. Fire detection and alarm provisions

D-3.2.1.1. Design approach

The D pool hall is monitored by an automatic fire detection (AFD) system which allows the alarm to be raised early in the event of fire.

The fire detection and alarm (FDA) system is designed and chosen according to the type of fire that could break out in the monitored rooms. It is dimensioned and installed in accordance with the principles established in rule R7 of the APSAD (*Assemblée Plénière des Sociétés d'Assurances Dommages* – Plenary Assembly of Damage Insurance Companies), a reference base listing the rules of good practices.

The information transmitted by the fire detection systems is processed by the fire control panels of the T0 unit /D pool. The fire control panels transmit this information to the PSM security station and to the station of the shift supervisor in the T0 operational control room. The triggering of a fire detector in the event of a fire outbreak or malfunctioning of the fire detection system causes audio and visual alarms:

- in the T0 unit/D pool operational control room;
- and/or in the operational control and monitoring station of the Site and Material Protection Service (PSM).

Personnel are present at all times in the T0 unit /D pool operational control room and in the operational control and monitoring station of the PSM service.

The detection system also functions in the event of loss of the normal and backed-up electrical power supplies thanks to an ultimate power supply from batteries giving about 12 hours of autonomy.

Further to the periodic safety review, the pool hall of the D pool building has been equipped with a fire detection system.

D-3.2.1.2. Types, main characteristics and performance expectations

The AFD system uses linear smoke detectors to detect a fire outbreak in large-volume areas.

The maintenance of the fire detection equipment applied to the pool D building is identical to that of the T2 unit (see C-II-3.2.1.2).

D-3.2.1.3. Alternative/temporary provisions

Unavailability of the fire detection system in the pool D hall gives rise to a repair service request. This repair is carried out within one month (partial unavailability) or one week (total unavailability). Pending repair:

- specific patrol rounds are carried out in the room at a frequency defined by an instruction;
- special measures are put in place for hot work.

Only the shop manager or their representative is authorised to disable a fire detection system. The compensatory measures are identical to those described for the T2 unit (see C-III-3.2.1.3).

D-3.2.2. Fire suppression provisions

D-3.2.2.1. Design approach

The fire extinguishing design principle of the pool D building is organised around the three same response levels as described in paragraph C-III-3.2.2.1.

D-3.2.2.2. Types, main characteristics and performance expectations

The use of water as a fire-fighting agent during interventions is compatible with the safety-criticality objectives of the facility.

Fire extinguishers are provided in sufficient numbers in the pool D building as the initial response means. The extinguishing agents are suited to the risks to cover, ensuring that they are appropriate for the class of fire while at the same time taking into account any constraints inherent to their effects (criticality risk, production of effluents in particular). Their locations are signalled and readily accessible. They can be used by all the personnel.

The following specific secondary response means are present in the pool D building:

- fire-fighting water standpipes: the T0 unit /pool D is protected by two water standpipes connected to a meshed network. This network has a delivery capacity of 600 m^3/h and a nominal pressure of 8 bars;
- dry risers: the T0 unit / pool D is equipped with 6 dry risers installed in the stairways of the T0 building. They are supplied with water by the pumpers of the PSM service, through the supply half-couplings located outside the buildings.

The pool D building is accessed through the T0 building which is accessible to the fire brigade's fire appliances on two of its sides.

When in service and during maintenance or intervention operations, the general prevention principles are based on verification of the correct operation of the fire-extinguishing systems by applying maintenance/servicing procedures. The maintenance of the fire extinguishing equipment applied to the pool D building is identical to that of the T2 unit (see C-III-3.2.2.2).

D-3.2.2.3. Management of harmful effects and consequential hazards

The civil engineering of the T2 unit has sufficient capacity to retain the volume of extinguishing agents required to put out a worst-case fire in a controlled area.

D-3.2.2.4. Alternative/temporary provisions

The facility has a sufficient number of fire extinguishers to enable an operator to respond rapidly to an incipient fire, even in the event of unavailability or failure of an extinguisher.

Furthermore, the PSM service has secondary response extinguishing means which can supplement or compensate for the failure or possible unavailability of the fixed extinguishing means.

D-3.2.3. Administrative and organizational fire protection issues

D-3.2.3.1. Overview of firefighting strategies, administrative arrangements and assurance

The fire intervention procedure in a controlled area takes into account the aim of limiting the dissemination of contamination by radioactive materials. This is similar to that of the T2 unit (see C-III-3.2.3.1).

D-3.2.3.2. "Firefighting capabilities, responsibilities, organization and documentation onsite and offsite"

The fire management organisation of the pool D building is identical to that of the T2 unit (see C-III-3.2.3.2).

D-3.2.3.3. Specific provisions, e.g. loss of access

The pool D building has one main fire brigade access point and two secondary access points. These accesses allow a fire-fighting intervention in all the rooms of the pool D building. They are sufficiently numerous to allow an intervention in the rooms of the pool D building even if one of the access points cannot be used.

D-3.2.4. Licensee's experience of the implementation of the active fire protection

D-3.2.4.1. Overview of strengths and weaknesses

Strengths

The fire alarms are transmitted to the T0 unit/pool D operational control room and to the PSM's control and monitoring room. The chosen ergonomics enable the location of the fire alarm triggered in the pool D building to be identified rapidly and with certainty.

The 24h/24 presence of the PSM service fire-fighting teams enables fire-fighting to begin immediately with heavy-duty means without waiting for the external emergency services (SDIS).

Weaknesses

The ageing of the fire control panels installed when the T0 unit was built means that they sometimes have to be replaced. The replacement equipment will incorporate recent technologies.

D-3.2.4.2. Lessons learned from events, reviews fire safety related missions, etc.

The last periodic safety review of the T0 unit/pool D led to the equipping of the pool D hall with an AFD system.

D-3.2.4.3. Overview of actions and implementation status

As mentioned in points D-3.2.1.2 and D-3.2.4.2, the pool D hall has been equipped with an automatic linear smoke detection system.

D-3.2.5. Regulator's assessment of the active fire protection

D-3.2.5.1. Overview of strengths and weaknesses in the active fire protection

During its last inspections ASN has noted that the response groups have sound knowledge of the procedures and that new fire detection systems have been installed in the unit as a whole, in accordance with Orano's commitments. The licensee could nevertheless further improve the clarity of the operating aids for certain items of equipment. The licensee must also ensure the availability of the equipment necessary for the intervention of the local response group.

D-3.2.5.2. Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

ASN notes the substantial amount of work carried out by the licensee to produce the fire risk studies for the facility as a whole. The licensee had however been asked to supplement its fire risks management case in accordance with the latest changes in the regulations. ASN also asked the licensee to implement the risks management provisions decided upon after completing the periodic safety review examination. The last inspections conducted on the T0 unit concluded that its standard of fire risks management is satisfactory. The provisions mentioned at the end of the safety review have been put in place and the required procedures were known to the personnel. The last inspections relating to fire risk prevention on the T0 unit / pool D were carried out in November 2022. This inspection revealed that the mobile, fixed and organisational fire-extinguishing provisions are operational.

With regard to the heavy fire-fighting means (PSM), for several years now it has been difficult to check their implementation during the exercises organised for the inspections. The multitude of missions assigned to these teams on this site means that they can only rarely participate in the exercises in a satisfactory manner.

E- On-site storage radioactive waste storage La Hague – Silo 130 – BNI 38

E-3.2.1. Fire detection and alarm provisions

E-3.2.1.1. Design approach

A specific fire detection system and been installed in pit 43:

- an automatic fire detection system;
- a temperature probe;
- detection by radiation monitoring of the ^{137}Cs brought into suspension when a fire breaks out.

These three devices are installed in the ventilation extraction duct of pit 43. They are transmitted individually to the monitoring room. A fire outbreak in pit 43 is reported by an indicator light and an audio alarm on the specific fire risk control cabinet (extinguishing cabinet) in pit 43, and at the PSM security station and the operational control station of the Silo 130 unit. A video camera and a thermal camera provide visual surveillance of the interior of pit 43.

A malfunction of the fire detection system causes audio and visual alarms.

Personnel are present at all times in the operational control room and in the operational control and monitoring station of the PSM service.

The detection system also functions in the event of loss of the normal and backed-up electrical power supplies thanks to an ultimate power supply from batteries. This ultimate power supply ensures about 12 hours of autonomy.

In addition:

- the waste retrieval unit is equipped with two redundant surveillance cameras whose images are transmitted to the operational control station of the Silo 130 unit. They serve to check for fire outbreaks in the waste in the transfer carriage;
- the quantification and filling unit is equipped with a camera at each workstation and a camera for filming the interior of the ECE drum (storage drums for hulls and end caps underwater), which can be viewed locally at the corresponding workstation and in the operational control room. Fire detection in the unit is ensured by an ambient environment detector installed in the connection gallery.

E-3.2.1.2. Types, main characteristics and performance expectations

The following types of fire detector are used:

- Optical smoke detector: it allows early detection of smouldering fires or flames with release of smoke. Its operating principle is based on the diffusion of light and smoke density measurement;
- Multicriteria smoke detector: it allows early detection of fires with flames or smouldering fires with release of smoke;
- Infrared flame detector: it is suitable for the detection of fires without smoke.

The pit 43 fire detection system includes a caesium 137 detection probe which contributes to the early detection of a possible fire.

The maintenance of the fire detection equipment is applied to the Silo 130 unit as follows:

- Fire detection control unit:
  - periodic inspection every 6 months: test of the indicator lights and verification of the power sources,
  - preventive maintenance every year: overhaul of the fire detection control unit,
  - preventive maintenance at between 4 to 8 years: replacement of the batteries,
- Fire detectors:
  - periodic inspection every 6 months: functional test of the detection loops,
  - preventive maintenance every year: functional test of all the detection loop detectors;
- Transmission of alarms:
  - periodic inspection every 6 months: information transfer test.

E-3.2.1.3. Alternative/temporary provisions

Partial unavailability of the fire detection system in one or more rooms gives rise to a repair service request. Repair is carried within one month at the most. Hot work is prohibited pending repair.

Total unavailability of the fire detection system in one or more rooms gives rise to a repair service request. This repair is carried out within one week at the most. Pending repair, specific patrol rounds are conducted in the rooms concerned at a frequency defined by an instruction, and hot work is prohibited in them.

Only the unit manager or their representative is authorised to disable a fire detection system. In this case, compensatory measures are provided for, such as:

- regular patrol rounds;
- provision of fire extinguishers;
- elimination of all ignition sources;
- removal of all combustible materials;
- hold point at end of works and checking for hot spots with thermal camera.

E-3.2.2. Fire suppression provisions

E-3.2.2.1. Design approach

The fire suppression design principle of the Silo 130 unit hinges around 3 levels of response:

- the initial response means specific to the unit;
- the Site's on-site secondary response means;
- the emergency services external to the Site.

E-3.2.2.2. Types, main characteristics and performance expectations

The use of water as a fire-fighting agent during interventions is compatible with the safety-criticality objectives of the facility.

The following specific initial response means are present in the Silo 130 unit:

- fire extinguishers in sufficient numbers;
- automatic extinguishing with argon in pit 43:
    - argon supply network consisting of a storage tank with a capacity of 40,000 L and 3 lines (2 normal, 1 emergency), each ensuring a delivery rate of 2,000 m3/h,
    - discharge of argon at a delivery rate of 4,000 m3/h until the fire is extinguished by removing O2 until its level is too low to sustain combustion (threshold of 7%, without interlocking),
    - continued release of argon at a reduced rate of 2 m3/h, to cool the waste to a temperature that prevents re-ignition,
    - stopping of argon discharge and maintaining control of air extraction by measuring the negative pressure in the silo 43 (leaks from silo), until the ambient temperature is reached (monitoring by thermal camera in pit 43),
    - return to normal ventilation by opening the air intake register;
- manual extinguishing of the transfer carriage in the waste retrieval unit:
    - if a fire is detected in the carriage, the argon is discharged into the carriage;

- manual extinguishing in the quantification and filling unit:
  - the quantification and filling unit workstation is equipped with a remotely manoeuvrable spray nozzle extinguishing system connected to a charge of extinguishing powder for metal fires;
- automatic extinguishing of the cabinets housing the blowing and extraction fan speed controllers.

The following specific secondary response means are present in Silo 130 unit:

- fires-fighting water standpipes: the Silo 130 unit is protected by three water standpipes connected to a meshed network. This network has a delivery capacity of 600 m^3/h and a nominal pressure of 8 bars;
- fixed manual fire-extinguishing system in pit 43: if inerting fails after two argon discharges, the waste in pit 43 can be flooded by a massive injection of water via a nozzle through a penetration in upper slab of the silo. This nozzle is equipped with a coupling allowing the connection of a water supply hose by PSM and a valve for shutting off connection of this hose to pit 43 during normal operation. To avoid PSM having to enter the facilities to connect the hoses, the valve is located outside the Silo 130 unit;
- Accessibility of the 130 unit: the Silo 130 unit buildings are accessible to the fire brigade's fire appliances.

When in service and during maintenance or intervention operations, the general principles of prevention are based on verification of the correct operation of the fire-extinguishing systems by applying maintenance/servicing procedures.

E-3.2.2.3. Management of harmful effects and consequential hazards

The potential effects of overpressure due to operation of the automatic extinguishing system can be compensated for by increasing the ventilation system extraction flow rate, as operation of the last filtration barriers (DNF) is monitored.

E-3.2.2.4. Alternative/temporary provisions

Unavailability of an inerting gas discharge line of the pit 43 fir extinguishing system leads to:

- a repair service request. Repair is carried out within one month at the most;
- the use of an emergency manual line if necessary.

Unavailability of the fire-extinguishing operational control cabinet in pit 43 leads to:

- application of the actions to take for manual control of fire extinguishing during the period of unavailability;
- a repair service request. This repair is carried out within one week at the most.

E-3.2.3. Administrative and organizational fire protection issues

E-3.2.3.1. Overview of firefighting strategies, administrative arrangements and assurance

The fire intervention procedure in a controlled area takes into account the aim of limiting the dissemination of contamination by radioactive materials. The defining of intervention zoning meets this objective. This zoning can potentially change during the intervention. It is defined by the PSM team and may change in relation to the work of the radiation protection team. The zoning defines three zones:

- zone A is the volume in which the fire occurs. It is postulated that this zone is contaminated;
- zone C is the zone defined and confirmed as being non-contaminated. It allows a safe exit to the exterior;
- zone B is situated between zones A and C, and acts as a radiological air lock, allowing in particular the radiological management of the entry and exit of workers.

E-3.2.3.2. "Firefighting capabilities, responsibilities, organization and documentation onsite and offsite"

The fire management organisation of the Silo 130 unit hinges around the following three response levels:

- The initial response means specific to the unit: a Local Response Group (LRG) can be mobilised immediately for the following missions:
  - reconnaissance and safeguarding,
  - protection,
  - attempting to extinguish the fire if possible using hand-held extinguishers pending the arrival of the site's emergency services (Site and Material Protection service - PSM). All the personnel working in the Silo 130 unit have been trained in the use of fire extinguishers;
- The facility's on-site secondary response means; The Site has a PSM service equipped with heavy fire-fighting and fire protection means. The service can be mobilised immediately 24 hours a day. The heavy means at its disposal are equivalent to those of a town of 10,000 inhabitants;
- The emergency services external to the Facility. The facility has an agreement with the SDIS (Departmental Fire and Emergency Service) of the Manche département).

In addition to the training sessions of the specialised secondary response teams, annual exercises are organised and conducted with the licensee in order to improve the coordination and intervention preparation of the fire-fighting teams.

E-3.2.3.3. Specific provisions, e.g. loss of access

The Silo 130 unit has 2 main fire brigade access points.

These fire brigade access points provide access to all the 130 unit rooms in case of fire. They are sufficiently numerous to allow an intervention in the Silo 130 unit rooms even if one of the access points cannot be used.

E-3.2.4. Licensee's experience of the implementation of the active fire protection

E-3.2.4.1. Overview of strengths and weaknesses

The automatic fire detection and extinguishing systems put in place in the context of waste retrieval and packaging (WRP) have considerably reinforced the fire risk control of the Silo 130 unit.

Furthermore, the 24h/24 presence of the PSM service fire-fighting teams enables fire-fighting to begin immediately with heavy-duty means without waiting for the external emergency services (SDIS).

Nevertheless, the ageing of the fire control panels installed when the Silo 130 unit was built combined with the growth in the number of rooms equipped with fire detection systems further to the periodic safety reviews, means that these panels are being replaced by recent technology equipment.

E-3.2.4.2. Lessons learned from events, reviews fire safety related missions, etc.

Further to the fire of 6 January 1981 and in the WRP context:

- fire detection systems specific to pit 43 and the retrieval, quantification and filling units have been installed (see E-3.2.1.1);
- fire detection systems specific to pit 43 and the retrieval, quantification and filling units have been installed (see E-3.2.2.2).

E-3.2.4.3. Overview of actions and implementation status

All the active protection measures (fire detection and extinguishing) set out in paragraph E-3.2.1.1 and E-3.2.2.2 have been taken.

E-3.2.5. Regulator's assessment of the active fire protection

E-3.2.5.1. Overview of strengths and weaknesses in the active fire protection

At present, fire detection in Silo 130 is ensured by several fixed means which have been supplemented in the context of the WRP operations by a fire detection system specific to pit 43 and surveillance cameras whose images are transferred to the Silo 130 unit operational control station for viewing.

In an earthquake situation, the functioning of the existing means cannot be guaranteed (as Silo 130 is not designed to withstand this extreme hazard). In this case the detection of a fire in silo 130 relies on detection by personnel during the "site diagnosis" patrol round which is planned in the first phase of emergency management after an extreme event.

The licensee's approach to fire risk control by means of active protection systems appears sufficient and has taken into account the lessons learned from the silo fire of 1981. The approach is notably based on different levels, with in particular:

- a detection system that is reinforced for the WRP operations and in the places representing risks;
- appropriate fire-fighting means (three fire-fighting water standpipes, one fixed manual extinguishing system in pit 43 in case inerting fails, one nozzle for massive injection of water, etc.);

- good accessibility of the Silo 130 unit to fire brigade fire appliances, with two main entrances;
- a three-level response organisation (a Local Response Group (LRG) specific to the unit, a PSM service equipped with heavy intervention and fire-fighting means specific to the Site and available 24h/24, plus the public fire and emergency services.

It must be pointed out that although the setting up of a specific organisation dedicated to fire control is necessary, it nevertheless relies on human skills. This organisation requires the maintaining of a high level of skill and organisation in the control and fighting of fires, and the training courses and fire exercise remain essential in this respect.

E-3.2.5.2. Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

Considering the lessons learned from Fukushima and the file submitted by the licensee in 31 March 2015, IRSN considered in its opinion of 1 March 2016 that in an extreme situation, fire detection and extinguishing could be problematic and recommended substantiating the earliness of fire detection and the feasibility and effectiveness of water extinguishing for Silo 130. The answers given by the licensee on 19 July 2016 provided proof that water can be used for fire extinguishing as a last resort.

During its various inspection missions, ASN has noted an improvement in the active fire protection means deployed, particularly for the prospective WRP operations. Further improvements are nevertheless expected in the implementation of fire-fighting means specific to worksites, which are numerous in the facilities undergoing decommissioning.

F- Installations under decommissioning

F-I- Research reactor OSIRIS – BNI 40

F-I-3.2.1. Fire detection and alarm provisions

F-I-3.2.1.1. Design approach

The automatic fire detection (AFD) system, of the addressable and looped back type, monitors all the rooms except those for which the fire risk analysis proved this unnecessary. This system transmits fire alarms and unavailabilities (technical faults):

- With detailed information (location of the detection point(s) concerned, etc.) to the central security statin (PC-S) of the Local Safety & Security Force (FLS); the putting out of service (disabling) actions are also transmitted to the PC-S;
- With detailed information to the operational control room of the OSIRIS reactor and summarily (type of alarm with no details) to the rooms dedicated to the security duty personnel (PMS) outside working hours.

Thus, the facility personnel and the FLS can take the planned measures immediately. Any technical fault or fire alarm requires verification and a response from the FLS.

The AFD system is supplemented by monitoring by the personnel. The alert can also be raised by the personnel present via the various interphones, telephones and manual call points (MCPs).

Following confirmation of an alarm, personnel evacuation is signalled by a general audio alarm which can be heard at all points in the buildings. Evacuation is supervised by the specially trained members of the local initial response team (LIRT). The personnel are directed to the appropriate assembly point according to the event.

Some AFD systems trigger interlocks, such as temperature probes in ventilation ducts causing closure of fire dampers and stopping the extraction fans.

F-I-3.2.1.2. Types, main characteristics and performance expectations

Fire detection is ensured by detectors installed so as to detect a fire very rapidly, in compliance with the rules and standards. All the buildings are divided into zones, and for each zone there is a detection loop to which the detectors are connected. All the detection loops are processed by monitoring and signalling equipment (MSE) installed in a technical room. This fire detection system has a backup electrical power supply (batteries) guaranteeing its continued operation if the normal electrical power supply fails.

The installed detectors use several technologies:

- optical smoke detectors (point-type, or multipoint-type associated with an aspirating unit);
- fixed temperature heat detectors;
- rate-of-rise heat detectors;
- infrared flame detectors (truck air lock).

Correct functioning of the fire detection system is checked through a programme of periodic tests and preventive maintenance operations.

The fire detectors installed in the hot cells have radiation resistance characteristics and can be remotely tested.

F-I-3.2.1.3. Alternative/temporary provisions

In case of intentional disabling of the AFD system, the FLS is informed and compensatory measures are applied (examples: hot work permit for hot work or work creating dust).

If the fire detection system suffers a technical failure, corrective maintenance is carried out without delay (technical call duty). As long as the failure has not been resolved, compensatory measures are defined (prohibition of certain activities, conducting patrol rounds, switching off electrical equipment, etc.).

F-I-3.2.2. . Fire suppression provisions

F-I-3.2.2.1. Design approach

Mobile fire extinguisher (hand-held or wheeled) appropriate for the nature of the fire risks are provided in sufficient numbers in the various zones of the facility. They are visible and accessible at all times. The only fixed extinguishing system is the manually activated one for the hot cells (including the powder extinguishers outside the cells connected to a diffuser that is positioned at the point of fire outbreak inside the cell by remote manipulators).

BNI No. 40 has specific means (dry penetrations) to which the emergency services can connect their fire extinguishing means without jeopardising the continuity of the containment barrier crossed for the deployment of the fire-fighting means:

- a dry wall penetration (for water) to the north-north-east in the controlled leakage containment of the OSIRIS pile hall;
- two dry wall penetrations (for water and powder) to the south-east of the ISIS hall wall.

Three standardised hydrants are located less than 50 metres from the facility and three other at less than 100 metres. They are connected to a meshed network. There are two meshed networks on the Saclay site which can simultaneously delivery the minimum required flow rate determined by the fire risks analysis and at the required minimum pressure.

F-I-3.2.2.2. Types, main characteristics and performance expectations

The mobile fire extinguishers are sprayed water, powder, and CO_2 extinguishers of various sizes (from 2 kg up to 50 kg). Correct functioning of these extinguishing systems is checked through a programme of periodic tests and preventive maintenance operations.

F-I-3.2.2.3. Management of harmful effects and consequential hazards

There is no ban on the use of extinguishing agents on account of criticality risk control.

The dry penetrations described above and the fixed extinguishing system of the hot cells maintain the containment barriers in the event of a fire-fighting intervention.

With regard to the extinguishing water retention means, the constructional provisions of the buildings enable retention tanks to be placed inside the water unit, around the effluent tanks and in the basement levels. Furthermore, isolation valves are provided in the gutters near the building to that the extinguishing waters can be confined in the facility's stormwater networks. These measures, which are implemented by the members of the LIRT or the FLS, are covered by specific instructions.

F-I-3.2.2.4. Alternative/temporary provisions

For special or temporary operations presenting fire risks (hot work), additional hand-held extinguishers may be placed at the disposal of the personal right next to the work.

If failure of extinguishing or retention equipment is observed, the FLS is informed in order to remedy the situation as quickly as possible and define compensatory measures if necessary.

F-I-3.2.3. Administrative and organizational fire protection issues

F-I-3.2.3.1. Overview of firefighting strategies, administrative arrangements and assurance

If a fire is detected, the operational control team asks for deployment of the LIRT. This team ensures the protection of people and takes the first safety measures until the Saclay site's specialised emergency services (FLS) arrive at the site of the fire. For BNI No. 40, the LIRT members undergo regular training (evacuation of the personnel, receiving the external emergency services, performing fire exercises). Some of the facility's personnel are trained in emergency management. The duties and actions to be taken by these personnel members are described in the documentary baseline standard, in particular in the on-site emergency provisions and the associated reflex sheets.

An agreement signed by the FLS of Saclay and BNI No. 40 sets out, among other things, the fire-fighting obligations of each party. For example, the facility is obliged to deploy the measures that facilitate the interventions of the FLS and to allow it to make technical visits in order to acquire a sound knowledge of the premises. The FLS is tasked in particular with:

- in the BNI No. 40 buildings, the operational management of the initial response equipment, of the alerting means (security telephones) and of the appliances provided for external defence against fire (fire-fighting water standpipes, fire hydrants);
- drawing up and keeping up to date an intervention file containing the response plans and the particular instructions which are validated by the facility.

BNI No. 40 is covered by a construction damage insurance contract for the fire risk. The insurers organise regular audits which can lead to supplementing of the provisions linked to the control of the fire risk.

F-I-3.2.3.2. "Firefighting capabilities, responsibilities, organization and documentation onsite and offsite"

A fire exercise involving BNI No. 40 and the response teams is organised each year.

If the consequences of an accident occurring in BNI No. 40 risk going beyond the boundaries of the facility, the BNI Head (or deputy) alerts the centre's senior management to decide whether to activate the on-site emergency plan (PUI) or not. An annual PUI exercise is carried out for the CEA Saclay site, with the participation of the response teams. The FLS, the Radiation Protection and Environmental Monitoring Service (SPRE) and the Prevention and Occupational Health Service (SPST) have put in place an Operational Engagement Plan (PEO).

The FLS personnel follow several weeks of initial operational training within a Departmental Fire and Emergency Services Centre (SDIS), supplemented by one week devoted to the particularities of the CEA's activities, and the nuclear aspects in particular (operational safety culture, radiation protection, nuclear ventilation, etc.). The operational readiness of the FLS teams is maintained on a daily basis (exercises, etc.). It should be pointed out that some of the FLS personnel are also volunteer firemen. This training curriculum can be supplemented according to the needs (chemical risk, radiological risk, etc.) and the level of responsibility (fire chief, brigade chief, etc.).

Furthermore, the response and fire-fighting means are deployed in accordance with a predetermined organisation described in the Saclay site Emergency Resources Engagement Plan (PEMS). This organisation defines 5 levels of fire intensity, with level 4 (extensive fire in the initial volume) being the level at which the on-site emergency plan (PUI) is activated. The PEMS defines:

- the various response teams called out in the event of a fire (FLS, SPST, SPRE, LIRT, competent staff of the facility concerned and the public emergency services);
- the organisation of the command chain according to the response teams present;

- the actions to take, the material resources (fire tenders etc.) and human resources (number of people, functions, etc.) and the organisation of the means implemented (whether internal or external to the facility);
- the command functions in the event of fire and the persons commanding them.

Depending on the fire situation, the FLS may deploy two fire tenders, making three two-person teams available immediately. Furthermore, the engagement of a fire tender on a confirmed fire in a BNI systematically activates the agreement with the SDIS of the Essone *département* which backs up the Saclay site's resources in accordance with the ETARE ("Listed Site") plan. The Saclay site has an Off-Site Emergency Plan (PPI) which falls within the scope of the ORSEC plan (French national emergency response plan) and is activated if consequences extend beyond the boundaries of the site. A PPI exercise is carried out at least once every 5 years on the Saclay site.

F-I-3.2.3.3. Specific provisions, e.g. loss of access

General information on the Saclay site

The research facilities of the CEA Saclay site do not require access to an abundant cooling source. Consequently, the site was built in 1952 on a raised plateau far from major rivers and the associated risks of flooding.

The climate is oceanic, with relatively low levels of precipitation; the immediate proximity of agricultural land with numerous drainage structures means that rainwater is readily drained and absorbed.

The seismicity of the area is moreover very low.

Access to the Saclay site

The CEA Saclay site has several access points, which limits the risk of the external fire-fighting services being unable to gain access.

The perimeter of BNI No. 40 is accessible via several access points on the Saclay site, which limits the risk of being unable to gain access to the stricken building.

The external emergency services are met by a Saclay site representative who informs them of the access procedures and how to get to the areas concerned.

Any measures that might have to be taken to ensure access to the facility and/or site depend on the type of incident/accident and are under the responsibility of:

- the head of the facility concerned in the event of an incident confined within a CEA facility;
- the emergency situation director and the on-site operations director in the event of an accident confined within the CEA site;
- the emergency operations director (usually the Prefect of the Essonne *département*) if the off-site emergency plan (PPI) is activated for an accident whose impact extends beyond the CEA site.

F-I-3.2.4. Licensee's experience of the implementation of the active fire protection

F-I-3.2.4.1. Overview of strengths and weaknesses

The fire safety system (FSS) of BNI No. 40 was renovated in 2016. The addressable technology and the transmission of detailed information to the PC-S allow for rapid detection and intervention of the FLS.

In the particular case of the hot cell fire detectors, the lack of accessibility complicates the periodic inspections and any necessary maintenance operations. The periodic operating checks are carried out applying a specific procedure.

F-I-3.2.4.2. Lessons learned from events, reviews fire safety related missions, etc.

Lessons learned from the main events concerning the means of detection and response.

In the period since the new FSS was installed, the main event has been the failure of the AFD system in the ISIS reactor hall. This detection system is of the multipoint type associated with an aspirating unit. A first technical fault that occurred in early 2018 triggered the technical fault alarm of the aspirating unit, while leaving the fire alarm function operational. During tests performed in April 2019, the fire alarm function was found to be inoperative during the tests with smoke. As the measures to remedy this situation had not yet been taken, when the facility noticed the failure of the fire monitoring system in the ISIS hall, measures were immediately put in place (informing the FLS PC-S of the absence of fire detection in the ISIS hall, conducting daily patrol rounds in the ISIS hall and banning hot work in the ISIS hall). The aspirating unit was rapidly replaced by a new one with more recent technology and the qualification tests were satisfactory.

Further to the analysis of the event, tracking of the periodic tests and maintenance operations has been improved, as has the layout of the event reports.

Lessons learned from the ASN inspections on the fire theme (means of detection and response).

The main demands relative to the means of detection and response further to the ASN inspections on the fire theme concern:

- the need to render more explicit some of the procedures used in the periodic tests of the FSS and the corresponding test reports;
- the need to keep the response plans and special instructions applicable in fire situations up to date;
- proof of the adequacy of the fire detection and extinguishing means provided in certain rooms;
- proof that the fire hydrant capacities meet the extinguishing water needs (evaluated with a very large safety margin in the fire risk management study).

F-I-3.2.4.3. Overview of actions and implementation status

The fire risk management study carried out during the last periodic safety review led to recommendations concerning the means of detection and response such as:

- the addition of fire detectors and mobile fire extinguishers;

- the addition of systems for injecting extinguishing agent (foam) from outside the buildings into the basement rooms in which the inverter battery banks are installed;
- analysis of the feasibility of rendering the dry wall penetration in the OSIRIS hall more operational;
- the installation of extinguishing water retention devices (cofferdams or movable barriers);
- the updating of some existing instructions.

These measures are deployed in the context of a safety improvement action plan.

F-I-3.2.5. Regulator's assessment of the active fire protection

F-I-3.2.5.1. Overview of strengths and weaknesses in the active fire protection

Under the commitments action plan following the safety review of the BNI, AFD systems were installed in 30 rooms in the second quarter of 2022.

In accordance with the safety analysis report, each hot cell in the facility is equipped with a fire detection system that triggers at 55°C. This system comprises 3 detectors arranged in series. These detectors are designed to react to temperature gradients of about 5°C/minute and they have a thermokinetic function whose threshold is set at 55°C. The procedures for checking these detection systems and proving performance of the checks are to be specified by the licensee.

F-I-3.2.5.2. Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

The Saclay centre underwent an inspection on the "fire" theme on 23 September 2020, during which the inspectors examined the organisation and means deployed by the centre to ensure the availability of the fire-fighting means.

This inspection found the availability of the fire-fighting means to be satisfactory. The CEA has been conducting renovation work on the centre's fire networks for several years. The results of the tests performed on certain water standpipes simultaneously were consistent with requirements. The inspectors underlined the ongoing development of several aids for the FLS, designed to improve the tracking and management of the fire-fighting means among other things.

F-II- UNGG Saint-Laurent des Eaux - BNI 46

F-II-3.2.1. Fire detection and alarm provisions

F-II-3.2.1.1. Design approach

The fire risk management case (DMRI) identifies the targets for which vulnerability to the effects of the fire could lead to compromising of the protection of interests (population and environment). In the case where the room, the building or the outside area:

- contains a target;
- does not contain a target but in case of fire could compromise a room, building or outside area containing a target.

It is mandatory to install a fire detection system with its interlocked safety devices.

The targets include all the systems that play a role in the containment of radioactive substances or protection against ionising radiation, as well as those involved in the containment of hazardous substances or the protection of persons and the environment against toxic effects, overpressure effects, thermal effects and effects associated with the impact of projectiles.

Other issues, independently of the fire risk management case, may make the installation of fire detectors necessary, such as the protection assets.

These detectors are installed consistently with the types of fire.

F-II-3.2.1.2. Types, main characteristics and performance expectations

Two types of fire detector are installed on the Saint Laurent A site:

- point smoke detectors;
- linear optical smoke detectors, in view of the dimensions of some rooms.

The fire alarms are transmitted to the Alarms Monitoring Station which is permanently manned during working hours. The alarms are also transmitted to Saint-Laurent B where monitoring is ensured outside working hours.

If an operator detects a fire during opening hours, fixed telephones in the buildings are connected to the internal network of the NPP.

F-II-3.2.1.3. Alternative/temporary provisions

When carrying out operations that could trigger unwanted fire detection, and in order not to generate an excessive number of alarms, the detectors monitoring the potentially impacted zone can be disabled. The disabling phase is limited to the strict necessary and only during the period when the risk of excessive triggering is identified. These operations can only be carried out with personnel permanently present in the disabled zone. Permanent monitoring by people effectively replaces the disabled detectors.

When hot cutting operations are involved, a patrol round is carried out one hour after completing the work to check there is no smouldering fire.

F-II-3.2.2. Fire suppression provisions

F-II-3.2.2.1. Design approach

The site is equipped with about 500 hand-held fire extinguishers, the location and type of which are determined by the risk analysis and the risks present in the facility.

Some rooms and buildings presenting specific risks may be equipped with automatic extinguishing systems (sprinklers installed in the electrical building where there are large numbers of electric cables).

There are two dry risers and fire hose cabinets in each reactor hall.

Fire-fighting water standpipes are provided close to the facilities.

These items are signalled and kept in good working order through a maintenance programme.

F-II-3.2.2.2. Types, main characteristics and performance expectations

The fire extinguishers are located on the different levels of the buildings and are mainly of the water and additives, CO_2 or powder type.

F-II-3.2.2.3. Management of harmful effects and consequential hazards

BNI No. 46 has adopted the principle of at-source containment of the fire extinguishing water that could potentially contain toxic and/or radiological products. Containment studies are carried out on the basis of the extinguishing water volumes resulting from the fire-fighting scenarios of the fire risk management case. These studies validated the feasibility the principle of containment at source and highlighted the works necessary for this (installation of appropriate means of retention, such as cofferdams).

F-II-3.2.2.4. Alternative/temporary provisions

Extinguishing means may be added for the needs of the worksite, depending on the conclusions of the worksite risk analysis.

F-II-3.2.3. Administrative and organizational fire protection issues

F-II-3.2.3.1. Overview of firefighting strategies, administrative arrangements and assurance

The fire-fighting intervention is based on a graded approach with the following main phases: fire detection (fire reporting call or automatic detection), fire confirmation by a first recon team, intervention of an emergency response team to carry out the initial actions and implementation of the associated means (closure of a fire door, stopping the ventilation, etc.) and lastly intervention of the external emergency services.

The organisation in place enables each phase to be carried out within the maximum response times. All the actions to be taken by the different response teams are set out in "fire action sheets" available in the facility.

The interventions carried out before the external emergency services intervene are ensured at the Saint Laurent NPP site level (comprising three BNIs) and are therefore centralised in a service at Saint Laurent B (PWR in service).

This mode of organisation provides a view of the situation on the site as a whole and improves intervention effectiveness. The organisation is therefore common to EDF and described in paragraph A-I-3.2.3.

F-II-3.2.3.2. "Firefighting capabilities, responsibilities, organization and documentation onsite and offsite"

The fire-fighting organisation is detailed in a protocol between the EDF unit operating the Saint Laurent A facility and the unit operating the adjacent NPP (Saint Laurent B – BNI No. 100). This aim of this protocol is to define the organisation of relations between the two licensees, the resources each one provides, the methods of exchanging information and communicating, and the responsibilities of each licensee. The NPP, for example, is responsible for drawing up, maintaining and implementing the emergency plans and the associated response means (See A-I-3.2.3.2 paragraph).

Fire exercises are organised several times per year in cooperation with the external emergency services. Discussion meetings are organised with the external emergency services to anticipate certain issues on specific worksites.

F-II-3.2.3.3. Specific provisions, e.g. loss of access

If there are on-site routing difficulties, the Emergency Operations Director coordinates the players to identify the most appropriate route for the external emergency services to gain access to the place of the fire with the equipment they deploy.

F-II-3.2.4. Licensee's experience of the implementation of the active fire protection

F-II-3.2.4.1. Overview of strengths and weaknesses

The centralisation on the Saint Laurent site provides an overall view of the site's BNIs as a whole in a fire situation and allows better coordination of the means. The fire exercises and discussion meetings with the external emergency services enables certain issues to be planned for in advance and ensure a fast and proportionate response.

F-II-3.2.4.2. Lessons learned from events, reviews fire safety related missions, etc.

The single significant event on a nuclear site undergoing dismantling concerns a fire that occurred in 2015 on the Brennilis site; the event is described in paragraph II-2.6.6.1. The analysis of this event did not reveal any weaknesses in the active fire protections.

F-II-3.2.4.3. Overview of actions and implementation status

The active protection measures are in place. BNI 46 is constantly changing due to the decommissioning operations, therefore the systems are adapted to follow these changes and the nature of the future worksites. The majority of these changes are covered by regulatory files.

F-II-3.2.5. Regulator's assessment of the active fire protection

As mentioned in F-II.3.1.4 for the risk prevention means, relating to the interfaces between the operation of the BNI and operation of the two in-service reactors of the Saint-Laurent NPP, deficiencies were identified in 2020 in the retransmission of the BNI 46 fire alarms to the NPP outside working hours; these deficiencies have since been remedied. ASN is vigilant with regard to this point.

F-II-3.2.5.1. Overview of strengths and weaknesses in the active fire protection

Considering the current fire risks in the facility, the fire detection and fire-fighting measures come under the standard industrial risks. No particular strengths or weaknesses have been identified.

F-II-3.2.5.2. Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

ASN's last assessments of the active fire protection measures implemented on the facility showed that the licensee's periodic checks of the fire detection systems and associated alarms and of the fixed and mobile fire-fighting means were satisfactory.

3.3. Passive fire protection

A- Nuclear Power Plants

A-I- TRICASTIN 1 - 900 MWe series – post-4th periodic safety review

A-I-3.3.1. Prevention of fire spreading (barriers)

A-I-3.3.1.1. Design approach

The fire stability of safety building structures is sufficient to enable the BNI to be brought to and maintained in a safe state in the event of fire, without calling into question the fire resistance of the fire sectors or zones situated in them. By design, the fire stability of the load-bearing parts of the structure of safety-classified buildings (pillars, beams, floors, shells, etc.) is at least 2 hours. This stability is calculated for a fire occurring inside or outside the buildings, considering the possible interactions with a fire developing in a nearby structure.

The aggravation and propagation of a fire are limited by dividing the building into fire safety sectors or zones (sectorisation) which use the principles of physical or geographical separation. In this respect, the first phase of the safety analysis, for each building of the nuclear island and independently of any fire scenario, consists in:

- identifying and locating the redundant equipment items fulfilling a same given safety function (mechanical equipment or electrical equipment and their electrical connections);
- then applying the principles of geographical or physical separation.

The electrical power supplies of the active fire protection equipment participating in safety sectorisation must be backed up in order to be able to control the fire if the external power supply is lost.

The fire protection equipment items participating in safety sectorisation are Protection Important Components (PICs) which have a safety classification.

The fire duration calculation is used at the design stage for sizing the sectorisation. It is based on the fire duration determined from knowledge of the fire load density, using the standardised thermal curve (per RRC-I-97).

The physical separation of two items of equipment with respect to fire means either installing them in two separate rooms, of which one at least constitutes a fire sector, or protecting one of them with a thermal coating. Physical separation is to be preferred to another arrangement. Likewise, priority is given to structural measures (fire resistance of the structures) rather than using a means of fire protection. The aim of these fire protection measures is to ensure the operability of the equipment they protect throughout the duration and at the end of the reference fire for the fire volume in which they are installed. Geographical separation of two materials with respect to fire consists in installing them in different rooms or at a sufficient distance from any combustible material to avoid fire-propagating heat transfers.

In addition to the approach of verifying the robustness of the sectorisation components and taking an aggravating factor into consideration on the active equipment, EDF has analysed the consequences of failure of the static equipment. EDF thus considered as a high safety risk certain fire doors that are not interlocked with the fire detection system (chapter 2) and whose failure would contribute significantly to the overall risk of core melt. For these doors, EDF is installing "door open" alarms with the aim of ensuring they are kept closed. This modification will be deployed in phase B of the RP4 900 MWe plant series on the Tricastin reactor No. 1. For the other passive sectorisation components also identified as representing high risks for safety, operating provisions are tightened: These equipment items will all be covered in operation by assigning them the maximum level of importance, that is to say like sectorisation components situated between opposing trains.

On account of the technical requirement associated with the lessons learned from Fukushima and the stress tests, EDF has assessed the Safe Shutdown Earthquake (SSE) resistance of the structures and equipment items that are subject to a requirement for resistance to the Operating Basis Earthquake (OBE) and contribute to fire safety sectorisation. The fire doors and the fire dampers are robust to the SSE.

To improve the fire resistance of sectorisation components or of cables with respect to the effects of smoke, pressure, etc., EDF will implement measures to improve the fire resistance of certain components (fire doors, fire sectorisation components, fire protection of electric cables, etc.) or to reduce the scale or intensity of possible fires. These measures consist more specifically in replacing fire sectorisation components (fire doors for example) by components with greater fire resistance. Other measures consist in protecting cables with a fire-resistant wrapping.

To increase the fire risk robustness of the system for removing residual power from the fuel in the spent fuel pool, EDF is retaining the need to protect the facility against the risk of complete loss of the spent fuel pool cooling function should fire break out on one of the two pumps of the pool water treatment and cooling system (installation of a shield between the 2 pumps).

A-I-3.3.1.2. Description of fire compartments and/or cells design and key features

There are different fire volumes: The safety fire sectors (SFS) are created to physically separate the safety equipment items ensuring functional redundancy. The fire resistance rating of the walls separating the redundant equipment items must not be less than 1 hour 30 minutes. Active or passive fire protection means are put in place if necessary to guarantee their integrity beyond this period. The safety fire sector is the option to choose in priority.

A fire and containment sector (SFC) is created when a fire could cause the release of radioactive materials which, without measures to prevent their dispersion outside the fire sector in question, would lead to exceeding of the limits associated with the design-basis operating conditions. The study of the radiological effects of the fire hazard did not lead to the setting up of a Fire and Containment Sector.

In some buildings, primarily the reactor building, the division into fire sectors can be limited by constructional measures or by the process. In this case, certain parts of the building or the entire building can be broken down into fire zones which use the principle of geographical separation.

A safety fire zone (ZFS) is a fire zone that is created to separate the redundant safety equipment. The boundaries of these ZFS's and the distance between the components to protect must guarantee the integrity of the safety functions for the time necessary to extinguish the fire (for example based on the duration of the reference file). Means of fire protection (shield, extinguishing system) installed if necessary.

The ZFS ensures the absence of propagation and common mode by geographical separation. The demonstration of non-propagation and absence of an induced common mode on the equipment must be established by analysing all the plausible modes of propagating the fire and the combustion products on either side of the boundary.

The fire zones are limited by walls and/or boundaries which may feature openings (Wall With Opening) or may be fictitious (Wall Not Materialised). Fire zones are adopted in cases where it was technically impossible to establish a fire sector.

The fire protection equipment items participating in safety sectorisation are PICs which have a safety classification in accordance with the classification rules.

There are two other types of Fire Volume:

Access Fire Zone (ZFA) (or evacuation route): The fire volume allows evacuation of the personnel and access of the emergency services. As such, if forms part of the safety sectorisation and is situated outside the safety fire volumes.

It can also constitute a protected route giving access in case of fire to the places necessary for placing and maintaining the BNI in a safe state. The "FAIop Access" studies define the paths, particularly the marked out fire volumes, which the trained persons must take in order to carry out the necessary operational control actions while remaining protected from the fire.

Save particular cases (ZFA, exterior) all the doors situated at the boundary of the safety fire sector have 90-minutes fire resistance.

Non-Sectorised Zone (ZNS): This volume groups the rooms that do not belong to any of the abovementioned volumes. It allows the management of the fire parameters of rooms that are not subject to safety or security sectorisation.

The wall elements are the components or devices situated on wall at the fire volume boundary, such as doors, dampers and penetrations. The envelopes and passive protections are used to treat a common mode that is functionally confirmed and not cleared. This treatment usually consists in removing the common mode object from the fire (in order to guarantee its operability) by installing a qualified isolating thermal protection such as:

- envelope;
- fire-resistant box;

- shield.

Constructional measures are taken to guarantee that the evacuation routes are kept free of fire and smoke.

As a general rule, an evacuation route does not contain any combustible mass other than those associated with the lighting and fire detection cables: it is accepted that cables associated with safety functions can pass through an evacuation route, on condition that they do not create any functionally confirmed common mode in the resulting fire volume.

A-I-3.3.1.3. Performance assurance through lifetime

The fire protection equipment involved in safety sectorisation (fire doors, cable raceway casings, cat-"cat-flap" shields, fire dampers, inter-block seals, sealing of penetrations, floor drains, etc.) must be designed to permit in-service monitoring of their main components in order to guarantee their availability to fulfil safety functions. These items of equipment are monitored as part of the fire protection equipment maintenance programmes which define the visual inspections to perform and their frequency.

By way of example:

- As regards the wrappings, the "Passive fire protection equipment (excluding doors)" maintenance programmes of the different plant series prescribe visual inspections of the casings to check they are not damaged (tears, holes, etc.). Inspection is carried out once per cycle for the Safety Fire Volumes (VFS) where works are carried out during the cycle, and at least once every 5 years. The inspection frequency of once per cycle for the VFS's in the zones where works take place during the Plant Unit Operating cycle allows the early detection of any damage to the wrappings.
- With regard to the floor drains, their trap is checked daily as part of routine servicing with a daily frequency and at least once a month (depending on the evaporation rate observed in the room).

A-I-3.3.2. Ventilation systems

A-I-3.3.2.1. Ventilation system design: segregation and isolation provisions (as applicable)

The sectorisation procedure integrates the resistance of the ducts or the installation of dampers. The ventilation systems are designed to comply with the sectorisation principles. In order to comply with the fire sector routings, the ducts that cross the fire sectors are equipped with fire dampers, or, in certain configurations, they may be coated with a fire-retardant material.

The ventilation network of any room or group of rooms constituting a fire volume must be routed to the exterior of the ventilated volume so that ventilation is only stopped in the affected room.

This is achieved by installing fire-resistant valves at the air intake and air return, either embedded in the shells, surface-mounted or offset.

If it proves impossible to install valves in one of the above arrangement and the network is routed inside the room or group of rooms to ventilate, one of the following arrangements may be required depending on the type of volume crossed:

- installation of dampers at the walls of the fire volume crossed;
- for the conduit and its supports, application of a degree of fire resistance at least equal to that of the room crossed.

The fire dampers are closed:

- by passive systems (melting of fuse) to guarantee safety sectorisation;
- by interlocking to the fire detection system to minimise the propagation of cold smoke in the ZFAs, and to guarantee safety sectorisation;
- by pressing a pushbutton for the fire-fighting actions.
- a smoke control system:
- controls and manages the smoke by inducing negative pressure in the room;
- reduces or delays the rise in the temperature of the room;
- clears the atmosphere of the room once the fire is extinguished.

The iodine traps consist of activated and impregnated charcoal granules contained in a bunker or in a metal box. The iodine traps equipped with a heater are considered to present a significant fire risk. Special measures are adopted:

- the iodine traps are subject to reinforced fire protection: they are equipped with upstream and downstream flame-retardant valves. The principle applied to avoid development of a fire is based on removing the ignition source by powering off the heater when an alarm is triggered (High Temperature safety thermostat) in the control room and minimising air intakes by closing the upstream and downstream fire dampers;
- in addition, to ensure complete extinguishing of a fire, the iodine trap is equipped with fire-fighting means: spray boom or spray line connection equipped with an isolating valve and a fire department connection installed outside the fictitious volume at a fixed station to allow connection of a fire hose cabinet.

The measures specific to each ventilation system are detailed in the safety analysis report (conformity with the design requirements).

The robustness of the facility against the risk of re-ignition of combustion residues in the ventilation ducts relies primarily on the presence of fire dampers at the boundary of the safety fire zones. For the Safety Fire Zones not equipped with fire dampers, the demonstration is based either on complementary fire risk studies, which for some situations are based on fire models showing there is no risk of unburned gases being propagated through the ventilation ducts, or on functional analyses showing there is no impact on safety.

A-I-3.3.2.2. Performance and management requirements under fire conditions

Monitoring programmes define the maintenance of:

- flaps and isolating fire-break components of the smoke control system;

- fire dampers of the ventilation systems (inspection of the actuators, inspection or replacement of intumescent seals, integrity of the damper, verification and replacement of fuses every 5 years, etc.).

The interlocked fire dampers undergo periodic manoeuvrability and closure tests following triggering of the fire detection system.

A-I-3.3.3. Licensee's experience of the implementation of the passive fire protection

A-I-3.3.3.1. Overview of strengths and weaknesses

On account of the lessons learned from Fukushima, EDF verified the robustness of the fire sectorisation (doors, fire dampers) and its resistance to the SSE revised without modification for the Tricastin site. Reinforcement works are planned for some of the CPY series NPPs.

EDF has set up an organisation with respect to fire sectorisation management in order to prioritise the addressing of anomalies according to type (loss of integrity / vulnerabilities and the risks (safety fire volume of opposing trains, etc.) with a specific supervisor mandated to manage it. The sectorisation is subject to periodic visual inspections.

A-I-3.3.3.2. Lessons learned from events, reviews fire safety related missions, etc.

In 2020, the IGSNR considered that the maintaining of sectorisation in operation (the fire doors in particular) was improving but still required vigilance.

A-I-3.3.3.3. Overview of actions and implementation status

Planned measures can improve the fire resistance of certain components (fire doors, fire sectorisation components, fire protection of electric cables, etc.) or reduce the scale or intensity of potential fires. These measures consist more specifically in replacing fire sectorisation components (fire doors for example) by components with greater fire resistance.

EDF has identified doors representing a safety risk that will be equipped with "door open" alarms aiming to ensure they are kept closed.

Lastly, passive sectorisation equipment will be identified as high risk for safety and their in-service requirements will be tightened.

A-I-3.3.4. Regulator's assessment of the passive fire protection

A-I-3.3.4.1. Overview of strengths and weaknesses in the passive fire protection

Regarding the strong points in terms of passive fire protection listed by the licensee, ASN also views positively the presence of a sectorisation officer on each NPP, and includes in these strong points the analyses of the sectorisation resistance carried out in the *RP4 900* (PEPSSI, effects of smoke pressure) and the identification of major risk sectorisation components (such as doors to be kept closed under all circumstances).

A-I-3.3.4.2. Lessons learned from inspection and assessment on the passive fire protection as part of its regulatory oversight

Fire sectorisation is the main level of defence against fire on which EDF bases its actions. The inspectors are therefore particularly vigilant to this subject during inspections.

During the last fire inspections at the Tricastin NPP, sectorisation management, particularly in the "major fire risk" fire sectors, was viewed positively on the whole.

During *RP4 900*, and at the request of ASN, notable improvements were made in the fire risks management case, in particular by performing sectorisation verification studies, based on the fire resistance characteristics of the sectorisation components and the movable fire load present in the rooms. These studies were supplemented by the verification of the effects of smoke pressure on the sectorisation components to ensure that they retain their effectiveness. In addition, the new methods used allowed the identification of sectorisation aspects for which correct working is particularly important. For example, the fire doors which must be kept closed have been identified and will be subject to specific monitoring.

It is to be noted however that the monitoring of sectorisation is a weak point on some sites in terms of detection of incidental losses of integrity and generation of losses of integrity during worksites but which are not recorded, meaning that in the event of fire, the response teams are not informed of this potential source of propagation of the fire. Significant safety events (ESS) on NPPs have been reported regularly over the last few years due to undetected sectorisation anomalies, which have sometimes gone undetected for several years despite the inspections carried out in the interim.

A-II- 1300 MWe & N4 series passive fire protection concept and its implementation

At the N4 series design stage, the fire protection measures are functional at the DBE.

At the 1300 MWe design stage, the sectorisation is functional at the OBE.

On account of the lessons learned from Fukushima, EDF verified the robustness of the fire sectorisation (doors, fire dampers) and its resistance to the SSE revised without modification for the Tricastin site but with reinforcement work on certain NPPs of the CPY series.

On the N4 series, unavailability limiting fire zones have been created in rooms not containing safety-classified equipment with generalised fire risk, to limit plant unit unavailability (assets aspect) and facilitate the intervention of the fire-fighting teams.

The robustness of the sectorisation to the effects of pressure was demonstrated in the 2nd periodic safety review of the N4 series (*RP2 N4)* and the 3rd period review of the 1300 MWe series (*RP3 1300)*.

The robustness of the facility against the risk of re-ignition of combustion residues in the ventilation ducts relies primarily on the presence of fire dampers at the boundary of the safety fire zones. The fire dampers on the N4 series are directly interlocked with the fire detection system. Due to this, the rapid closure of the fire dampers in the event of fire renders the risk of re-ignition of unburnt gases in the ventilation ducts negligible.

EDF has upgraded the fire dampers of the N4 plant series due to problems of reliability and equipment obsolescence.

A-III- EPR passive fire protection concept and its implementation

Sectorisation

The safety fire volumes SFS / ZFS (see A-I-3.3.1.2) also exist on the EPR. The walls of these sectors however have 2-hour fire resistance rating. As a general rule, the fire resistance of physical separations is never less than 1 hour. The sectorisation of the buildings has been implemented so as to maximise the separation of redundant-classified equipment by creating safety fire volumes. Each of the divisions of the buildings containing classified equipment is included in a safety fire volume.

The fire volumes intended to allow safe evacuation of the personnel in the event of fire and access of the response teams are the Access Fire Sectors (SFA). The walls of these sectors have a 60-minute fire-resistance rating.

The Intervention Fire Sectors (SFI) and the Unavailability Fire Zones (ZFI) have been created when the installation conditions mean that the possibility of a generalised fire is plausible, to facilitate the intervention of the fire-fighting team and limit plant unit unavailability. The walls of these fire volumes have a fire resistance rating appropriate for the consequences of a fire in the volume, without being less than 60 minutes.

The Storage Zones (ZS) were created at the design stage to allow the licensee to store the materials and equipment necessary for operation with the plant unit in operation and in outage condition. If necessary, these zones are equipped with fire prevention, detection and fighting means.

Management of fire loads

One particularity of the Flamanville 3 EPR reactor is the reduction of the fire load of the room through a modification of the facility or the installation of fire-resistant protections (wrapping cable races with cable Wrapping for example). Fire barrier duct wrapping has been installed on most of the PFG cables for example (formed by cable raceway configurations) outside the SFI sectors.

In relation with the reduction in fire load, temporarily stored fire loads are managed in line with the EPRESSI method (see ISO 18195); a list of rooms with high safety risks and therefore unsuitable for use as storage rooms has been defined.

Monitoring smoke and ventilation

The management strategy for fire outbreaks is based on fire sectorisation which allows both control of the fire by suffocation (by cutting off the supply of oxidising agent) and limiting of the dissemination of hazardous or radioactive substances by static containment. This fire management strategy is particularly appropriate in rooms where the containment constraints associated with hazardous or radioactive substances are high.

The principles applied on the EPR are the same as those found on the reactor fleet in operation, that is to say that the ventilation systems are designed to respect the principles of fire sectorisation (volume / fire zone, physical / geographical separation) in order to contain and limit the development of a fire in the buildings.

In the event of fire, the fire sectorisation on the ventilation and smoke control systems leads to:

- automatic closure of the fire dampers by the JDT (Fire Detection System) in response to an alarm;
- placing of the SFAs in overpressure condition and opening of their smoke-removal hatches when signalled by the JDT.

In rooms that have a smoke monitoring system, the fans are switched on manually after the JDT alarm and verification of the room.

B- Research reactors RHF – BNI 67

B-3.3.1. Prevention of fire spreading (barriers)

The third level of defence in depth for fire risk management is based on the means of limiting fire propagation and the response and fire-fighting means. This paragraph describes the provisions aiming to avoid fire propagation by creating fire sectors or installing passive protections.

B-3.3.1.1. Design approach

The reactor building can be considered as being designed to mitigate the consequences of a fire (concrete containment with 2-hour fire stability, cable penetrations through the concrete containment provided with a fire-retardant complex giving them class EI60 fire resistance– once the containment is isolated, the direct leakage rate from the concrete containment is negligible in comparison with the volume of air in the reactor containment available for the fire and given the overpressure in the containment annulus (space between the concrete containment and the metal containment, with respect to the reactor building).

Some rooms of the ILL (Laue Langevin Institute) are protected by fire sectorisation, chosen according to the following criteria:

- either, should a fire break out in the room, to avoid contamination by a radioactive substance or propagation of the fire outside the room;
- or to preserve the availability or integrity of the equipment located inside the room should a fire outside the room be propagated into it;
- or to allow the installation of an automatic gas extinguishing system (AGES).

The radioactive sources storage room (ILL4-S26) is a fire sector (classified PIC).

The other rooms classified as fire sectors in the buildings housing PICs are as follows:

- the batteries room of the building ILL4 (avoid fire propagation to the exterior of the room);
- the central core rooms of building ILL4: converters room, inverter room, relay circuitry room, electronics room (avoid fire propagation from the exterior). These last four rooms are also equipped with an AGES to preserve equipment availability to the maximum possible extent should a fire break out within the room;

- the alpha laboratory situated at level C of the reactor building ILL5 (avoid contamination outside the room);
- the room for storing fresh fuel elements (avoid fire propagation from outside the room).

B-3.3.1.2. Description of fire compartments and/or cells design and key features

The central core rooms, the batteries room and the radioactive sources room are fire sectors classified REI 60 and therefore present, as a minimum, shells and slabs classified REI 60, beams and pillars classified R 60 for their fire resistance. Their openings are equipped with sectorisation components i.e. fire doors equipped with door closers and fire dampers with a minimum fire resistance EI 60.

The alpha laboratory and the fresh fuel element storage room of the reactor building ILL5 are fire sectors classified (R)EI 120.

B-3.3.1.3. Performance assurance through lifetime

The functioning of these sectorisation components (fire dampers and fire doors) is checked annually. The fire sectors housing AGES's also undergo periodic negative pressure tests ("Ventitest" infiltrometry tests).

Further to the creation of new passive protections of objects or electric cables in 2022 (see 2.2.5.1), procedures were created to periodically check integrity.

B-3.3.2. Ventilation systems

B-3.3.2.1. Ventilation system design: segregation and isolation provisions (as applicable)

Reactor building ILL5: there is no "sub-fire sector" inside the containment constituting the reactor building.

In the event of an uncontrolled fire outbreak in the reactor building, containment isolation is triggered (and nuclear ventilation is cut off) which enables the deterministic worst-case fire scenarios envisaged to include self-smothering of the fire before the building can suffer structural damage (see 2.2.4)

The only fire sector situated outside the reactor building which is connected to the gaseous effluent systems is the radioactive sources room S26 in building ILL4; this room is equipped with fire dampers which close automatically when the temperature in the room rises.

B-3.3.2.2. Performance and management requirements under fire conditions

There is no performance requirement concerning the ventilation system in the event of fire since it must be switched off if there is a developed fire in the reactor building. The operational instructions specify that, once the fire is under control, the nuclear ventilation and gaseous effluents (GE) are put back into service after consulting the FLS/SDIS teams and the Service Engineer, after checking the integrity of the equipment, and switching the GEs over to the reserve HEPA filters / Iodine absorber.

B-3.3.3. Licensee's experience of the implementation of the passive fire protection

B-3.3.3.1. Overview of strengths and weaknesses

The main advantage of the passive protection measures, apart from the protection of objects, is to avoid the propagation of a fire. Another advantage is their reliability and low maintenance needs, other than a regular check of their integrity. It is therefore a preferred approach that ILL considers during facility modifications when there is a question of reducing the level of fire risk.

For some experimental zones situated in the reactor building it is not feasible, for questions of available space, to fit out a zone or to protect a PIC with a passive protection system, such as a fire-resistant partition.

Conversely, the fire sectorisations undertaken during the post-stress test works are a strong point of the ILL (emergency command post (PCC), emergency control room, electrical distribution room, "hardened safety core" diesel generator sets room). The same goes for the horizontal cold source tank (containing gaseous Deuterium) which was successfully protected in 2022 by a flexible passive means of protection.

B-3.3.3.2. Lessons learned from events, reviews fire safety related missions, etc.

The retrofitting of passive protection systems in an old facility has proved to be a complex and long process. The installation of passive protections on numerous cable penetrations between building ILL4 and the reactor building ILL5 in 2022 provides a good illustration of the difficulties in carrying out this type of work (a "forest" of existing cables, cramped spaces, resistance to a pressure differential of 135 mbar).

Likewise, level C of the reactor where the experimental areas are situated is a very dense level grouping the instruments and their bunkers, the experimental booths and certain laboratories or units. The solutions of installing passive protections to prevent the propagation of a fire from one experimental area to the next are planned and implemented on a case-by-case basis when the experimental areas undergo modifications, always with the available space constraint.

B-3.3.3.3. Overview of actions and implementation status

A large amount of passive protection installation work was carried out in 2022, as part of commitments made during the last periodic safety review in 2017. The main results have been set out in §2.2.5.1.

B-3.3.4. Regulator's assessment of the passive fire protection

B-3.3.4.1. Overview of strengths and weaknesses in the passive fire protection

The configuration of the experimental halls does not allow effective fire sectorisation, therefore following the last periodic safety review ASN prescribed the setting up of an active fire control system in these areas.

B-3.3.4.2. Lessons learned from inspection and assessment on the passive fire protection as part of its regulatory oversight

The last periodic safety review identified certain weaknesses that could be addressed to improve passive protection against the fire risk. In its periodic safety review resolution, ASN prescribed measures to limit the development of a fire, particularly in the reactor building. This resulted for example in the installation of thermal protections on a number of structural components (beams and pillars).

C- Fuel cycle facilities

C-I- Fuel enrichment facility - George Besse II – BNI 168

C-I-3.3.1. Prevention of fire spreading (barriers)

C-I-3.3.1.1. Design approach

The measures aiming to prevent the propagation of a fire and mitigate its consequences are based on:

- the fire stability of the plant buildings: load-bearing or self-supporting elements and floors have a minimum fire resistance rating of 2 hours. Failing this, a specific demonstration is carried out (using a modelling calculation for example);
- installing walls and fire doors to partition the stairways and passageways and the vertical ducts passing through floors;
- sectorisation of the fire risk rooms by means of constructional elements with suitable fire resistance;
- building finishings designed to fire standards which comply with construction Eurocodes.

In the rooms classified as fire sectors, the fire-resistance rating of the walls, doors, hatches, sealing of openings and fire dampers is at least 2 hours (REI 120).

For rooms or groups of rooms called "sheltered rooms", the fire-resistance rating of the walls, doors and sealing of peripheral is 1 hour.

The peripheral openings featuring ventilation ducts are blocked using materials with the same fire resistance as the wall crossed.

The various buildings of BNI No. 168 are accessible to the emergency service appliances via roads that take into account the width and manoeuvring needs of these appliances. Aerial ladder road sections are dimensioned so that the vehicles can manoeuvre on the facility without difficulty. The various access points for the fire-fighting personnel are identified and kept clear.

C-I-3.3.1.2. Description of fire compartments and/or cells design and key features

In the rooms classified as fire sectors, the fire-resistance rating of the walls, doors, hatches, sealing of openings and fire dampers is EI 120.

For rooms or groups of rooms called "sheltered rooms", the fire-resistance rating of the walls, doors and sealing of peripheral is 60 minutes.

The peripheral openings featuring ventilation ducts are blocked using materials with the same fire resistance as the wall crossed.

The various buildings of BNI No. 168 are accessible to the emergency service appliances via roads that take into account the width and manoeuvring needs of these appliances. Aerial ladder road sections are dimensioned so that the vehicles can manoeuvre on the facility without difficulty. The various access points for the fire-fighting personnel are identified and kept clear.

C-I-3.3.1.3. Performance assurance through lifetime

The measures taken in operation to maintain sectorisation are based on periodic verifications of the functioning of the systems contributing to fire protection, particularly the fire dampers, the fire doors and the means of intervention. Furthermore, if an EI-rated opening has to be opened, its subsequent re-closure is verified.

C-I-3.3.2. Ventilation systems

C-I-3.3.2.1. Ventilation system design: segregation and isolation provisions (as applicable)

The ventilation is designed so that it does not propagate a fire. Consequently:

- ventilation transfers to or from fire sector rooms are prohibited;
- ventilation ducts are preferably routed outside fire sector rooms;
- the air handling units (AHU) recycling the air from several rooms and the extraction systems equipped with HEPA (High Efficiency Particulate Air) filters are stopped automatically in the event of automatic fire detection (AFD);
- in the fire sector rooms, fire dampers are installed on the ventilation blowing and extraction conduits;
- rooms of more than 300 m^2 containing no radioactive or toxic materials (living areas, passageways), blind rooms or basement rooms of more than 100 m^2 are equipped with natural or mechanical smoke removal systems.

C-I-3.3.2.2. Performance and management requirements under fire conditions

Nuclear ventilation contributes to the control of smoke and radioactive releases during the fire.

Consequently, ventilation management in the event of fire is based on monitoring the correct operation of the Last Filtration Level (DNF) by measuring the clogging of the HEPA filters of the DNF (differential pressure sensors in chemical trap boxes and HEPA filtration boxes of the DNF), with transmission of the indications to the control room).

By design, the HEPA filters of the DNF withstand 200°C for 2 hours. They are installed in sheltered rooms.

The fire dampers close automatically when a temperature threshold is reached or by interlocking with the AFD system.

The natural or mechanical smoke removal devices are interlocked with the AFD system in the rooms that do not contain radioactive or toxic materials.

C-I-3.3.3. Licensee's experience of the implementation of the passive fire protection

C-I-3.3.3.1. Overview of strengths and weaknesses

The robustness of the passive protection is based on:

- the dimensioning of the sectorisation components intended to contain the effects of a fire (fire sectors);
- ventilation management to limit the risk of dispersion of nuclear material in a fire situation.

No significant weaknesses in the passive design with respect to the fire risk have been revealed during plant operation.

C-I-3.3.3.2. Lessons learned from events, reviews fire safety related missions, etc.

There have been no particular events from which lessons could be learned for passive protection.

However, a commitment was made during the ongoing periodic safety reviews of the plants to check all the EI-fire-rated openings as presented in point C-I-3.4.

C-I-3.3.3.3. Overview of actions and implementation status

The actions carried out further to experience feedback are detailed in chapter C-I-3.4.

C-I-3.3.4. Regulator's assessment of the passive fire protection

C-I-3.3.4.1. Overview of strengths and weaknesses in the passive fire protection

Passive fire risk control measures were defined from the design stage for BNI No. 168. These measures include in particular:

- walls whose behaviour prevents any propagation of a fire;
- the use of components characterised by a certain degree of fire resistance;
- ventilation intended to avoid any propagation of fire but which nevertheless, by its robustness to thermal effects, prevents the dispersion of radioactive materials.

These measures mitigate the potential consequences in the event of fire, including the dispersion of radioactive substances.

It must be pointed out that passive fire risk control systems require particular attention and periodic verifications are carried out, particularly to check the sealing of fire doors.

C-I-3.3.4.2. Lessons learned from inspection and assessment on the passive fire protection as part of its regulatory oversight

No major deviations were detected during the inspections conducted in BNI No. 168 on the themes relating to the passive fire risk control devices. It was noted however that particular vigilance had to be maintained regarding keeping all fire doors closed: the fire doors are sometimes kept open to bring the comfort of air circulation. This shows a shortcoming in the personnel's safety culture.

C-II- Fuel fabrication facility _ Romans Sur Isère / CERCA – BNI 63-U

The measures to limit the aggravation and propagation of a fire and to manage ventilation are defined in accordance with the national regulations and the standards in effect. They also take into account the non-statutory baseline requirements in terms of good practices, such as the rules of APSAD (*Assemblée Plénière des Sociétés d'Assurances Dommages* – Plenary Assembly of Damage Insurance Companies). The provisions are set out in the safety report and broken down in the operating procedures and the procedures governing the creation or modification of facilities.

C-II-3.3.1. Prevention of fire spreading (barriers)

C-II-3.3.1.1. Design approach

The distance between the buildings accommodating nuclear materials and the structure of these buildings enable a fire-resistance rating of at least 2 hours to be achieved with respect to an external fire.

The structural load-bearing elements of the main buildings housing nuclear materials are stable to fire for at least 2 hours in order to guarantee evacuation of the personnel and the safety of the emergency response teams.

Fire sectors or fire zones are defined within the buildings and substantiated in the fire risks management case (DMRI). The creation of fire sectors is preferred.

As a general rule, the following rooms or group of rooms are arranged in separate fire sectors:

- rooms with high fire loads and presenting a high fire risk, such as electrical rooms. The aim is to prevent the propagation of a fire should one break out in these rooms;
- rooms containing large quantities of radioactive materials (storage areas, process rooms). The aim is to protect these materials from a fire that breaks out in a neighbouring zone;
- the rooms of the Last Filtration Level (DNF). The aim is to protect the DNF HEPA filters that contribute to the containment safety function if a fire breaks out in a neighbouring zone;
- the rooms in which significant quantities of radioactive materials in the form of readily inflammable powders (e.g. non-oxidised uranium-bearing powders). The aim is to both protect these materials from a fire in a neighbouring zone and to prevent the propagation of a fire that breaks out within these rooms;
- the protection important components protecting the interests against the effects of a fire and ensuring functional redundancy (e.g. the ventilation system extraction fans), in different fire sectors. If this requirement cannot be satisfied, these components can be separated by a firewall, or the components have sufficient protection to prevent a failure caused by a given fire.

The fire sectors are made up of physical fire walls (walls, floor, ceiling), openings (doors, hatches, etc.) and fire dampers. The penetrations (ventilation, fluids, cables) are sealed so as to restore the fire-resistance rating of the fire sector.

The pipes and ducts crossing the fire sectors (without opening out into them) are kept to the strict minimum. In this case, they are protected by a means of fire protection.

For buildings or rooms that do not meet these rules, special compensatory measures are taken, such as:

- verification of the low level of movable fire loads present in the rooms;
- protection of the load-bearing elements situated nearby or in the plume of the potential fires;
- the installation of an automatic extinguishing system over the zone or equipment representing a particular risk with respect to the stability of the building;
- the defining of fire zones associated with substantiations and complementary measures, such as defining zones where the storage of fire loads is prohibited.

Consumables or documents present in large quantities are stored in a fire-proof cabinet.

Outside working hours, inflammable liquids are stored in appropriate locked cabinets.

Given that the management of the existing fire loads and the nature of the conductors or electric cables can also be considered like passive protection measures, refer to paragraph C-II-3.1.1 for the provisions on this subject.

Certain corridors or stairways are designed as protected access / evacuation routings to guarantee evacuation of the personnel and access of the emergency teams with the equipment necessary to place and maintain the facility in a safe state in a fire situation. Protected evacuation routes are defined for all the buildings. The protected access routes are currently being defined and deployed on the site (see paragraph C-II-3.2.4.3).

In order to ensure the containment safety function in a fire situation, any room or group of rooms containing radioactive or hazardous materials that could be harmed in case of fire is taken into account in the DMRI to determine whether containment sectors need to be set up.

C-II-3.3.1.2. Description of fire compartments and/or cells design and key features

The fire sectors have a fire-resistance rating of 2 hours, classification EI 120 in accordance with the Order of 22 March 2004, or REI 120 if a fire stability requirement is applicable. For the civil engineering elements that do not meet the fire-resistance duration criterion, a study is carried out to assess their resistance by means of real fire scenarios. Reinforcement measures are taken if necessary.

Openings have a fire-resistance EI 120, that is to say at least equal to that of the fire sector they serve. The same goes for the fire dampers, the sealing of penetrations (ventilation, fluids, cables) and the complementary fire protections for the through-pipes and ducts and the load-bearing elements of the civil works.

The fire-resistance performance of the products, construction elements and structures can be determined by one or more of the following approaches:

- conventional test leading to a direct area of application;
- calculation method and dimensioning rule;
- reference to an approved manufacturing or construction process;

- approved laboratory assessment.

With rooms that are normally used with the doors open, detection of a fire in the room concerned or close to it triggers closing of the doors and any other openings by interlocking.

The interlocking logic of the fire dampers situated at the boundaries of the fire sectors is based on general principles, supplemented by particularities according to the nature of the room concerned (see C-II-3.3.1.1) and the equipment or processes used. The interlocks are analysed as part of the DMRI.

As a general rule, to limit the introduction of fresh air in the event of a fire, the blowing fire dampers are closed by interlocking when a fire is detected in the room or close to it. Closure of the extraction fire dampers is ensured, depending on the case, either by interlocking in the case of fire detection in the room or close to it, or by tripping a thermal fuse, or, in a very small number of cases, by operator action.

The following fire dampers can be re-opened, at least locally: the extraction fire dampers of the fire sectors containing radioactive materials, at the boundary of the fire sectors consisting of ventilation rooms (containing the DNF filters) and installed at the main extraction ducts, in order to be able to restore the dynamic containment.

The fire dampers can be controlled (closing and opening) at least locally, and from a fire cabinet (if necessary), for the ventilation control needs in case of fire (maintaining the dynamic containment, control of overpressure in the room).

The fire dampers are equipped with open and closed position end-of-travel switches. This information is transmitted so as to be accessible in a fire situation.

The fire dampers are equipped with a local manual control installed on the side of the fire sector to be protected or which presents the lowest fire risk (outside or inside the fire sector, depending on the DMRI analysis).

It should be noted that some fire sectors can also be made safe in other risk situations, such as the detection of an inflammable gas or reaching a temperature threshold.

C-II-3.3.1.3. Performance assurance through lifetime

The fire sectorisation components and the other passive measures for limiting aggravation and preventing the propagation of a fire (walls, floor, ceiling, openings, fire dampers, fire protections) are classified as protection important components (PICs). As such, they are subject to in-service monitoring requirements intended to maintain their performance over time, particularly through inspections and periodic tests.

More particularly, the civil engineering of buildings housing uranium-bearing materials is subject to a monitoring plan as well as an analysis of compliance with the related requirements during the 10-yearly periodic safety review.

C-II-3.3.2. Ventilation systems

C-II-3.3.2.1. Ventilation system design: segregation and isolation provisions (as applicable)

The ventilation system contributes to the containment of radioactive materials by ensuring the dynamic containment of the equipment and the rooms. It is made up of a blower network and one or more extraction networks, depending on the building. In the latter case, the "process" ventilation and the "building" ventilation networks of the rooms of the building are distinguished. In view of the difference in the potential level of contamination between process extraction (potentially higher risk) and room extraction (low risk), the process and building extraction networks are separated insofar as possible. When there is only one extraction network, the process ventilation is connected to the building ventilation.

Depending on the required level of containment for the equipment or the rooms, the process or building ventilation networks are equipped with HEPA filters constituting a First Filtration Level (PNF). Before discharge at the chimney, the networks are also equipped with HEPA filters which constitute the last filtration level (DNF). These filters comply with the technical specification CTHEN 93-030 (withstand 200°C for 2 hours with a head loss of 2000 Pa). The extraction fans are situated downstream of the DNF filters.

In order to control the operating range of the DNF filters in terms of temperature and pressure differential, they are monitored by a temperature probe situated in a duct upstream of the filters, and a pressure differential measurement between upstream and downstream of the filtration. The extraction network of some buildings is also equipped with a smoke detection system in the duct downstream of the fans.

As seen in paragraph C-II-3.3.1.1, the rooms housing the HEPA filters of the DNF are organised in fire sectors. Furthermore, the redundant extraction fans are installed in different fire sectors insofar as possible. If this requirement cannot be satisfied, these equipment items can be separated by means of a separating fire wall.

C-II-3.3.2.2. Performance and management requirements under fire conditions

In the event of a fire, the automatic protection actions aim to maintain dynamic containment in the building for as long as permitted by the development of the fire.

As seen in paragraph C-II-3.3.1.2, automatic protection systems are in place in case a fire outbreak or another risk situation that could lead to a fire is detected. These protection actions are local, that is to say they are geographically limited to the room or rooms concerned. Closure of the openings and fire dampers in the blowing direction limits the introduction of fresh air to the fire. Maintaining extraction helps to remove smoke and limit the rise in temperature and pressure in the room by extracting the smoke and hot gases. Lastly, maintaining the extraction in the building allows the recovery of the radioactive fumes which can escape by leakage from the seat of the fire room (notion of containment sector).

However, if the fire becomes too large, automatic or manual fall-back measures are planned for and can lead to partial or complete stoppage of the ventilation to preserve the integrity of the DNF filters. The aim in this case is to limit the discharge of radioactive fumes that have not been filtered by the ventilation system by relying on the static containment of the building during the fire management and extinguishing phase, then being able to restore the dynamic containment of the building as soon as possible after the fire.

Procedures for managing the ventilation (blowing and extraction) in a fire situation are provided for the buildings housing uranium-bearing materials. The procedures detail the means of monitoring the state of the fire dampers and the ventilation system, including monitoring the temperature upstream of the DNF filters and the pressure differential on these filters. They describe the manual actions to be carried out (remotely or locally), or the verifications of operation of the automatic systems, particularly those that cut off the ventilation if a high threshold is reached on the temperature upstream of the DNF filters or on the pressure differential.

The places for carrying out the manual actions or checking operation of the automatic safeguarding systems are accessed by protected routes currently being defined and deployed (see paragraph C-II-3.2.4.3).

C-II-3.3.3. Licensee's experience of the implementation of the passive fire protection

C-II-3.3.3.1. Overview of strengths and weaknesses

The site's currently identified strengths and weakness with regard to ventilation management and limiting the aggravation and propagation of a fire are listed below.

Strengths

- The site has shared and formalised design rules concerning fire sectorisation and ventilation.
- The large majority of the actionable safety devices (fire doors, other openings, fire dampers, etc.) are covered by automatic systems (by interlocking or by design).
- The fire sectorisation elements and the safeguarding measures are subject to periodic inspections and tests.

Weaknesses

- Although the design rules of the sectorisation and ventilation components are formalised, there is substantial variability between the site buildings housing uranium-bearing materials, notably for historical reasons. This weakness is overcome by procedures specific to each building, particularly regarding ventilation management in fire situations.
- To be in conformity with the Order of 20 March 2014, protected paths must be defined and deployed for the buildings housing uranium-bearing materials.

C-II-3.3.3.2. Lessons learned from events, reviews fire safety related missions, etc.

The events mentioned in paragraph C-II-3.1.3.2 have also been taken into account. With regard to the limitation of the aggravation and propagation of a fire and ventilation management, these events have led to the following action:

- For the event of 21 September 2022, the conformity of all the sectorisation components and of the safeguarding measures has been verified. It is planned in the medium term to deploy protected routes in the buildings housing uranium-bearing materials.

C-II-3.3.3.3. Overview of actions and implementation status

The main ongoing and planned actions regarding measures limiting the aggravation and propagation of a fire and ventilation management in view of the identified weaknesses and experience feedback are as follows:

Action in progress:

- Deploy protected routes in the buildings housing uranium-bearing materials.

C-II-3.3.4. Regulator's assessment of the passive fire protection

C-II-3.3.4.1. Overview of strengths and weaknesses in the passive fire protection

The dynamic containment of the rooms of BNI No. 63-U and the operational management of this containment in the event of fire have been worked on following a previous periodic safety review bringing a significant improvement. Complementing this, new walls preventing any fire propagation have been installed in the facility and the fire loads have been moved away as much as possible. Lastly, it is to be noted that the protected routes and their signalling in the buildings containing radioactive materials are currently being updated.

C-II-3.3.4.2. Lessons learned from inspection and assessment on the passive fire protection as part of its regulatory oversight

The inspections have revealed no major deviations in the passive risk control measures, but the measures have been improved following a previous periodic safety review.

C-III- Fuel reprocessing facility - UP3A – T2 - BNI 116

C-III-3.3.1. Prevention of fire spreading (barriers)

C-III-3.3.1.1. Design approach

The T2 unit has 2-hour fire stability due to the reinforced concrete design of the civil engineering. In this respect, the framework of these blocks is made up of vertical load-bearing elements (shells or pillars), horizontal elements (slabs and beams) and secondary elements (stairways, parapets, etc.) made from reinforced concrete. Only the BVE (Ventilation and Energy Building) has a metal framework above level -01.50 m. The T2 unit accommodates numerous rooms with reinforced concrete walls and floors. On account of this they present numerous isolating compartments and the functionalities of the rooms and their content. The openings in walls or floors for cables and pipes are blanked so as to ensure a fire resistance equivalent to that of the wall they cross. In addition to this partitioning by design, some rooms are isolated by fire sectors.

The fire sectors of the T2 unit are elementary volumes delimited by construction elements whose resistance has been chosen according to the type of fire considered and the time corresponding to the indicated fire-resistance rating. A fire sector prevents the propagation of a fire to another room and vice versa. The T2 unit fire sectors are volumes consisting of walls, doors and fire dampers with a 2-hour fire rating.

C-III-3.3.1.2. Description of fire compartments and/or cells design and key features

Some rooms in the T2 unit have specific passive fire protections:

- The electrical rooms of the T2 unit with a high fire risk are organised in fire sectors;
- The cells containing solvents have fire walls and are equipped with a valve for isolating air extraction in the event of fire. These motorised valves can equally well be controlled remotely from the control room, locally from a pneumatic control unit, or even manually directly from the valves. The cells containing solvents are also equipped with a blowing fire damper interlocked with the fire detection system and with a local manual control;
- The stairways of the T2 unit are enclosed with 2-hour fire resistance and equipped at each landing with doors with a 1-hour fire rating;
- The air locks are located between the corridors and the stairways. The allow personnel evacuation and intervention of the emergency services while keeping the stairway free of smoke. They are therefore equipped with 1-hour fire-proof doors;
- The stores and storage rooms are enclosed with 1 hour fire resistance and fitted with fire doors with a 1-hour fire rating.

The electrical equipment items serving to maintain the unit in a safe state are identified. These electrical equipment items:

- are redundant;
- are supplied by two electrical channels (channels A and B). The electrical production of each of these two channels is ensured by a dedicated generator set. These two generator sets are located in two separate rooms.

As a general rule, the channel A and channel B electric cables are routed through separate rooms. When two different channels supplying the same functions are obliged to follow the same path, they are separated by a 2-hour fire barrier placed between the two channels throughout the length of this path. The measures defined for routing the electric cables of channels A and B are designed to conserve functional redundancy of the channel A and B cables and thereby maintain the associated safety function in a fire situation.

C-III-3.3.1.3. Performance assurance through lifetime

In the course of operation, maintenance operations or interventions, the general prevention principles are based on the licensee's measures detailing the procedures for performing functional checks of the systems involved in fire protection, particularly the fire dampers, the fire doors and the means of intervention, and the reclosing of the fire sector openings.

The requirements applicable for the maintenance and periodic inspections of the fire protection equipment are detailed in manuals. The maintenance of passive fire protection equipment in the T2 unit is applied as follows:

- fire-resistant and/or flame-retardant doors, dampers and hatches, sectorisation valves and interlocking of air-conditioning units to the fire detection system:
  - periodic inspection every year: functional test,
  - preventive maintenance every year: servicing;
- actuating Detector (AD) for the fire and/or flame retardant doors:
  - periodic inspection every 6 months: functional test using a pole and local manual test.

C-III-3.3.2. Ventilation systems

C-III-3.3.2.1. Ventilation system design: segregation and isolation provisions (as applicable)

The ventilation systems are designed such that, in the event of a fire, they do not contribute to its propagation, while at the same time limiting:

- the dissemination of radioactive substances in the unit;
- environmental releases of radioactive substances.

The following principles are applied to limit environmental releases of radioactive substances:

- installation of last filtration barrier HEPA filters approved by the CTHEN 200°C – 2 hours;
- installation of measurements of clogging and temperature at the Last Filtration Level (DNF).

The following principles are applied to limit propagation from the fire sectors:

- installation of fire dampers on the ventilation networks serving the fire sectors (blowing, extraction);
- as a general rule, the ventilation ducts must not route through the fire sector (FS) rooms. If this requirement cannot be strictly followed, the ducts are protected by a means of protection affording a fire resistance rating equivalent to that of the walls passed through;
- ventilation transfers between two fire sectors are prohibited.

C-III-3.3.2.2. Performance and management requirements under fire conditions

Ventilation management in a fire situation is governed by a procedure. More specifically:

- The DNF filters undergo regular measurements of clogging and temperature;
- For the hot cells containing solvents, the actions on the ventilation system consist firstly in closing the fire damper to blowing and maintaining the isolation valve in the open position for extraction in the event of fire (valve not interlocked with the AFD system) with monitoring of the last filtration level. Closure of the valve of the cell concerned is envisaged in the event of excursion from the correct operating range of the ventilation network DNF. This enables the fire and its effects to be restricted to the cell and to achieve, insofar as possible, static containment. Furthermore, isolation is also carried out at the DNF to isolate the unit from the environment;
- For rooms classified as fire sectors (equipped with blowing and extraction fire dampers), their closure is planned in the event of excursion from the correct operating range of the ventilation network DNF in order to restrict the fire and its effects to the room and to achieve, insofar as

possible, static containment. Furthermore, isolation of the ventilation network can also be carried out at the DNF to isolate the unit from the environment.

C-III-3.3.3. Licensee's experience of the implementation of the passive fire protection

C-III-3.3.3.1. Overview of strengths and weaknesses

Strengths

The division of the unit into numerous rooms with reinforced concrete walls greatly limits the development and propagation of a fire.

Weakness

Not all the rooms are equipped with fire doors, therefore the periodic safety review methodology aims to confirm the adequacy of the measures.

C-III-3.3.3.2. Lessons learned from events, reviews fire safety related missions, etc.

The redundant electrical equipment items serving to maintain the unit in a safe state have been subject to the following measures:

- installation of a thermal shield between the redundant electrical equipment items;
- installation of fire protection around at least one of the two channels providing electrical power to these equipment items.

Furthermore, the unavailability or failure of a means of controlling the fire-related risks was analysed in the last periodic safety review.

This unavailability or failure must not call into question the maintaining of the T2 unit in a safe state. Thus:

- the installation of fire doors has been recommended;
- the installation of fire protections around the electrical power supplies of the redundant electrical equipment for maintaining the T2 unit in a safe state has been recommended.

C-III-3.3.3.3. Overview of actions and implementation status

Passive means of protection (fire doors, fire dampers, thermal shields, protection of the power supplies of redundant electrical equipment serving to maintain the unit in a safe state) have been installed further to the last safety review.

C-III-3.3.4. Regulator's assessment of the passive fire protection

C-III-3.3.4.1. Overview of strengths and weaknesses in the passive fire protection

Once again, the licensee has put in a substantial amount of work. Greater attention must however be paid to the site's fire sectorisation.

C-III-3.3.4.2. Lessons learned from inspection and assessment on the passive fire protection as part of its regulatory oversight

The last inspections conducted on the site reveal a satisfactory level of passive protection against the fire risk, although particular attention must nevertheless be paid to the fire doors, some of which were installed recently and already display numerous defects.

C-IV- Fuel fabrication facility - MELOX – BNI 151

C-IV-3.3.1. Prevention of fire spreading (barriers)

The measures for limiting the aggravation and propagation of a fire aim to control the risks of propagating the fire and disseminating material from a room on fire.

C-IV-3.3.1.1. Design approach

By design, the concrete walls of the building rooms have a fire rating of at least EI 120. Furthermore, sectorisation against fire risks is put in place within the buildings to prevent a fire within a room from propagating to the exterior and vice versa (barrier).

The sectorisation takes into consideration the fire risks in the rooms and, if applicable, the risks linked to the presence of nuclear materials.

It is made up of Fire Sector rooms, Protected Sectors and Containment Sectors, whose characteristics are specified below.

C-IV-3.3.1.2. Description of fire compartments and/or cells design and key features

The sectorisation is based on partitions, walls and floors and the components blanking the openings (doors and valves, sealing of penetrations) with a fire rating of EI 120.

Fire sector

The rooms containing a fire load density of more than 400 MJ/m^2 are classified as fire sectors. They have the following characteristics.

A fire sector can be a group of rooms when the propagation of a fire inside the sector does not aggravate the consequences with respect to safety.

These rooms are equipped with fire detection systems and may have a fixed extinguishing system.

Their walls are rated EI 120 by design and the openings in the walls to allow the entry/exit of voluminous items of equipment are blanked by removable panels guaranteeing an overall fire rating of EI 120.

The pipe penetrations guarantee the reconstitution of the EI 120 rating of the penetrated wall.

Small-diameter pipes (ND < 50) do not require any particular protection. Small-diameter pipes of 50 < ND < 150 are protected outside and inside the fire sector by an EI 120 material over a length of about 2 metres, including EI material in the thickness of the EI wall. No pipe of diameter exceeding ND 150 is inventoried at MELOX (such a diameter would require having an EI isolation component interlocked with the AFD system).

Insofar as possible, fluid pipes do not pass through the fire sectors and containment sectors. If such transits cannot be avoided, the pipes are protected over the entire length by a material rated EI 120, whatever their diameter.

The systems for sealing the various penetrations (pipes, electric cables) are compatible with the EI rating of the walls.

The fire sector access doors and hatches are rated EI 120. The doors are equipped with a door closer.

Beside the fire sector wall penetrations, the ventilation ducts are equipped with valves rated EI 120.

When EI valves cannot be mounted in the fire sector wall, the duct section separating the wall from the fire sector is shorter in length and fitted with a protection rated EI 120.

If ventilation ducts pass through the fire sector rooms without serving them, these ducts are protected by a covering ensuring EI protection equivalent to that of the walls of the room crossed.

Some equipment items are interlocked with the AFD system to restore sectorisation: the EI valves of the rooms (except the rooms containing glove boxes ventilated with nitrogen) and the process hatches and doors.

When a transfer of nuclear material is in progress, the door or hatch closure order is not given until the transfer is completed.

Protected sectors

The layout of the protected sectors (PS) is designed to prevent a fire that develops in the vicinity of a room from being propagated to the interior of that room. A protected sector can group several rooms whose functionalities are complementary and inseparable.

The protected sectors concern the places:

- which must remain accessible for personnel evacuation and/or fire fighting (stairways, corridors, etc.);
- where there is a risk of vertical propagation of the fire (lift, goods elevator);
- containing nuclear materials or inflammable products in significant quantities under an incombustible covering;
- containing operational control equipment.

These rooms are equipped with fire detection systems, their walls by design are at least rated EI 120.

The openings in the walls to allow the entry/exit of voluminous items of equipment are blanked by removable panels with a fire rating of EI 120. The materials for blanking off the various penetrations are compatible with the EI rating of the walls.

The fire sector access doors and hatches are rated EI 60. The doors are equipped with a door closer.

Containment sector

The containment sectors serve to contain any nuclear materials that could come from the fire sectors if fire breaks out in them. A containment sector can include several fire sector-classified rooms, protected or non-classified sectors.

The containment sectors are situated as close as possible to the fire sectors they encompass.

The containment sectors are characterised by air locks for the personnel and equipment, ventilated by different ventilation ducts from those of the fire sector rooms. The arrangement enables ventilation to be maintained in the air lock in the event of fire and therefore to ensure negative pressure with respect to the adjacent rooms. These air locks are equipped on the fire sector side with an EI 120 door and on the external side with a minimum-leakage metal door.

Operating rules

The modifications concerning the fire sectors (FS) and containment sectors (SC) (e.g. creation of an opening) are covered by procedures or instructions.

The openings and penetrations (cable chases, pipes, ventilation ducts) that may exist in these walls are addressed in accordance with the rules of good practice using qualified processes to restore the EI rating of the penetrated wall.

The integrity of the fire and containment sectors is maintained and verified periodically.

C-IV-3.3.1.3. Performance assurance through lifetime

The changes in fire load density (FLD) during worksite work or facility modifications are covered by a procedure for managing their consequences (FEM-DAM) in order to ensure compliance with the authorised FLD values and if this is not possible, to define compensatory measures.

Operational patrol rounds are carried out check there is no drift regarding the accumulation of combustible materials in the rooms. These weekly patrol rounds are carried out by the operating teams of the production units to check the conformity of the rooms regarding the various safety and security aspects, which includes the interim storage of combustible materials. Regular security inspection visits are conducted to check the tidiness and cleanliness of the sites. The value of the fire load present in target rooms is checked during the periodic safety reviews.

The sectorisation components (fire dampers, fire doors, etc.) undergo periodic inspections and verifications.

C-IV-3.3.2. Ventilation systems

The management of ventilation in a fire situation aims to help to:

- control the dispersion of nuclear materials by ensuring for as long as possible the dynamic containment achieved by high negative pressure (HNP) extraction, maintaining negative pressure cascades between the rooms of containment enclosures and preserving the effectiveness of the last filtration levels (DNF);

- control of the fire by limiting the introduction of air, by protecting the extraction networks from the fire and by allowing removal of the heat and effluents from the fire.

C-IV-3.3.2.1. Ventilation system design: segregation and isolation provisions (as applicable)

By design, fire dampers are installed on the ventilation ducts (enclosures or rooms classified as fire sectors) as near as possible to the walls of the volume that these fire dampers isolate.

They are installed systematically on the ventilation ducts at the air blowing and extraction points at the boundary of each fire sector room, on the ventilation networks of the containment enclosures and on the very high negative pressure (VHNP) extraction network of the enclosures at the boundary of a fire sector room.

The dampers are rated EI 120 in order to restore the EI rating of the rooms crossed and not foster propagation of the fire. Their rest position is identical to the safety position (Normally Open). The can be manoeuvred up to 400°C.

When there is a contamination risk, the fire dampers are of the sealed casing type (VRACO). The control mode of the fire dampers depends on the importance of the ventilation networks concerned being available:

- they are remotely controlled (can also be manoeuvred manually and locally using compressed air cylinders):
    - for extraction in the glove box rooms to avoid reversing the negative pressure cascades,
    - for blowing in the glove box rooms ventilated with nitrogen, helium or argon in order to avoid reversal of the negative pressure cascade between these rooms and the interior of the glove boxes,
    - for blowing of the glove box nitrogen and helium systems;
- they are manoeuvred automatically for blowing of the rooms with no containment enclosure or rooms containing only glove boxes ventilated by transfer from the room.

In the other cases the fire damper is of the ALDES "standard intumescent seal" type. These dampers are placed on the ambient air blowing and extraction networks at the boundary of the fire sectors containing no nuclear material. They can be manoeuvred and reset locally but they can be closed remotely. They close automatically if the temperature of the networks exceeds 70°C.

The fire dampers are equipped with a local control system which reports the damper position in a room situated outside the fire sector. The local manoeuvring of the VRACO fire dampers is carried out using compressed air cylinders.

C-IV-3.3.2.2. Performance and management requirements under fire conditions

Control of ventilation in a fire situation is governed by the Response Operational Supervisor (RI) with the assistance of the utilities operating service in order to facilitate the fire-fighting intervention while maintaining containment of the radioactive materials in the facility.

For rooms classified as Fire Sector and containing containment enclosures, the following principles are applied.

In the event of confirmed rupture of the 1st containment barrier:

- closure of the VHNP extraction fire damper for the glove boxes (GBs) ventilated with air;
- closure of the blowing fire dampers at the extraction of the GBs (for the GBs ventilated with nitrogen);
- closure of the room's blower fire damper;
- local opening of the bypass of the 1st barrier filter when an HNP extraction temperature exceeding 100°C is reached or a ΔP at the first filtration level (PNF) of the HNP network exceeding 500 Pa;
- switching of the discharge valve to high extraction of the room when it is decided to start the gas discharge sequence(s) with the fixed extinguishing system;
- closure of the HNP extraction fire damper when the following is/are reached:
    - a temperature exceeding 350°C at the HNP extraction,
    - or ΔP at the last filtration barrier of the HNP network exceeding 1000 Pa,
    - or a temperature exceeding 100°C at the last filtration barrier of the HNP network,
    - or a significant reduction (more than 15%) in the flow rate at the chimney;

For the Fire Sector-classified rooms with no risk of nuclear material dispersion:

- closure of the blowing fire damper and the extraction fire damper of the room is interlocked with the AFD system;
- these dampers are equipped with a fuse causing their closure if a high temperature threshold (70°C) is reached.

C-IV-3.3.3. Licensee’s experience of the implementation of the passive fire protection

C-IV-3.3.3.1. Overview of strengths and weaknesses

Strong points

The robustness of the passive protection is based on:

- the dimensioning of the sectorisation components intended to contain the effects of a fire (fire sectors, protected sectors and containment sectors);
- ventilation management to limit the risk of dispersion of nuclear material in a fire situation.

Areas of improvement

Certain partitions separating a production room and a passageway constitute a single wall situated both at the boundary of a fire sector and at the boundary of a containment sector. They have a fire resistance rating and a sealing requirement. One of these partitions must be reinforced to prove the sealing (against nuclear materials) despite the temperature and pressure effects created by a fire.

C-IV-3.3.3.2. Lessons learned from events, reviews fire safety related missions, etc.

The lessons learned are set out in detail in chapter C-IV-3.4. It concerns an event relating to the untimely activation of an extinguishing gas discharge interlock.

C-IV-3.3.3.3. Overview of actions and implementation status

The actions carried out further to experience feedback are detailed in chapter C-IV-3.4.

C-IV-3.3.4. Regulator's assessment of the passive fire protection

C-IV-3.3.4.1. Overview of strengths and weaknesses in the passive fire protection

The passive fire-fighting systems of BNI No. 151 comprise:

- walls preventing any risk of propagation of a fire;
- main components of elements characterised by a certain degree of fire resistance;
- ventilation networks ensuring dynamic containment of the rooms.

These systems mitigate the potential consequences in the event of fire, including the dispersion of radioactive substances.

It should be underlined that the passive fire risk control systems require particular attention and management of the ageing phenomena must be monitored.

C-IV-3.3.4.2. Lessons learned from inspection and assessment on the passive fire protection as part of its regulatory oversight

The last three inspections on the fire theme at BNI No. 151 did not call into question the passive fire risk control measures.

D- Dedicated spent fuel storage facility La Hague – SFP D - BNI 116

D-3.3.1. Prevention of fire spreading (barriers)

D-3.3.1.1. Design approach

The fire stability of the pool D building is REI 120, given its reinforced concrete civil engineering structure. The pool hall which is a metal structure is monitored by the automatic fire detection system.

The pool D building is separated from the T0 building by concrete walls and EI 120 doors. The 3 rooms of the pool D (pool hall and below the pool) are not electrical rooms, therefore they are not sectorised.

D-3.3.1.2. Description of fire compartments and/or cells design and key features

The electrical equipment items serving to maintain the pool D building in a safe state are identified. These electrical equipment items:

- are installed outside the pool D building;
- are redundant;
- are separated by thermal shields;

- are supplied by two electrical channels (channels A and B). The electrical production of each of these two channels is ensured by a dedicated generator set. These two generator sets are located in two separate rooms.

As a general rule, the channel A and channel B electric cables are routed through separate rooms. When two different channels supplying the same functions are obliged to follow the same path, they are separated by an EI 120 fire barrier placed between the two channels throughout the length of this path.

The measures defined for routing the electric cables of channels A and B are designed to conserve functional redundancy of the channel A and B cables and thereby maintain the associated safety function in a fire situation.

D-3.3.1.3. Performance assurance through lifetime

In the course of operation, maintenance operations or interventions, the general prevention principles are based on the licensee's measures detailing the procedures for performing functional checks of the systems involved in fire protection, particularly the fire doors interconnecting the buildings of the T0 unit and the D pool and the means of intervention.

The requirements applicable for the maintenance and periodic inspections of the fire protection equipment are detailed in manuals. The maintenance of passive fire protection equipment in the pool D building is applied as follows:

- doors:
    - periodic inspection every year: functional test;
    - preventive maintenance every year: servicing.

D-3.3.2. Ventilation systems

D-3.3.2.1. Ventilation system design: segregation and isolation provisions (as applicable)

The ventilation systems are designed such that, in the event of a fire, they do not contribute to its propagation, while at the same time limiting:

- The dissemination of radioactive substances in the unit;
- Environmental releases of radioactive substances.

The following principles are applied to limit environmental releases of radioactive substances:

- Installation of last filtration barrier HEPA filters approved by the CTHEN 200°C – 2 hours;
- Installation of clogging and temperature measurements at the Last Filtration Level (DNF).

D-3.3.2.2. Performance and management requirements under fire conditions

Ventilation management in a fire situation is governed by a procedure. The DNF filters in the T0 building, in particular, undergo regular clogging and temperature measurements in the event of fire.

D-3.3.3. Licensee's experience of the implementation of the passive fire protection

D-3.3.3.1. Overview of strengths and weaknesses

Strengths

The rooms necessary for operation (storing consumables or combustible waste) are situated in the T0 unit, which greatly limits the risks of the pool hall suffering fire damage.

Furthermore, the pool D building is equipped with EI 120 doors separating it from the adjacent to building.

Weaknesses

The building comprises just 3 rooms presenting a low fire load. Due to their design functionality, these rooms (pool hall and below pool) have large dimensions and cannot have any fire walls.

D-3.3.3.2. Lessons learned from events, reviews fire safety related missions, etc.

The redundant electrical equipment for maintaining the pool D building in a safe state, situated outside the pool D building, has nevertheless undergone the following improvements:

- installation of a thermal shield between the redundant electrical equipment items (cooling pumps);
- installation of fire protection around at least one of the two channels providing electrical power to these equipment items.

D-3.3.3.3. Overview of actions and implementation status

All the passive means of protection (fire doors, thermal shields, protection of the power supplies of redundant electrical equipment serving to maintain the unit in a safe state) recommended following the last safety review have been installed.

D-3.3.4. Regulator's assessment of the passive fire protection

D-3.3.4.1. Overview of strengths and weaknesses in the passive fire protection

The passive fire risk control systems are satisfactory. The licensee must nevertheless redouble its sectorisation efforts to achieve an adequate level of passive protection.

D-3.3.4.2. Lessons learned from inspection and assessment on the passive fire protection as part of its regulatory oversight

The reinforcement work aiming to avoid the propagation of a fire and mitigate the consequences has been carried out on the T0 unit – Pool D. However, shortcomings in fire sectorisation have been observed. These concern in particular shortcomings in signalling the presence of equipment.

E- On-site storage radioactive waste storage La Hague - Silo 130 - BNI 38

E-3.3.1. Prevention of fire spreading (barriers)

E-3.3.1.1. Design approach

The fire resistance of the Silo 130 unit is based on the traditional partitioning of the rooms:

- the superstructures are made from reinforced concrete with masonry infill;
- the partitions are made from reinforced concrete. The silo pits have been built with vibrated concrete to avoid air pockets;
- some technical rooms are built using conventional masonry techniques;
- the constructions and fitting out materials used in the waste retrieval and packaging (WRP) facilities are at least of fire reaction class A1, A2 s1 d0, otherwise B s1 d1.

E-3.3.1.2. Description of fire compartments and/or cells design and key features

Some rooms in the Silo 130 unit have specific passive fire protections:

- the electrical rooms of the Silo 130 unit that present a high fire risk are organised in fire sectors. The fire sectors of the Silo 130 unit are elementary volumes delimited by construction elements whose fire resistance has been chosen according to the type of fire considered and the time corresponding to the indicated fire-resistance rating. A fire sector prevents the propagation of a fire to another room and vice versa. The Silo 130 fire sectors are volumes consisting of walls, doors and fire dampers with a 2-hour fire rating.
- the two extraction fans of pit 43 are separated by a thermal shield to prevent the propagation of a fire from one to the other.

E-3.3.1.3. Performance assurance through lifetime

Procedures provide for the performance of periodic tests and verifications of the correct functioning of the systems involved in fire protection, particularly the fire dampers, fire doors and means of intervention, along with the re-closing of the fire sector openings.

E-3.3.2. Ventilation systems

E-3.3.2.1. Ventilation system design: segregation and isolation provisions (as applicable)

The ventilation systems are designed such that, in the event of a fire, they do not contribute to its propagation, while at the same time limiting:

- the dissemination of radioactive substances in the unit;
- environmental releases of radioactive substances.

The following principles are applied to limit environmental releases of radioactive substances:

- installation of last filtration barrier HEPA filters approved by the CTHEN 200°C – 2 hours;
- installation of measurements of clogging and temperature at the Last Filtration Level (DNF).

E-3.3.2.2. Performance and management requirements under fire conditions

Ventilation management in a fire situation is governed by a procedure. More specifically:

- The DNF filters undergo regular measurements of clogging and temperature;
- For rooms classified as fire sectors (equipped with blowing and extraction fire dampers), their closure is planned in order to restrict the fire and its effects to the room. Furthermore, isolation

of the ventilation network can also be carried out at the DNF to isolate the unit from the environment;

- activation of the argon gas automatic extinguishing system of pit 43 leads to:
  - an increase in the speed of the pit 43 air extraction fan to limit the disturbance of the negative pressure when the argon is released. During the argon gas extinguishing phase, the containment of pit 43 is ensured by regulating the negative pressure,
  - deceleration of the pit 43 extraction fan during manual stoppage of inerting to limit the negative pressure when argon is not being injected.

E-3.3.3. Licensee's experience of the implementation of the passive fire protection

E-3.3.3.1. Overview of strengths and weaknesses

The creation of a structure for the retrieval and packaging of the waste contained in pit 43 of the silo has enabled the fire protection measures to be substantially increased compared with the initial situation.

E-3.3.3.2. Lessons learned from events, reviews fire safety related missions, etc.

The measures adopted when creating the WRP structure led to the installation of passive fire protection in the rooms presenting a safety risk (DNF and electrical rooms).

E-3.3.3.3. Overview of actions and implementation status

All the equipment items described in paragraph E-3.3.1.2 are in place.

E-3.3.4. Regulator's assessment of the passive fire protection

E-3.3.4.1. Overview of strengths and weaknesses in the passive fire protection

The passive fire protection work necessary for the WRP operations is now completed, which is satisfactory and enabled retrieval of waste from silo 130 to begin in January 2020.

The licensee's choice in terms of passive fire-fighting systems is based essentially on conventional partitioning of the rooms with regard to sectorisation, the choice of materials presenting the lowest fire reaction classes and a ventilation system intended to prevent any propagation of fire.

ASN does not see any major strength or weakness concerning passive fire protection.

E-3.3.4.2. Lessons learned from inspection and assessment on the passive fire protection as part of its regulatory oversight

The inspections did not reveal any particular shortcomings relating to passive fire protection.

F- Installations under decommissioning

F-I- Research reactor OSIRIS – BNI 40

F-I-3.3.1. Prevention of fire spreading (barriers)

F-I-3.3.1.1. Design approach

One of the main constructional measures adopted at the design of the facility concerns the geographical and physical separation (delimited by reinforced concrete walls) between the nuclear zones and the specific fire risk zones (electrical rooms, nuclear ventilation rooms, etc.). In addition, during operation of the facility, the measures taken consist essentially in reconstituting the fire rating (REI) ensured by the civil engineering, by installing fire doors and fire walls. The main openings to allow the passage of cables and pipes are protected by fire-resistant systems designed to limit propagation.

Furthermore, the studies of the fire stability of the load-bearing structures of the buildings demonstrate that the majority of the structures (particularly those in the nuclear zones) have a conventional fire stability (ISO 834) of at least 90 minutes and stability in a real fire in certain conditions of ventilation management (early stopping of the nuclear ventilation in a fire situation).

F-I-3.3.1.2. Description of fire compartments and/or cells design and key features

BNI No. 40 has no fire sectors. Numerous fire protection improvements have been gradually introduced since BNI No. 40 was built, notably with the reinforcement of the fire partitioning of the electrical rooms (HV/LV, batteries, relaying), of the rooms housing the nuclear ventilation extraction systems, the filtration systems, the measuring instruments for monitoring releases and the operational control room of the OSIRIS reactor with the adjacent rooms (including the associated industrial ventilation). This reinforcement work is materialised by the installation of several fire dampers, and fire-resistant doors, hatches and walls and the installation of fire-proof products on sections of ducts and on electrical cable chases.

Furthermore, some zones housing conventional rooms (offices, corridors) have fire-resistant doors to limit the risk of a fire being propagated towards the abovementioned rooms.

For the nuclear zones, the main provisions in place to limit fire propagation are:

- fire dampers in the nuclear ventilation ducts;
- fire curtains placed at the moderator flaps penetrating the wall of the OSIRIS pile hall;
- fire curtains at the truck air lock of the hotshops.

Nevertheless, some penetrations from nuclear zones to the adjacent zones do not have a fire-resistance qualification. Some of these penetrations have intrinsic characteristics that limit the risk of propagation (for example the access air locks to the OSIRIS and ISIS pile halls). For those identified as being sensitive to the propagation risk, specific measures have been defined by the fire risk control study (fire load exclusion zones on either side of these penetrations). These measures are currently being deployed.

F-I-3.3.1.3. Performance assurance through lifetime

Periodic test campaigns and maintenance campaigns are carried out on the fire protection systems (fire doors, fire dampers, fire curtains) to check their operational availability. Any faults observed are corrected without delay (repair, replacement).

F-I-3.3.2. Ventilation systems

F-I-3.3.2.1. Ventilation system design: segregation and isolation provisions (as applicable)

The different nuclear and industrial ventilation systems have fire dampers which serve in particular to limit the propagation of a fire.

F-I-3.3.2.2. Performance and management requirements under fire conditions

Ventilation management in a fire situation is covered by specific instructions, whose implementation serves to ensure that the various objectives of containment management in a fire situation (dynamic and static containment or static containment only) are duly observed, that is to say:

- limit the dissemination of radioactive (or hazardous) substances in the facility and uncontrolled releases into the environment (emission into the natural environment which could take place outside the normal operating range);
- not contribute to propagation of the fire;
- limit the introduction of oxidising agent;
- limit the risk of creating an explosive atmosphere by limiting the introduction of oxidising agent.

These objectives involve a strategy of nuclear ventilation management in fire situations that is compatible with the resistance of the nuclear ventilation network components to the effects of a fire. This strategy must also be consistent with the organisation allowing switching to static containment if predetermined criteria are exceeded (accessibility of actuation devices, organisation (personnel numbers and procedures) and training of the facility personnel and the emergency services personnel).

Given the technical and human resources in place, the strategy adopted for BNI No. 40 in a fire situation is to stop the ventilation as soon as a fire outbreak is confirmed. This has the following advantages:

- simplicity of the operations to be carried out by the facility personnel, and all the more so since the Security Duty Watch (PMS – *Permanence pour Motif de Sécurité*) system was introduced after stopping the shift teams;
- limitation of the risk of propagation at certain ventilation networks which do not have fire dampers at certain wall penetrations;
- limitation of the introduction of oxidising agent;
- guarantee of the stability of the civil engineering structures.

The assessment of the radiological consequences justifies the appropriateness of this ventilation management strategy in a fire situation.

F-I-3.3.3. Licensee's experience of the implementation of the passive fire protection

F-I-3.3.3.1. Overview of strengths and weaknesses

The zones housing the electrical rooms and equipment associated with nuclear ventilation have numerous provisions for limiting the propagation of a fire, such as fire dampers and fire doors. The openings and penetrations are sealed with materials that are non-combustible and/or are fire-resistance rated.

By virtue of their design, the nuclear zones (OSIRIS and ISIS halls, hotshops) are not partitioned (example: intercommunication of the different levels of the OSIRIS reactor building by stairways and by the ventilation networks). Nevertheless, the risk analysis substantiates the adequacy of the measures adopted (examples: quantification of the effects of the fire, appropriate packaging of the waste, automatic fire detection systems, mobile extinguishers, dry wall penetrations facilitating the intervention of the emergency services, etc.) in order to greatly limit the risk of a fire developing and to ensure rapid detection and response.

F-I-3.3.3.2. Lessons learned from events, reviews fire safety related missions, etc.

Lessons learned from the main events concerning the means of limiting propagation

During the periodic test and maintenance campaigns, deviations have been observed in the functioning of certain fire dampers (e.g. excessive closing time) or fire hatches (slight damage due to an impact). These deviations were resolved each time without any particular difficulty.

Lessons learned from the ASN inspections on the fire theme (means of limiting fire propagation)

Before the years 2000, during the ASN inspections on the fire theme, several requests relating to the means of limiting propagation were formulated (reports on the fire-resistant devices, the need to add certain provisions such as fire dampers, sealing of openings, etc.).

Major works were carried out between 1995 and 2005 to take into account these demands and thereby improve the partitioning of certain zones (electrical rooms, rooms housing the nuclear ventilation, operational control room of the OSIRIS reactor and related rooms).

In 2016, an ASN inspection detected a few points in the fire partitioning of the electrical and technical rooms (ventilation) that required improving. The fire risk management study conducted for the last periodic safety review enabled some improvements to be defined, including those identified by ASN.

F-I-3.3.3.3. Overview of actions and implementation status

The fire risk management study carried out during the last periodic safety review led to recommendations concerning the means of limiting propagation, such as:

- the installation of complementary sealing means;
- the installation of fire dampers, fire doors and protective thermal shields;
- the installation of blanking covers or isolating hatches;
- the updating of some existing instructions (ventilation management in fire situation).

These measures are deployed in the context of a safety improvement action plan.

F-I-3.3.4. Regulator's assessment of the passive fire protection

F-I-3.3.4.1. Overview of strengths and weaknesses in the passive fire protection

The list of equipment contributing to the control of propagation of the fire risk (fire doors, smoke removal systems) is presented in the fire risk management study, but some of these equipment items are not subject to any periodic operating checks.

F-I-3.3.4.2. Lessons learned from inspection and assessment on the passive fire protection as part of its regulatory oversight

Deviations may be observed during inspections, such as doors blocked in the open positon and openings not properly closed again after works. These deviations are rapidly corrected.

F-II- UNGG Saint-Laurent des Eaux - BNI 46

F-II-3.3.1. Prevention of fire spreading (barriers)

F-II-3.3.1.1. Design approach

By design, the fire stability of the load-bearing parts of the structure of numerous safety-classified buildings (pillars, beams, floors, shells, etc.) is 2 hours. This stability is calculated for a fire occurring inside or outside the buildings, considering the possible interactions with a fire developing in a nearby structure.

The limiting of the aggravation and propagation of a fire is based primarily on point protective measures, such as the installation of thermal shields or observing a separation distance when the vulnerability of a target is confirmed. The appropriateness of the chosen protection is provided in the fire risk management case. Otherwise, it is necessary to put in place a fire volume. The sole aim of a fire volume is the protection of interests (population and environment) and of the equipment contributing to this protection. Personnel protection is ensured by setting up protected evacuation routes; the fire volumes can also contribute to their protection.

F-II-3.3.1.2. Description of fire compartments and/or cells design and key features

The fire resistance rating of the elements involved in defining the fire volume is determined with regard to the duration of the design-basis fire scenario of the fire risk management case. This fire-resistance rating must be compatible with the fire stability of the building in which it is located.

The Saint Laurent A buildings, apart from the electrical building, do not have a fire safety volume (it is noteworthy that even though it is no longer necessary for safety today, the sectorisation of this building, a legacy from the production phase, is conserved to ensure better control of the fire risk).

F-II-3.3.1.3. Performance assurance through lifetime

The elements involved in defining the fire volume are kept in good working order by following a periodic maintenance programme.

F-II-3.3.2. Ventilation systems

The elements involved in defining the fire volume are kept in good working order by following a periodic maintenance programme.

F-II-3.3.2.1. Ventilation system design: segregation and isolation provisions (as applicable)

The choice of static or dynamic containment or of smoke removal in rooms where there is a risk of release of radioactive or hazardous substances into the environment in the event of fire is substantiated by the assessment of the consequences of the fire with regard to releases.

When the licensee identifies situations for which it chooses static containment, this choice is substantiated in the fire risks management case. In this case, the risk management case takes into account the phenomena of increased pressure and temperature, the creation of explosive atmospheres and the possibility of opening the fire volumes, by the response teams in particular.

The assessment of the consequences of the dissemination of radioactive or hazardous substances in the event of fire can also authorise the installation and utilisation of a smoke removal system. If a smoke removal system is chosen:

- It limits the risks of propagating the fire and the effects of the convective thermal phenomena on the structures;
- It facilitates the intervention of the emergency services.

The smoke removal systems are dimensioned to remove the gases and smoke produced by the fire. Smoke removal can be activated automatically and/or manually depending on the technical baselines and/or the requirements for the safety of the personnel in the room in question.

Whatever the case, the protections to be installed on the ventilation systems mainly concern the means for preventing or limiting propagation of the fire and its effects via the ventilation network (primarily fire dampers).

All the nuclear buildings of the Saint Laurent site are equipped with mechanical ventilation to cover the needs of the decommissioning work site. Systems specific to the ventilation of the concrete containment structure are used permanently, independently of the decommissioning activities. Only the electrical building has a smoke removal system. Worksite ventilation systems are installed temporarily and connected to the building ventilation network.

F-II-3.3.2.2. Performance and management requirements under fire conditions

Control of the ventilation systems in the event of fire (essentially keeping in operation or stopping) is specific to each worksite and detailed in the corresponding work files, particularly for worksites with a high fire risk. These worksites form the subject of specific fire instructions.

As a general rule and in the event of fire in a ventilated nuclear room:

- air introductions are limited by closing the doors of the room and stopping air blowing if any;
- extraction of air in the room is stopped at the request of the Emergency Services Leader):
  - either by isolating only this room from the ventilation network (closure of the sealed valves at the boundary of the room),
  - or by stopping the general ventilation system (the most frequent cases). The valves and dampers at the periphery of the room are also closed to prevent the diffusion of smoke;

- if worksite ventilation systems have been installed in addition to the existing ventilation system, the latter is stopped.

F-II-3.3.3. Licensee's experience of the implementation of the passive fire protection

F-II-3.3.3.1. Overview of strengths and weaknesses

As indicated in paragraph II-2.6.6.1, the strength of EDF is that it can use first and foremost the experience feedback and lessons learned from its BNIs, as well as from other external sources, whether French or international.

The number of fire outbreaks on the Saint Laurent A site (none in 2021 and 2022) testifies to good management of the fire risk.

The single significant event on a nuclear site undergoing dismantling concerns a fire that occurred in 2015 on the Brennilis site; the event is described in paragraph II-2.6.6.1. The analysis of this event showed weaknesses in the prevention of fire outbreaks, which were addressed as described below.

This fire had no consequences on the interests to protect (population and environment) against toxic and radiological releases alike.

F-II-3.3.3.2. Lessons learned from events, reviews fire safety related missions, etc.

The fire at Brennilis remained limited to the air lock in which the fire broke out. A portion of the air lock walls melted in that zone. The waste packaging zone was not affected, neither were the walls and basemat of the reactor containment. The measures taken were sufficient to limit propagation of the fire.

The analysis of this fire revealed the good control of ventilation stoppage and of the static containment management of the fire. More specifically, this prevented the filters from being damaged.

F-II-3.3.3.3. Overview of actions and implementation status

The lessons learned from the Brennilis fire of 2015 led to prioritising instructions to stop the ventilation systems and air extraction rapidly in the event of fire detection on the EDF sites undergoing dismantling.

F-II-3.3.4. Regulator's assessment of the passive fire protection

F-II-3.3.4.1. Overview of strengths and weaknesses in the passive fire protection

The facility's passive devices for controlling the fire risk are satisfactory. Attention must continue to be focused on the equipment periodic maintenance plan. The changes in the facility due to its decommissioning necessitate vigilance with respect to the fire risk, particularly when setting up and putting into operation the containments associated with the worksites.

F-II-3.3.4.2. Lessons learned from inspection and assessment on the passive fire protection as part of its regulatory oversight

The last ASN assessments of the passive fire protection measures implemented on the facility are satisfactory, particular with regard to the periodic inspections of the dynamic containment equipment items and their in-service monitoring.

3.4. Licensee's experience of the implementation of the fire protection concept

A- Nuclear Power Plants

A-I- TRICASTIN 1 - 900 MWe series – post-4th periodic safety review

The reactors of the 900 MWe plant series have integrated protection against fire risks from the design stage. The implementation of the Fire Action Plan (1999-2006) has already led EDF to significantly reinforce fire prevention, detection and fighting on all the units, from the material and organisational aspects alike.

The re-evaluations during the successive periodic safety reviews, and notably the integration of experience feedback have led to subsequent improvements in the procedures for taking the fire risk into account.

Modifications were thus introduced during the 3rd periodic safety review of the 900 MWe series (*RP3 900*), particularly following the assessment studies of the design-basis margins of the protections of wiring against common modes and the fire resistance of the minimum operational control means (10 minutes of additional margin compared with the design basis as at the 2nd periodic safety review (*RP2 900*).

With the aim of improving the safety requirements for fire-related risks targeted by EDF, significant improvements in the integration of the effects of the fire in the deterministic studies and the introduction of WENRA reference levels (aggravating factor, operator delay) have made it possible to verify the robustness of the facility and identify, where applicable, the modifications necessary to meet the safety requirements associated with protection against the fire risk. More specifically, to guarantee the robustness of the sectorisation components of the safety fire volumes, EDF takes measures to protect cables, replaces or adds fire doors, reinforces the fire resistance of the "passive protection" sectorisation components, operating measures aiming to reduce the fire load in certain rooms presenting risks for safety, etc.

The robustness of the facility against the risks of re-ignition of combustion residues in the ventilation ducts has also been demonstrated, without introducing modifications to the facility.

In application of the procedure for the specific case of static equipment failure, EDF has identified the fire doors that are very important for safety and are not interlocked with the fire detection system. For these doors, EDF is installing "door open" alarms with the aim of ensuring they are kept closed. These equipment items will all be covered in operation by assigning them a maximum level of importance, that is to say like sectorisation components situated between opposing trains.

Lastly, further to the lessons from the Fukushima accident, EDF has demonstrated the robustness of the fire protection measures to the SSE (Safe Shutdown Earthquake) revised further to the studies and the deployment of the associated modifications.

A-II- 1300 MWe & N4 series

The robustness of the facility against the risk of re-ignition of combustion residues in the ventilation ducts has also been demonstrated, without introducing modifications to the facility.

On the N4 plant series, the fire protection provisions are designed to withstand the DBE (Design Basis Earthquake).

The studies of the application of the methodology for taking into account the phenomenon of increased pressure induced by a fire concluded on the robustness of the sectorisation and consequently the absence of risk. Consequently, no modification in this area is necessary for the 2nd periodic safety review of the N4 series (*RP2 N4)*.

On completion of RP2 N4, the robustness of the N4 plant series with respect to fire has been confirmed.

The lessons learned from the Fukushima accident in terms of robustness of the fire protection measures shall be verified at the next periodic safety review, *RP4 1300*.

On the 1300 MWe plant series in 3rd ten-yearly outage (VD3) state, the studies on the passive protections required on account of the safety sectorisation show that these protections present a positive margin of at least 10 minutes with respect to the significant fire duration (chapter 2) of the room in which they are situated, with the exception of a fire-resistant box situated in the reactor building of some of the 1300 MWe series reactors. It is therefore planned to reinforce this structure to increase is fire resistance and meet the objective in terms of margins. The absence of risk linked to the effects of pressure in the event of fire on the 1300 MWe reactors has been demonstrated.

A-III- EPR

No particular lessons have been learned from the implementation of the fire protection measures so far.

B- Research reactor RHF – BNI 67

The concept of applying the four levels of defence in depth when taking fire protection into account is well established at the ILL. The fire safety analyses have been carried out considering the vulnerability of the protection-important components (PICs) according to their degree of importance as well as by studying deterministic scenarios. The safety functions comprising control of responsiveness, control of cooling and control of containment would not be compromised in the event of a fire, even generalised, and the safety objectives would be preserved.

With regard to prevention of the fire risk, the deployment of prevention measures is also a principle that is well integrated in the facility modification processes, whether in the reactor building or in the related buildings which accommodate the experimental areas. Limitation of the fire load and management of inflammable products or cylinders of inflammable gases on the experimental areas are documented practices that are well integrated by the BNI personnel.

The method of quantifying the fire risk in the rooms subject to the Fire Risk Study thus allows a prior assessment of the impact of any modification and to plan ahead for possible measures to reduce the level of risk that might be induced by the planned modification.

Likewise, intervention procedures involving hot work always include a fire risk analysis from the moment PICs are present in or near the worksite zone, so that adequate preventive measures can be taken.

The fire detection systems remain an essential strong point, particularly in the sensitive rooms of the ILL, which are widespread, and their installation has continued to extend in view of the positive feedback observed in the early detection of fire outbreaks or even simple onsets of combustion.

To prevent the propagation of a fire, gas extinguishing systems, automatic or not, and sprinkler extinguishing systems have been reserved for specific rooms of the ILL with heavy fire loads and for which it is desirable to stop any spreading of a fire beyond the protected room. A new sprinkler system is in the design phase for level C (experimental) and should be operational in 2025 when the reactor is restarted after this long outage for works. Its end-purpose is to limit the propagation of a fire from one experimental area to another as well as to increase the fire-resistance margins of the structures.

Fire sectorisation was not envisaged in the original design of the RHF reactor. Only about ten fire sectors have been created in certain buildings over the years with the essential aim of preserving the availability of certain equipment items to the greatest possible extent by preventing propagation of a fire into a room from the exterior, or from inside the room to the exterior. These rooms are usually equipped with gas extinguishing systems.

It is not planned to go further with the sectorisation of rooms; on the other hand, the deployment of passive protections (to protect objects or to limit the propagation of a fire) is an approach that is applied insofar as it is technically and economically feasible when a modification to the facility provides an opportunity to reduce a fire risk level.

Lastly, the personnel receives regular training in the organisation of fire fighting. The members of the Local Initial Response Team (LIRT) are more specifically tasked with verifying fire situations, evacuating the personnel, ensuring the first response and accompanying and guiding the external emergency services. The ILL can effectively count on the proximity of the CEA's FLS (Local Safety and Security Force) and the Grenoble fire brigade, with which exercises are conducted regularly with joint debriefings to improve the coordination between the ILL's internal forces and the external forces.

C- Fuel Cycle Facilities

C-I- Fuel enrichment facility - George Besse II – BNI 168

The experience feedback over the 2009-2020 period was analysed. 2 significant events (ES) relating to control of the fire risk occurred on the enrichment plants:

- in 2014, the incorrect positioning of the hot air blowing system (HAB) at a cylinder opening needle valve caused thermal degradation of a cardan joint bellows, leading to the emission of smoke;
- in 2015, during the 1st annual inspection of the fire detection system, it was discovered that the fire interlock was disabled at the cooling unit power supply terminal strips by a shunt installed for the commissioning tests.

The corrective actions in response to these events were essentially:

- the replacement of all the needle valve motorisation cardan joint bellows by bellows in M2 materials;
- change in the cylinder connection/disconnection procedures, to include systematic verification of the correct positioning of the HAB;
- defining a method of attaching the HAB system and deployment of the solution on all the stations;
- reminder of compliance with the shunt installation procedure principle.

The low occurrence of significant events linked to the fire risk underlines the good design to the latest safety standards and the appropriateness of the measures implemented to control this risk.

The analysis of interesting events has also led to the identification of events relating to electrical equipment heating incidents. These events have led to the taking of thermographs and replacing or repairing the equipment concerned (batteries, cables, electrical cabinets, terminal blocks, etc.).

As part of the experience feedback from other enrichment companies, the reactive nature of the activated charcoal has been confirmed. Urenco has effectively observed events involving a rise in pressure followed by loss of containment on activated charcoal traps in its enrichment plants. This has been corroborated by temperature rises in the activated charcoal traps during operation in the plants. Consequently, the activated charcoal of the traps on the networks in which fluorine is removed (present in the top gas phase of supply cylinders) has been replaced by sodium fluoride (NaF).

In the plants, the fire openings are referenced. In addition, a display beside each of the openings provides a visual indication of its sectorisation function.

Moreover, the following maintenance improvements have been made:

- periodic verification of the fire-resistant doors to ensure that the peripheral plays remain within the acceptable range specified on their fire resistance report;
- repair of the intumescent seals of doors having a fire-resistance criterion;

- updating of the procedure for inspecting the condition of openings to integrate complementary verifications of the sealing materials and monitoring of their ageing with the identification of a control sample of openings.

C-II- Fuel fabrication facility Romans Sur Isère / CERCA – BNI 63-U

The strengths and weaknesses presented in this paragraph are a summary of the elements stemming from paragraphs C-II-3.1.3, C-II-3.2.4 and C-II-3.3.3. The associated actions are listed in the said paragraphs.

Strengths

- The processes and means linked to control of the fire risks, whether in the design, production, operation or in-service monitoring phase, are robust and tried and tested. All the lines of defence to be defined are covered, namely the prevention of fire outbreaks, detection and rapid extinguishing of fire outbreaks, limitation of the aggravation and propagation of a fire, and management of the accident situations resulting from a fire;
- All the Framatome and outside contractor personnel receive general safety training ("safety induction") which must be successfully validated to obtain site access authorisation. Refresher training is provided annually for outside contractors and every three years for the site personnel;
- The independent safety organisation maintains an effective surveillance over the risks as a whole. More generally, the site deploys the appropriate resources to conduct all the necessary surveillance actions;
- The items of equipment involved in the control of the fire risks undergo periodic inspections and tests;
- The site is a partner of the inter-licensee working group on the fire theme. This group shares experience on topical subjects, such as singular events. It would however be beneficial for this group to meet up more often. Moreover, a community on the fire risks theme was recently created within Framatome;
- The site is equipped with a fire safety system (FSS), an automatic fire detection system and automatic safeguarding systems deployed in all the buildings, and centralised permanent monitoring by dedicated personnel;
- The site has human resources who undergo training and periodic refresher courses, including firemen and emergency response equipment. These human and material resources are available and maintained on the site at all times to intervene in a fire situation;
- A robust emergency organisation is in place, with the periodic organisation of exercises, some carried out jointly with the external emergency services and the other stakeholders (ASN, IRSN, the Prefecture of the Drôme département, municipal councils of the neighbouring municipalities). The interfaces with the external emergency services are taken into account.

Weaknesses

- The culture with respect to fire risks, especially their prevention, must be further developed at all hierarchical and activity levels;
- Actions are still required regarding the site's conformity with the Order of 20 March 2014, particularly in defining the maximum fire loads in the rooms, the deployment of fire load monitoring, the implementation of fire load exclusion zones and defining protected routes;
- There are difficulties in freeing up resources to acquire knowledge on the new or emerging risks associated with new battery technologies (lithium-ion, etc.), to establish robust and shared recommendations and to implement them;
- The site's fire standard must be updated with regard to the applicable regulations and good practices;
- The FDS currently in service, and its communication network, will soon be obsolete, which will create system maintenance problems (software, spare parts);
- The organisation of the site does not include the FSS coordination missions such as they are defined in standard NF S 61-931;
- Two buildings must undergo improvements in order to retain and recover fire extinguishing effluents. If water runs off to the exterior of the buildings, it is taken up by the stormwater drainage network and retained in stormwater tanks.

C-III- Fuel reprocessing facility - UP3A – T2 - BNI 116

Experience feedback on the Orano La Hague site is covered by a set process. Indeed, the subjects that could lead to experience feedback actions are identified from the following sources:

- daily monitoring based on the daily reports;
- notified internal or external events;
- deviations and malfunctions;
- monthly reports transmitted to ASN;
- the requests for experience feedback actions made by ASN or the Health Safety Environment Directorate (DHSE) of the Orano group.

The potential experience feedback subjects are covered by Experience Feedback Action Opening Sheets which are used to define:

- the events and/or requests behind the experience feedback action;
- the theme and scope of the action;
- the experience feedback action supervisor and the representatives in the sectors concerned, according to their area of expertise and their coordination means.

They are then circulated internally for information, as well as to entities external to the site. The sheets are presented for information at the meetings of the Experience Feedback Steering

Committee. External subjects stemming from letters from ASN or the Orano head office and identified as potential experience feedback subjects always give rise to the opening of a sheet.

After opening a sheet, a preliminary study is conducted to decide whether or not to follow up the subject with an experience feedback action. This study is carried out with the assistance of the representatives of the various entities concerned, who provide their expertise and collect the relevant information in their entity (licensee, modification expertise, maintenance, etc.).

On completion of the preliminary study:

- If the subject is not of a generic nature or of strong interest for improving safety or environmental protection, it will be classified "closed without further action", giving the reasons why. The sheet is then closed to justify and trace the non-follow-up of the subject by the experience feedback entity (subject addressed by another entity, non-generic subject, not significant in terms of safety, etc.);
- If the subject is of a generic nature and of strong interest for improving safety or environmental protection, it will undergo an experience feedback study. An experience feedback technical notice formalises the objectives, the chosen methodology and the planning of the study.

The results of the experience feedback study are recorded in an experience feedback technical notice and in an experience feedback sheet which is sent out to the entities concerned so that they can take its recommendations into account. The sheet corresponding to the experience feedback sheet is then closed.

The defining and tracking of the recommendation implementation procedures are the responsibility of the addressee sectors or the *ad hoc* steering committee. If the recommendations are not taken into account, arguments supporting this decision are drawn up by the sector concerned and made known to the experience feedback entity.

The progress of the actions is tracked at periodic meetings between the entities receiving the recommendations and the Safety Engineers in charge of experience feedback. It is also presented to the Site's experience feedback steering committee.

An experience feedback subject is considered closed once all the recommendations have been applied in all the entities concerned. The experience feedback technical notice is then revised to integrate any lessons learned from the application of the recommendations. The aim of this is to have one self-supporting document per experience feedback subject. The closed experience feedback sheet and the revised experience feedback technical notice are then issued.

Several fire-related events have formed the subject of operating experience feedback sheets from the last safety review of the BNI 116 units. None of these events concerned the T2 unit. What's more, none of the experience feedback sheets has led to a generic procedure that has been transposed to the T2 unit.

On the other hand, technical recommendations issued during the periodic safety reviews of the T2 unit are implemented under a dedicated project. This project is divided into two parts:

- a first part addressing active protection (fire detection);
- a second part addressing passive protection (fire doors, fire dampers, thermal shields, protection of the power supplies of redundant electrical equipment serving to maintain the unit in a safe state).

This project has led to the creation of a dedicated project owner for the deployment of these technical recommendations. These recommendations undergo detailed design studies before being passed on to installers. The installers are then responsible for:

- the production studies;
- procuring the active and passive protective system equipment;
- installing the equipment;
- updating the documentation.
- all these items of equipment are installed:
- with the T2 unit in service;
- under the Site's procedures associated with the operations or projects / modifications enabling the fitting out of the premises to be managed during the transient phases.

C-IV- Fuel fabrication facility - MELOX – BNI 151

The BNI's last periodic safety review in 2021 presents the assessment of internal events. The events relating to the control of fire risks represent about 5% of the internal events. Three main themes emerge with regard to the significant events:

- the emission of smoke in glove boxes (GB);
- the untimely activation of fire interlocks;
- automatic fire detection (AFD) system fire monitoring fault (absence of monitoring).

The emission of smoke from the suction system of the cutting tool situated in a maintenance GB was observed. The fire risk control provisions take into account the lessons learned from this event through the control of hot work, the risk of ignition in a GB in an atmosphere of air and the protection of the suction or ventilation equipment.

Several unintentional activations of automatic systems linked to fire risk control have been observed. These concerned:

- automatic closure of the valves of the argon / hydrogen mix distribution network in the production building (during a maintenance operation and when using analysis ovens in the laboratory);
- discharge of extinguishing gas in the false floor of the room housing a control console used in backup situations.

These unintentional activations have resulted in changes in the maintenance procedures and in the oven cooling system safety devices.

The disconnection of a fire detector cable in a glove box caused a detection fault (absence of detection). This fault was not detected in the main monitoring station due to the presence of a previous fault on the same line. The system could not take into account more than one fault. A technical change was made to the system to take this event into account.

External events are also reviewed during the periodic safety review to enrich the experience feedback. More specifically, several external events relating to the pyrophoric risk have been identified in plants working in the same sector of activity as the MELOX BNI. The risk control measures at MELOX have been verified.

Additional elements of proof had to be presented during the periodic safety review. The additional proof essentially concerned the verification of compliance of the Fire sectorisation and Containment elements with the fire resistance and sealing requirements, and the fire stability of the civil engineering structures of the laboratory rooms and various rooms containing nuclear material.

Complementary studies show the good behaviour of the fire sectorisation elements despite the increase in calorific potential.

In the BNI's operational organisation, activities important for safety are defined in the baseline requirements. Safety requirements are therefore associated with these activities. With regard to the activities that could have an impact on the control of the fire-related risks, the associated requirements concern in particular:

- the use of water or hydrogenated products (including in case of fire) in water-prohibited rooms is subject to the prior agreement of the nuclear criticality engineer and the head of the facility;
- the constant monitoring 24h/24 of the fire detection alarms;
- the maintaining and periodic verification of the integrity of the containment fire sectors;
- the defining and maintaining of the compatible fire load density for each room;
- limiting the dihydrogen content of the argon/hydrogen mix supplying the sintering furnaces to 9%;
- implementation of special measures to control the risks of pyrophoricity due to zircaloy chips;
- the authorisation for hot work in the air-atmosphere maintenance glove box;
- the periodic inspections and tests of the automatic fire safety systems, of the fire detection and extinguishing systems and of the integrity of the fire and containment sectors;
- the training of the personnel of the Secondary Response Team in the specific fire risks and the practical exercises to prepare for interventions;
- the regular conducting of safety exercises.

D- Dedicated spent fuel storage facility La Hague – SFP D (T0) – BNI 116

Experience feedback on the Orano La Hague site is covered by a set process. Indeed, the subjects that could lead to experience feedback actions are identified from the following sources:

- daily monitoring based on the daily reports;

- notified internal or external events;
- deviations and malfunctions;
- monthly reports transmitted to ASN;
- the requests for experience feedback actions made by ASN or the Health Safety Environment Directorate (DHSE) of the Orano group.

The potential experience feedback subjects are covered by Experience Feedback Action Opening Sheets which are used to define:

- the events and/or requests behind the experience feedback action;
- the theme and scope of the action;
- the experience feedback action supervisor and the representatives in the sectors concerned, according to their area of expertise and their coordination means.

After opening a sheet, a preliminary study is conducted to decide whether or not to follow up the subject with an experience feedback action. This study is carried out with the assistance of the representatives of the various entities concerned, who provide their expertise and collect the relevant information in their entity (licensee, modification expertise, maintenance, etc.).

The results of the experience feedback study are recorded in an experience feedback technical notice and in an experience feedback sheet which is sent out to the entities concerned so that they can take its recommendations into account. The sheet corresponding to the experience feedback sheet is then closed.

Several fire-related events have formed the subject of operating experience feedback sheets from the last safety review of the BNI No. 116 units. No event concerned the Pool D building; moreover, none of the experience feedback sheets has led to a generic procedure that has been transposed to the Pool D building.

On the other hand, technical recommendations issued during the periodic safety reviews of the Pool D building are implemented under a dedicated project. This project is divided into two parts:

- a first part addressing active protection (fire detection);
- a second part addressing passive protection (fire doors).

This project has led to the creation of a dedicated project owner for the deployment of these technical recommendations. These recommendations undergo detailed design studies before being passed on to installers. The installers are then responsible for:

- the production studies;
- procuring the active and passive protective protection system equipment;
- installing the equipment;
- updating the documentation.

E- On-site storage radioactive waste storage La Hague - Silo 130 - BNI 38

The following measures were taken further to the fire of 1981:

- stopping of the acceptance of magnesian waste;
- installation (in 1982) of a fire extinguishing network on the silo cover slab;
- installation of a system for recovering water from the silo;
- improvement in the silo containment.

The lessons learned from this fire were taken into account in the design studies of the Silo 130 unit WRP rooms:

- with the installation of fire detection systems specific to pit 43 and to the retrieval, quantification and filling units (see E-3.2.1.1);
- with the installation of fire extinguishing systems specific to pit 43 and to the retrieval, quantification and filling units (see E-3.2.2.2).

F- Installations under decommissioning

F-I- Research reactor OSIRIS – BNI 40

Overview of the strengths and weaknesses in the fire risk control measures

Since BNI No. 40 came into operation, a very small number of fire outbreaks have been recorded, and each time they have been brought under control without necessitating major fire-fighting means. This shows the appropriateness of the technical provisions and of the operational management of the fire risk prevention means.

The FSS of BNI No. 40 was renovated in 2016. The technology used allows rapid detection and intervention of the FLS.

In addition to the constructional measures of geographical and physical separation, measures for limiting the propagation of a fire (fire doors and fire dampers, sealing of penetrations) have been added in the electrical rooms and the rooms housing equipment involved in nuclear ventilation.

As part of the decommissioning preparation work, worksite air locks and radioactive waste temporary storage zones are set up, bringing changes in the fire risk (introduction of fire loads, ignition sources, dispersibility of the radioactive inventory, etc.). These changes were taken into account in the fire risks control study carried out for the first periodic safety review and the specified measures have been deployed. Some of these measures take the form of technical specifications corresponding to input data for the studies of future projects necessary for decommissioning.

Lessons learned from the main events concerning the fire risk control measures

The rare fire outbreaks have served to improve the procedures for operations representing a specific fire risk (NaK neutralisation in hot cell) and the management of electromechanical equipment ageing (selection of robust equipment appropriate for the conditions of use).

The event concerning the failure of the automatic fire detection system in the ISIS reactor hall, rated level 1 on the INES scale, led to improvements in the tracking of the periodic tests and maintenance work.

The systematic resolving of deviations observed during the periodic tests and preventive maintenance work (for example, slight impact damage on a fire hatch) bear witness to the effectiveness of the process for maintaining the systems limiting the risk of fire propagation in operational and safe condition.

Feedback from the ASN inspections on the fire theme

The main demands stemming from the ASN inspections on the fire theme concerned the need to improve:

- management of the fire loads (monitoring and traceability);
- the fire detection system (AFD coverage and procedures used for the periodic tests and associated reports;
- keeping up to date the response plans and the instructions to apply in a fire situation;
- proof that the fire hydrant capacities meet the extinguishing water needs (evaluated with a very large safety margin in the fire risk management study);
- the means of limiting fire propagation (addition of certain measures between 1995 and 2005).

The study of the control of the fire-related risks carried out in the last periodic safety review led to the defining of an improvements plan taking into account the change in the operation of the facility (decommissioning preparation phase, then decommissioning operations) and integrating ASN's requests (e.g. partitioning to be improved, further to an ASN inspection in 2016).

F-II- UNGG Saint-Laurent des Eaux - BNI 46

The facilities undergoing decommissioning such as the gas-cooled reactors (GCR) of Saint Laurent BNI No. 46 present very low risks for the environment and the neighbouring populations. This is because there is no more fissile material in these facilities and the majority of the radioactivity was removed with the nuclear fuel. The two safety functions that must be guaranteed are the containment of radiological material and protection of the public against ionising radiation.

The remaining radioactive source term is situated essentially inside the reactor pressure vessels and consists essentially of non-dispersible radioactive materials (activated waste in the form of inert materials, mainly metal structures and equipment, solid graphite bricks.

The main sources of risks of radioactive material dissemination come from the contamination and dust present on the activated waste of the reactor or in the systems that can be set in motion either during the decommissioning operations or accidentally. The analyses and methods are therefore adapted to these issues.

Operations excluded, there are few ignition sources and they present a low risk of ignition (electrical boxes, lighting). The electrical switchgear undergoes preventive maintenance defined in a maintenance programme.

During decommissioning operations, the main ignition source is associated with hot work operations (welding, mechanical cutting, thermal cutting, etc.). When these operations are carried out on contaminated equipment, a containment air lock must be installed, conventionally made from combustible material but nevertheless with a good fire reaction rating (class C s1 d0 per European standard NF EN 13501-1). Propagation to the combustible air lock is improbable but cannot be excluded. The deterministic approach of the safety case makes it obligatory to study these scenarios.

Control of the fire risk on BNI No. 46 is based on the following main factors:

- taking account of experience feedback from all the BNIs of EDF and other licensees, and internationally;
- the continuous improvement of safety which takes this experience feedback into account;
- intrinsic robustness, a legacy from the design of BNI 46;
- generic prevention measures;
- safety analyses which consider the fire scenarios deterministically without taking into account the generic prevention or fire-fighting measures and which identify the necessary mitigation measures to be put in place to guarantee that the safety objectives are met;
- fire-fighting means appropriate for the characteristics;
- a centralised organisation for the site, making for effective coordination;
- a periodic equipment maintenance plan;
- periodic exercises and training of the EDF and service provider teams.

The number of fire outbreaks on the Saint Laurent A site (none in 2021 and 2022) testifies to good management of the fire risk.

3.5. Regulator’s assessment of the fire protection concept and conclusions

A- Nuclear Power Plants

As far as the prevention of fire outbreaks is concerned, the management of combustible materials is improving thanks to the studies which have been and continue to be conducted on the fleet, although further progress must be made, particularly in the management of temporary storage of combustible materials. When the EPR enters service, it should have a higher level than that of the fleet because fire protection has been taken into account as of the design phase. As far as hot work permits are concerned, the process in itself is up and running, but weaknesses in its application (management of disabling permits, inappropriate risk analyses) mean that it is not one of EDF's strong points.

For the detection of and response to fire outbreaks, the renovation of the fleet fire detection systems over the last few years represents an improvement in safety. Although EDF has good command of the fire detection and alarm management process, ASN considered that the fire-fighting response had to be improved, therefore EDF is currently deploying a new fire-fighting strategy that will allow a faster response and better protection of the EDF response teams. On the other hand, there are questions concerning the condition of the fire-fighting means (water standpipes, fire water networks), as anomalies have been observed.

Lastly, EDF considers the fire sectorisation to be the most robust level of defence and main feature of the safety demonstration, and reinforcements are being made or are scheduled further to the verification studies carried out as part of the last periodic safety reviews of the fleet. Better operational management of the sectorisation anomalies would nevertheless bring greater reliability of this level of defence.

B- Research Reactors RHF – BNI 67

Of an older design, the RHF has undergone upgrades during the periodic safety reviews which have improved its capacities with respect to the fire risk. ASN notes that substantial work has been carried out to improve the fire stability of the reactor building, along with regular efforts to control the fire load introduced by the numerous experiments that take place in the building. The fire outbreaks have been rapidly brought under control thanks to the good organisation of the teams responsible for fire-fighting on the site. This point also comes out further to the exercises conducted during inspections.

C- Fuel Cycle Facilities

C-I- Fuel enrichment facility - George Besse II – BNI 168

The fire detection system is of recent design and meets the expected requirements.

The active fire-fighting means are appropriate for the needs of the facility.

Part of the effectiveness of the active fire-fighting systems is dependent on the personnel and their skills. This necessitates vigilance with regard to the personnel's preparation and training for events of this type.

Lastly, the system implemented concerning the passive fire control devices is robust from the sectorisation and ventilation aspects, both of which contribute to maintaining the radioactive material containment safety function.

It must nevertheless be pointed out that the passive systems are also partly based on a safety culture in the personnel, who must be made aware of the importance of maintaining the integrity of the fire sectors, notably by being attentive in daily work to keeping the fire doors closed and not placing obstructions to their closure when they are interlocked to a fire detection system.

C-II- Fuel fabrication facility Romans Sur Isère / CERCA – BNI 63-U

The fire risk control system put in place by the licensee is robust and has been tried and tested over a good number of years. The licensee has retained 4 events (in 8 years of operation) considered as being marking events.

There are still improvements to be made, particularly in the tracking and control of the maximum fire loads authorised in the rooms.

Organising training courses dedicated to the fire risk is essential for maintaining the responsiveness and skills when faced with a fire outbreak.

The creation of an emergency command post on the Framatome site with appropriate intervention equipment and trained personnel is a definite improvement in the licensee's response capability should a fire break out on the site. Regular exercises organised with the local authorities supplement the protection system.

Framatome has automated a large part of its fire safety systems.

Conformity work remains to be done in the setting up and signalling of protected routes for the rooms containing radioactive materials.

C-III- Fuel reprocessing facility - UP3A – T2 - BNI 116

The updating of the "fire safety baseline requirements" by the licensee has brought a number of improvements in the control of the fire risks. In its fire risks analysis, Orano now uses a deterministic approach to study the fire outbreaks that could affect some protection-important components (PICs).

The automatic fire detection systems enable the level required by the regulations to be achieved with a good degree of reliability. Improvements are expected in terms of the proximity fire-fighting means, particularly with regard to their appropriateness for the types of fire loads encountered in the facility. Additional water spray fire extinguishers must be planned for, to comply with regulations. ASN reserves its assessment concerning the readiness of the site's fire-fighting teams given that these teams are rarely available for the exercises initiated during inspections.

With regard to the control of sectorisation, work to replace fire doors is in progress on several of the La Hague site facilities, as weaknesses are still observed; ASN will be attentive to his point.

C-IV- Fuel fabrication facility - MELOX – BNI 151

The licensee has retained 3 events (over the 1999-2019) it considers to be marking events.

The fire risk control system put in place by the licensee has been in place for many years. The particularity of the Melox site is that there are many zones in which the nature of the substances handled limits the fire control capabilities (in particular due to the fact that water cannot be used to cool down or put out an incipient fire because of the criticality risk). This implies putting in place particularly stringent fire outbreak prevention measures. Control of ignition sources and of the fire load are therefore two prevention factors that are essential for controlling the fire risk.

The site has appropriate fire-fighting means and several response levels (local initial response teams and secondary response teams). These means are very rapidly backed up by reinforcements from the CEA Marcoule centre, which has specially trained fire-fighting teams. The organisation and tracking of training courses dedicated to the fire risk on this site is essential for maintaining the responsiveness and skills when faced with a fire outbreak.

The creation of a new emergency command post on the Melox site (in 2023) with appropriate intervention equipment and trained personnel is an asset for the licensee's response capability should a fire break out on the site. Regular exercises organised with the local authorities supplement the protection system.

The design of the buildings is relatively recent and integrates the notions of sectorisation and control of radioactive material containment. Efforts must still be made in the defining and control of protected routes which must be identified and meet the requirement to allow the required actions to be taken when the facility has to be placed and maintained in a safe state in the event of fire.

D- Dedicated spent fuel storage facility La Hague – SFP D (T0) - BNI 116

ASN notes the substantial amount of work carried out by the licensee to produce the fire risk studies for the facility as a whole. The work carried out since the last periodic safety review to bring the unit into conformity has also been noted positively. ASN nevertheless considers that the licensee must be more rigorous in fire risk prevention.

E- On-site storage radioactive waste storage La Hague - Silo 130 - BNI 38

In January 1981 Silo 130 was the site of a fire, the cause of which could not be identified. Before starting the waste retrieval and packaging (WRP) operations on silo 130, which involve considerable risks for safety, the licensee had to reinforce the fire prevention, detection and extinguishing means by taking into account, in the design of the new WRP unit, the age of the facility (commissioned in 1973) and the regulatory changes associated with control of fire risks on the one hand, and the lessons learned from this fire on the other. This new design associated with the management and monitoring of the fire load and ignition sources should make it possible to prevent fire outbreaks in the facility during the WRP and decommissioning operations. Retrieval of the waste from pit 43 did not start until January 2020.

The licensee has deployed active fire-fighting means with a system comprising different levels (detection according to the risks of the room, adequate fire-fighting equipment and organisation) as appropriate for the risks that this facility undergoing decommissioning represents. It is worthwhile pointing out that part of the effectiveness of the active fire-fighting systems is dependent on the personnel and their skills. This leads to increased vigilance with regard to the personnel training and the conducting of fire exercises.

Given the future of this facility undergoing decommissioning, the passive fire control systems implemented (such as sectorisation and ventilation) are satisfactory and proportionate to the risks of the WRP operations to be carried out in order to maintain the radioactive material safety containment function. It must nevertheless be underlined that the passive systems are also partly dependent on the safety culture of the personnel who must guarantee the maintaining of sectorisation and control of the fire loads.

F- Installations under decommissioning

F-I- Research reactor OSIRIS – BNI 40

ASN notes that the CEA team in place at BNI No. 40 has a sound knowledge of the fire subject. Having a good knowledge of the facility moreover makes it possible to identify the issues related to this risk and to assess the solutions to deploy. The fire risk study of BNI No. 40 sets out a diagnosis of the risk control and several actions have been started but are still to be finalised. As the feasibility study of sealing of the openings is now finished, the CEA must issue a new position statement on the work to be undertaken. ASN will remain attentive to the satisfactory accomplishment of this work within time frames compatible with the risks of the facility.

F-II- UNGG Saint-Laurent des Eaux - BNI 46

The fire prevention, detection and fighting measures implemented on BNI No. 46 by EDF are standard risk management provisions for the nuclear facilities, based on defence in depth in accordance with the regulations in effect.

Nevertheless, these measures must be adapted to the specific risks presented by the ongoing decommissioning worksites, other than the pressure vessels of the facility's two reactors, and the future risks during the decommissioning of the reactor pressure vessels, planned for 2050. For this work, EDF must take into account the presence of carboxide and hydrogenated carboxide deposits, which cause risks of fire, explosion and poisoning during thermal cutting operations.

ASN's last assessments of fire risk management at the facility showed that the licensee's periodic checks of the fire detection systems and associated alarms and of the fixed and mobile fire-fighting means were satisfactory. Improvements are nevertheless expected, more specifically in tracking the fire extinguisher inspections and lifting hot work permit hold points on worksites. Further to the last inspections performed by ASN, the site has implemented corrective measures to improve the management of the fire extinguishing waters (work on the retention systems), which is satisfactory.

ASN has nevertheless identified a number of deficiencies in risk management whose causes are mainly linked to the interfaces with operation of the two in-service reactors of the Saint-Laurent NPP, with which BNI No. 46 shares some of the fire risk management means. In 2022, unauthorised temporary storages of fire loads from maintenance work on the in-service reactors were thus observed on BNI No. 46. In addition, in 2020 deficiencies were identified in the transmission of fire alarms from BNI No. 46 to the NPP outside working hours.

3.6. Conclusions on the adequacy of the fire protection concept and its implementation

A- Nuclear Power Plants

The sectorisation verification analyses carried out in *RP4 900* and taken up in *RP4 1300* and *RP3 N4* have confirmed improvements in safety. They are based on methods put in place at the EPR design stage and which have been adapted for the existing facilities.

Generically, for the fleet as a whole, EDF is currently deploying a change in its fire response strategy requested by ASN (with the putting in place of appropriate personal protective equipment (PPE) for fire fighting). ASN wants the sites to have greater fire-fighting independence and be less reliant on the external emergency services, on which the EDF strategy is based at present.

It can also be underlined that a point requiring particular attention concerning the condition of the fire-fighting means has recently been raised and is being discussed by the licensee and ASN.

B- Research reactor RHF – BNI 67

The principle of defence in depth applied to the RHF with the implementation of successive barriers is in line with the regulations governing BNIs. ASN has a favourable opinion of the development of fire risk control.

C- Fuel Cycle Facilities

C-I- Fuel enrichment facility - George Besse II – BNI 168

ASN has noted the robustness of the Georges Besse II facility to the fire risk, as much in its design as in its fire-fighting organisation.

Its inspections have highlighted the importance of effective implementation of this organisation in the field, particularly when the human factor is essential for control of the fire risk. It is effectively necessary to keep all the response personnel suitably trained. Moreover, further to its inspection findings, ASN underlines the importance of disseminating a safety culture within the personnel, as much about the need to maintain sectorisation as the need to restrict the temporary storage of fire loads. These actions help to prevent the occurrence and propagation of a fire.

C-II- Fuel fabrication facility Romans Sur Isère / CERCA – BNI 63-U

ASN has noted the robustness to the fire risk of the Framatome facilities on the Romans-sur-Isère site, as much in its design as in its organisation to combat the fire risk.

Since 2021, ASN has carried out 4 inspections on BNI No. 63-U research activity and power activity, including one reactive inspection following the fire of 21 September 2022.

Further to an inspection in 2022, ASN considers that the management of the fire risk on the "research fuels activity" of BNI 63-U is satisfactory.

Following an inspection (2022) in the "power fuels activity" of BNI 63-U, ASN considers that the fire risk management measures are satisfactory, particularly with regard to organization, periodic inspections and tests and intervention.

These inspections have nevertheless shown that improvements can be made. Prevention measures have thus been requested including, among other things, the tracking and reduction of fire loads (transient loads included) and the setting up of protected routes.

With regard to the human factor, it is essential to keep all the response personnel suitably trained. Framatome organises regular training programmes to maintain the skills of its personnel.

C-III- Fuel reprocessing facility - UP3A – T2 - BNI 116

ASN considers that the fire risk control systems are satisfactory. ASN also underlines the substantial amount of work carried out since the last safety review on the La Hague site as a whole concerning the fire risk studies and bringing the fire risk control systems into conformity. The licensee must continue the efforts made to ensure the proper uptake of the actions to be implemented by the local response groups and be more rigorous in the management of hot work permits and fire loads, fire sectorisation and more generally the fire-fighting means specific to the work sites.

C-IV- Fuel fabrication facility - MELOX – BNI 151

Through its various inspections ASN has observed the robustness of the Melox facility to the fire risk, both in its design and in its organisation to fight the fire risk.

ASN carried out 3 inspections on the fire theme between 2019 and 2022, and no insurmountable problems were found. The results of these inspections were satisfactory, including in situational fire exercises.

The last inspection in 2022 enabled ASN to confirm that the fire risk control measures are satisfactory over the three levels of defence in depth: prevention, detection, extinguishing and the mitigation of consequences.

The licensee must nevertheless continue to focus attention on the management of fire loads (including on worksites) and on the protected routes.

D- Dedicated spent fuel storage facility La Hague – SFP D (T0) - BNI 116

ASN considers that the fire risk control systems are satisfactory. ASN also underlines the substantial amount of work carried out since the last safety review of the La Hague site concerning the fire risk studies and bringing the fire risk control systems into conformity. The licensee must nevertheless pay closer attention to the proper uptake of the actions to be implemented by the local response groups and to the management of hot work permits and fire loads, and more generally the fire-fighting means specific to the work sites.

E- On-site storage radioactive waste storage La Hague - Silo 130 - BNI 38

ASN has noted significant improvements in the silo 130 unit facility's response to the fire risk, as much in the design of the silo's new WRP equipment, in the performance of tests that exclude the possibility of ignition of waste during recovery linked to the reactivity of uranium hydride, as in the integration of the lessons learned from the fire of January 1981 and in the facility's fire-fighting organisation in extreme situations.

The inspections have moreover enabled ASN to track the implementation of these improvements and to underline the importance of holding fire exercises, of remaining rigorous in the issuing of hot work permits and the management of fire loads, in order to prevent the occurrence and propagation of a fire during the legacy waste retrieval operations in facilities undergoing decommissioning.

F- Installations under decommissioning

F-I- Research reactor OSIRIS – BNI 40

ASN considers that the fire prevention measures are generally satisfactory. ASN also underlines the work carried out since the last inspections relating to the fire risk. The licensee must nevertheless grant greater attention, particularly to the management of fire loads, to the training of the facility's personnel who have an operational role in the event of fire, and to the checks of the operability of the fire dampers and fire hatches.

F-II- UNGG Saint-Laurent des Eaux - BNI 46

The principle of defence in depth applied on BNI No. 46 for the two Saint-Laurent des Eaux GCRs undergoing decommissioning is in line with the regulations and the fire resolution. ASN has a favourable opinion of the development of fire risk control.

4. OVERALL ASSESSMENT AND GENERAL CONCLUSIONS

This conclusion is intended to be generic and reflect the ASN's overall viewpoint on the various aspects of the protection of the French nuclear facilities against the fire risk. On this account, the findings that are put forward for the chosen representative facilities may not all be applicable entirely and *in extenso* to all the French nuclear facilities, but must be interpreted as points requiring particular attention. The applicability of these findings to a given nuclear facility is assessed in the body of the report in the corresponding chapter.

4.1. Regulations

France has:

- general regulations relative to basic nuclear installations (BNIs) which take into account the fire risk;
- specific regulations relating to:
    - the content of the nuclear safety case, including control of the fire risks;
    - provisions concerning the control of the fire risks.

These regulations are based on texts of a general nature which are applicable to all the nuclear facilities, at all stages of their life cycle. They do not prescribe specific means, but objectives for the prevention, detection and rapid extinguishing of fire outbreaks, for mitigating the consequences of a fire and for placing and maintaining the facilities in a safe state. The licensee thus remains responsible for and free in its choices and the means implemented to control the fire risks in its facility. For this the licensee can use a number of industrial norms or standards acknowledged by the professionals, such as the French standards, rules established by bodies such as APSAD (*Assemblée Plénière des Sociétés d'Assurances Dommages* – Plenary Assembly of Damage Insurance Companies), or professional guides. The principle of proportionality to the risks is also applied.

ASN considers that the regulatory framework with respect to the fire risk is appropriate and in conformity with the principle of responsibility of the licensee. It does however note that vigilance is required in the use of the industrial standards when they need to be modified to adapt to the specific context of the nuclear domain.

4.2. Fire safety analysis

The particularity of certain facilities, the existence of specific risks or the obligation to comply with basic safety rules sometimes makes it necessary to adapt certain standards to make them applicable to the nuclear domain. For example, the need to guarantee the containment of nuclear material in a fire situation or to prevent the criticality risk can oblige waiving of practices such as smoke removal or the use of certain extinguishing means on fire outbreaks.

The regulatory framework which contributes to ensuring nuclear safety in France sometimes leads the licensee to define conservative rules through safety reports or general operating rules which are not always updated to match the changes in status of the facilities or the nature of the risks. This is the case in particular during decommissioning operations: the nature of the risks, particularly the fire risk, changes rapidly sometimes, necessitating adaptations in the prevention and control provisions which are sometimes in contradiction with the legacy baseline requirements in effect for the facility.

The updating of the fire risk provisions by the licensees must be improved, particularly to enable them to adapt to the actual state of the facility.

4.3. Prevention of fire risks

Worksites involving hot work, particularly on certain renovation or repair worksites, and above all during decommissioning operations, constitute persistent weaknesses in the fire risk prevention system and are the cause of a significant number of fire outbreaks each year.

In effect, the risk analyses carried out to support a hot work permit application delivered by the licensee too often turn out to be insufficient or inexact, and the countermeasures identified in the analysis are also not always implemented in the field.

This finding concerning the vulnerability of the prevention of fire outbreaks associated with worksite activities is not specific to the nuclear sector.

The concept of defence in depth applied in the facilities has nevertheless, until now, limited the consequences of such situations on the protection of interests.

The licensee's checking of the goodness of fit between the risk associated with the condition (including temporary) of the facility and the measures it proposes implementing must be improved. For hot works, the safety analysis must be improved and the countermeasures must be correctly implemented.

4.4. Active fire protection

It is regularly found in the French nuclear facilities that the fire extinguishing means used are not entirely appropriate for the nature of the combustible materials.

Historically, many French facilities were designed with a ban on sprayed water fire extinguishers in the nuclear zones. Although this practice allows situations in which the use of water would induce a criticality risk to be addressed, it nevertheless means that its widespread application leads to a weakness in the second line of defence in depth and requires particular vigilance and stringency in the control of the fire load present in the facility. However, the regulations relative to worker protection demand the presence of sprayed water fire extinguishers. Consequently, a large number of facilities are now taking compliance steps by installing sprayed water extinguishers in addition to the means already in place.

The installation of sprayed water extinguishers in the zones that are not incompatible with the other risks present (criticality risk in particular) must be continued systematically.

Furthermore, with regard to the heavy fire-fighting means that constitute the emergency response teams present on the majority of the nuclear sites, ASN remains attentive to the actual availability of these teams. The reason for this is that on some sites, the many duties these teams must carry out (particularly in terms of security) reduce their actual capacity to effectively respond to a fire outbreak. For the nuclear power plants, an action plan is currently being deployed following the repeated demands from ASN to reinforce these means and render more effective the initial actions necessary to rapidly extinguish a fire outbreak, before calling the public emergency services.

The rapid response capacities of the on-site fire-fighting teams must be preserved. The fire-fighting duties of these teams must not be placed in competition with other duties that might be assigned to them.

4.5. Passive fire protection

With regard to the third level of defence in depth, which globally comprises the sectorisation and the nuclear material containment measures, new regulatory requirements have been established after the construction of a large number of facilities. These mainly concern fire stability requirements of the structures. These deviations were identified during the periodic safety reviews and in the majority of cases have led to actions plans to improve the fire stability of the buildings containing:

- nuclear material;
- Safety important components necessary for maintaining the facilities in a safe state in a fire situation.

Sectorisation or equipment fire protection work has been carried out to improve the reliability of this level of defence in depth.

The upgrading of the oldest buildings with regard to the fire stability of the structures and the limitation of fire propagation represents significant progress in their protection against the fire risk. It must be continued following the action plans established by the licensees.

To conclude, ASN considers that the level of fire protection of the French nuclear installations is satisfactory on the whole. The diversity of the facilities and their specific constraints has nevertheless led ASN to identify specific points which require regular monitoring.

5. REFERENCES TO THE NATIONAL ASSESSMENT REPORT

[1] ENSREG - Terms of reference for the topical peer review process on fire protection HLG-r(2022-49)_646 ToR TPR Review Process on Fire Protection – 16 June 2022

[2] Topical Peer Review 2023 - Fire Protection – Technical Specification for the National Assessment Reports- Ad-hoc TPR II WG report to WENRA - 21 June 2022

[3] Décision CODEP-CLG-2022-026838 du président de l'Autorité de sûreté nucléaire du 1er juin 2022 établissant la liste des installations nucléaires de base au 31 mai 2022

[4] Arrêté du 07 février 2012 fixant les règles générales relatives aux installations nucléaires de base

[5] Décision no 2014-DC-0417 de l'Autorité de sûreté nucléaire du 28 janvier 2014 relative aux règles applicables aux installations nucléaires de base (INB) pour la maîtrise des risques liés à l'incendie

[6] Décision no 2015-DC-0532 de l'Autorité de sûreté nucléaire du 17 novembre 2015 relative au rapport de sûreté des installations nucléaires de base

[7] Guide nº 22 -Version du 18/07/2017 relatif à la Conception des réacteurs à eau sous pression

[8] WENRA – Niveaux de référence de sûreté pour les réacteurs existants 2020 Thème SV - Rapport du 17 février 2021

[9] WENRA – Niveaux de référence de sûreté pour les réacteurs de recherche existants Thème S - Rapport de novembre 2020

[10] WENRA - Niveaux de référence de sûreté pour l'entreposage des déchets et du combustible usé – Rapport version 2.2, avril 2014

[11] WENRA - Niveaux de référence de sûreté pour le démantèlement- Rapport version 2.2, 22 avril 2015

APPENDICES TO THE NATIONAL ASSESSMENT REPORT

Development of the national selection of installations

The following subchapters provide short description of the installation and justifications about their position (candidate, represented or excluded) in the French selection.

1. Nuclear power plants

1.1. NPP in operation

There is only one operator for the NPPs in operation, the approach implemented by EDF is the same for all the reactors.

1.1.1 Candidate installations

Candidate NPP which will be reported on in the NAR is: TRICASTIN 1 (BNI 87) - 900 MWe Series - Post PSR4.

The NAR will also include a description of differences between this candidate facilities and other series of reactors: 1300 MWe, N4 and EPR with regard to fire safety.

1.1.2 Represented installations

None

1.1.3 Excluded installations

None

1.2. NPP under decommissioning

1.2.1 Candidate installations

Following the recommendation of the TPR Board, UNGG – Saint Laurent des Eaux A1 (BNI 46), a gas-cooled graphite moderated reactor is included in the national selection.

1.2.2 Represented installations

The pressurized water NPPs under decommissioning have specificities in terms of fire: the activity and storage areas, the activities themselves vary regularly. However, these pressurized NPPs have not been included in the selection because of the low stakes they present in case of fire. Indeed, there is no longer a source term in these installations: the cores are evacuated, including for the Fessenheim 1 and 2 reactors since 2022.

As UNGG – Saint Laurent des Eaux A1 (BNI 46) is included is the selection as a candidate installation, all other GCR under decommissioning listed below are represented by BNI 46:

- Chinon A1D (BNI 133);
- Chinon A2D (BNI 153) ;

- Chinon A3D (BNI 161) ;
- Bugey Nuclear Power Plant (reactor 1, BNI 45).

1.2.3 Excluded installations

The EL4D reactor (BNI 162) was definitively shut down on 31 July 1985. The fuel and fluids evacuation operations have been completed since December 1992. At the end of these operations, a large part of the source term was evacuated. The consequences of an accident, including a fire, do not require the implementation of measures to protect the public. The site does not have a special intervention plan. This installation is therefore excluded from the selection as it does not present any significant risks, including in the event of fire.

2. Research reactors

2.1. Research reactors in operation

2.1.1 Candidate installations

RHF - BNI 67. This research reactor of 58 MW is a heavy water high neutron flux reactor (HNFR), which produces very intense thermal neutron beams for fundamental research. The latest safety reviews have led to modifications resulting from the fire studies.

2.1.2 Represented installations

None

2.1.3 Excluded installations

The radiological consequences in the event of fire in the CABRI reactor (BNI No. 24) would be less than 1 mSv. This installation does not present significant risks in the event of fire and is therefore excluded from the exercise.

2.2. Research reactors under decommissioning or in consruction

2.2.1 Candidate installations

OSIRIS (BNI 40) is a nuclear research reactor with a thermal power of 70 MW. It was used to perform technological irradiation of materials and fuels for nuclear power plants operators. It was also used for the production of radioelements for industrial and medical use, including technetium-99m, and doped silicon. The ISIS reactor (BNI No. 40), with a power of 700 kWth, is the critical mock-up of the OSIRIS reactor.

The OSIRIS reactor was shut down at the end of 2015. The ISIS reactor was definitively shut down in March 2019. The last spent fuel from the reactors OSIRIS, ISIS and ORPHEE, stored in the facility was removed in the second half of 2021. The quantities of radioactive waste on site are limited. Although the radiological risks in case of fire are limited, it is proposed to add this installation to the selection so that the CEA's approach to fire prevention and protection is included in the French report.

2.2.2 Represented installations

The RJH (BNI 172) is not included in the selection because the fire prevention and protection approach is at an early stage (definition of principles). The ASN considers that some of the lessons learned from the examination of the RHF could be transferred to the RJH.

2.2.3 Excluded installations

ITER (BNI 174) is not included in the selection because of its specificity. There is no similar facility to which compare this reactor. Furthermore, it is under construction, its operation is not envisaged for several years and the approach to fire prevention and protection is at an early stage (definition of principles). The lessons that could be learned from this installation would only be transferable to similar installations, of which there are none in the countries participating in the TPR.

The RAPSODIE research reactor (BNI 25) was definitively shut down in April 1983. This reactor was used to carry out research on the fuel of the fast neutron reactor line and on the technology of its components. The core is currently unloaded, the fuel has been removed from the plant, the fluids and radioactive components have been removed and the reactor vessel is contained. The reactor pool has been emptied, partially remediated and dismantled, and the waste containing sodium has been removed. The facility does not present a significant risk in the event of a fire.

The MASURCA research reactor (BNI No. 39), with a power of 5 kW, made it possible to acquire basic physical data in the context of studies on fast neutron reactors with gas or sodium coolant. This installation is currently shut down. Preparatory operations for dismantling are under way, such as the removal of fuel and waste, asbestos removal from the premises, rehabilitation of buildings and removal of conventional equipment. This installation does not present a significant risk in the event of fire.

The EOLE and MINERVE (BNI 42 and BNI 95) experimental reactors are critical, very low-power models (less than 1 kW), which were used to carry out neutron studies, in particular to evaluate the absorption of gamma rays or neutrons by materials. Teaching and research activities were carried out on these models until their final shutdown on 31 December 2017. The radioactive waste present in the installation is limited in quantity (about 5 m3) and of very low activity. These two dismantled research reactors do not present a significant radiological risk in the event of fire.

The PHEBUS reactor (BNI No. 92) is an experimental pool-type reactor with a power of 38 MWth that operated from 1978 to 2007. This reactor was designed to study severe accidents in light water reactors and to define operating procedures to avoid core meltdown or to limit its consequences. The removal of the spent fuel from the reactor was completed in January 2019. The last non-irradiated fuels were evacuated in December 2021. The quantities of radioactive waste present on site are limited (about 5 m3). This facility does not present a significant risk in the event of fire.

ULYSSE (BNI 18) is the first French university reactor. The installation has been definitively shut down since February 2007 and no longer contains fuel since 2008. The CEA submitted a decommissioning application to the ASN in February 2021, with a view to removing the ULYSSE reactor from the list of BNIs. The clean-up objectives have been achieved and the facility no longer contains any pollution (chemical or radioactive). This installation no longer presents any nuclear safety or radiation protection issues.

The ORPHEE reactor (BNI 101), a neutron source reactor, is a pool-type research reactor with an authorised power of 14 MWth. The very compact core is located in a heavy water tank that serves as a moderator. This reactor was shut down on 29 October 2019. The spent fuel was removed from the installation and the heavy water circuit was drained. This installation does not present a significant risk in case of fire.

The PHENIX plant (BNI 71) is a sodium-cooled demonstration fast breeder reactor. This reactor, with an electrical power of 250 MWe, was definitively shut down in 2009 and is currently being dismantled. The disposal of irradiated fuel and the removal of equipment continued in 2021. This installation is excluded from the French selection because of its reduced source term and the specificity of the presence of sodium. The lessons that could be learned from this installation would only be transferable to a limited number of similar installations.

The SUPERPHENIX fast reactor (BNI 91), an industrial prototype cooled with sodium with a power of 1,200 MWe, is located at Creys Malville in Isère. It was definitively shut down in 1997. The reactor was unloaded and most of the sodium was neutralised in the form of concrete. SUPERPHENIX is associated with another BNI, the workshop for fuel storage (APEC – BNI No. 141). This installation is excluded from the French selection because of the limited radiological risks in case of fire and the specificity related to the presence of sodium. The lessons that could be learned from this installation would only be transferable to a limited number of similar installations.

3. Fuel cycle facilities

3.1. Fuel cycle facilities in operation

3.1.1 Candidate installations

The candidate installations are the ones which present the most significant radiological risk in case of fire and/or the ones which can provide meaningful insights.

- Georges Besse II plant for centrifugal separation of uranium isotopes (BNI 168);
- Nuclear fuels fabrication plant (MELOX – BNI 151). The MELOX installation is particularly interesting regarding the containment;
- Reprocessing plant for spent fuel elements from light water reactors (UP3 A – BNI 116). The NAR will focus on the T2 facility which performs the separation of uranium, plutonium and fission products, concentrates and stores fission product solutions. The T2 facility has the highest risk profile in this plant.
- Nuclear fuels fabrication unit (Framatome Romans) – BNI 63-U.

3.1.2 Represented installations

- Reprocessing plant for spent fuel elements from light water reactors (UP2-800, BNI 117). This BNI is the twin installation of UP3 plant. T2 facility, inside UP3 plant, will represent UP2-400.

- Plutonium Technology facility (ATPu, BNI 32). ATPu produced plutonium-based fuel elements intended for fast neutron or experimental reactors as from 1967, then, from 1987 until 1997, for Pressurized Water Reactors (PWRs) using MOX fuel. Shut down in 2008. All processing campaigns for drums containing alpha waste have been completed in 2022. The evacuation of waste resulting from this treatment is in progress.
- Liquid effluent and solid waste treatment station (STE3, BNI 118). This installation is dedicated to effluent collection and treatment and storage of bituminised waste packages. This installation has the same operator and is on the same site than UP3A (BNI 116). It will be represented by BNI 116.
- TU5 and W facilities (BNI 155). This installation is dedicated to conversion of uranyl nitrate resulting from the reprocessing of spent fuels into triuranium octoxide. Operated by the same operator than BNI 168. This installation presents a lower risk profile in case of fire than BNI 168. It will be represented by BNI 168.

3.1.3 Excluded installations

- Laboratory for research and experimental fabrication of advanced nuclear fuels (LEFCA, BNI 123). This installation is preparing for shutdown. Activities have been transferred to ATALANTE (laboratory). Therefore, this installation doesn't present a significant risk in case of fire.
- Uranium clean-up and recovery facility (BNI 138). This installation contains very low quantities of radioactive material and of combustible material. Radiological risk in case of fire is not significant.
- AREVA Tricastin analysis laboratory (ATLAS, BNI 176). This installation is included in another FCF. This laboratory processes samples analysis and performs environmental monitoring. This installation contains very low quantities of radioactive material and of combustible material. Consequently, radiological risk in case of fire is not significant.
- Tricastin uranium-bearing material storage yard (BNI 178). Storage of radioactive material (UF6) in containers. There is no combustible material on site. The likelihood of a fire is very low. There is no significant radiological risk in case of fire.
- P35 (BNI 179). Storage of radioactive material (uranium oxides) in containers. There is no combustible material on site. The likelihood of a fire is very low. There is no significant radiological risk in case of fire.

3.2. Fuel cycle facilities under decommissioning

3.2.1 Candidate installations

None

3.2.2 Represented installations

- Spent fuel reprocessing plant (UP2-400) – BNI 33. This installation is very similar to UP3 plant and is operated by the same operator. T2 facility (BNI 116), inside UP3 plant, will represent UP2-400.

- High level oxyde (HAO) FACILITY (BNI 80). This installation is operated by the same operator than UP3A plant. It's represented by UP3A plant.
- Enriched uranium processing facility (ATUE, BNI 52). Insights from similar fuel fabrication facilities can be transferable to ATUE (foreign facility or BNI 63-U which includes previous CERCA and FBFC facilities)

3.2.3 Excluded installations

- Chemical purification laboratory (LPC, BNI 54). This installation doesn't present significant radiological risk in case of fire.
- Georges Besse plant for uranium isotope separation by gaseous diffusion (EURODIF, BNI 93). After stopping production at this plant in May 2012, the licensee carried out, from 2013 to 2016, the EURODIF "Prisme" process of "intensive rinsing followed by venting", which consisted in performing repeated rinsing of the gaseous diffusion circuits with chlorine trifluoride ($ClF3$), a toxic and dangerous substance. These operations, which are now completed, allowed the extraction of virtually all the residual uranium deposited in the diffusion barriers. The main residual risk of BNI 93 is now associated with the$UF6$ containers in the storage yards, which are still attached to the perimeter of the facility. The radiological risk in case of fire is not significant.
- Liquid effluent and solid waste treatment station (STE2, BNI 38). The STE2 station of UP2-400 was used to collect the effluents from the UP2-400 plant, treat them and store the precipitation sludge resulting from the treatment. The sludge in STE2 is therefore composed of the precipitates which fix the radiological activity, and is stored in seven silos. A portion of the sludge has been encapsulated in bitumen and packaged in stainless steel drums in the STE3 facility. BNI 38 is operated by the same operator and is on the same site than UP3A (BNI 116). BNI 38 is represented by BNI 116.

4. Dedicated spent fuel storage facility

4.1. Dedicated spent fuel storage facility in operation

4.1.1 Candidate installations

- La Hague - Spent Fuel Pool D (T0), included in BNI 116

4.1.2 Represented installations

- Fuel storage facility (APEC) – BNI 141. Very little residual power and therefore long grace periods in case of loss of cooling. Consequently, no significant radiological risk in case of fire.

4.1.3 Excluded installations

- Nuclear fuel dry storage installation (CASCAD, BNI 22). Storage in wells. This installation is very specific and may not provide transferrable insights.

4.2. Dedicated spent fuel storage facility under decommissioning

None

5. On-site storage radioactive waste storage

In most cases, on-site waste storage facilities are considered part of the installation. Information on waste storage facilities will be included in the chapters corresponding to those of the installations to which they relate.

5.1. On-site storage radioactive waste storage in operation

5.1.1 Candidate installations

La Hague - Silo 130, included in BNI 38. Silo 130 is a waste storage facility constituting a BNI in its own right.

5.1.2 Represented installations

See §5

5.1.3 Excluded installations

See §5

5.2. On-site storage radioactive waste storage under decommissioning

5.2.1 Candidate installations

See §5

5.2.2 Represented installations

See §5

5.2.3 Excluded installations

See §5

6. Installations under decommissioning

See para. 1.2, 2.2, 3.2, 4.2, 5.2.