CONSEJO DE SEGURIDAD NUCLEAR

National Assessment Report Fire Protection in Spanish Installations

Topical Peer Review 2023

INDEX

Foreword

The European Union's Nuclear Safety Directive 2014/87/EURATOM (NSD) requires the member states to undertake, on a coordinated basis, Topical Peer Reviews (TPRs) at least every 6 years with the first starting in 2017. For each review the directive requires the following:

(a) that a national assessment is performed, based on a specific topic related to nuclear safety of the relevant nuclear installations1 on their territory,

(b) all other member states, and the Commission as observer, are invited to peer review the national assessment referred to in point (a),

(c) that appropriate follow-up measures are taken of relevant findings resulting from the peer review process,

(d) that relevant reports are published on the above mentioned process as well as its main outcome when results become available.

The member states, acting through the European Nuclear Safety Regulators Group (ENSREG), have decided that the topic for the second TPR is fire protection. As the scope of the TPR is wide, there is a need for selection amongst the installations, to preserve the feasibility and quality of the exercise.

In compliance with this mandate, the Nuclear Safety Council (CSN) has prepared the National Assessment Report that includes, in accordance with the Technical Specifications prepared by WENRA [1], the analysis of fire protection at the facilities proposed in the scope, the selection of which is also justified in this document.

01 General information

01.1 Identification of nuclear facilities

The set of nuclear facilities in Spain within the scope of the TPR II –installations for which a nuclear license is granted and in force as of the cut-off date of June 30th, 2022- results in the following list:

Name	Type	License status	License holder
CN Almaraz 1	NPP – W-PWR	In operation	CNAT
CN Almaraz 2	NPP – W-PWR	In operation	CNAT
CN Ascó 1	NPP – W-PWR	In operation	ANAV
CN Ascó 2	NPP – W-PWR	In operation	ANAV
CN Cofrentes	NPP – GE-BWR	In operation	Iberdrola
CN Santa María de Garoña	NPP - GE-BWR	In permanent shutdown	NN
CN Trillo 1	NPP – KWU-PWR	In operation	CNAT
CN Vandellós 2	NPP – W-PWR	In operation	ANAV
CN Almaraz	ISFSI (*)	In operation	CNAT
CN Ascó	ISFSI (*)	In operation	ANAV
CN Cofrentes	ISFSI (*)	In operation	Iberdrola
CN Santa María de Garoña	ISFSI (*)	In operation	NN
CN Trillo	ISFSI (*)	In operation	CNAT
FC Juzbado	fuel fabrication	In operation	Enusa
CN José Cabrera	NPP – W-PWR	In decommissioning	Enresa
CN Vandellós 1	NPP– Graphite-gas	In latency period after decommissioning	Enresa

(*) The issuance of a license for a nuclear activity (e.g. nuclear reactor, dedicated spent fuel storage facility) includes the necessary support activities and facilities at the site and, in particular, the treatment/temporary storage facilities for nuclear/radioactive waste. Hence, these waste storage facilities do not operate in Spain under a specific license but constitute an integral part of the "mother" licensed facility. Consequently, hereinafter the Independent Spent Fuel Storage Installations (ISFSIs), as well as the waste treatment and/or temporary storage facilities associated to a nuclear power station, will not be considered standalone but will be detailed as a part of the analysis of the nuclear station since both are owned and operated under the same license holder in the Spanish framework.

In addition, since the fire regulation and approach (deterministic), design (dry-cask storage), radiological characteristics and risks derived form a fire, as well as operational procedures at ISFSIs are quite similar to one another, the ISFSI at the nuclear power plants proposed as candidates are considered to be representative of any of the other ISFSI.

01.1.1 Qualifying nuclear installations

In a second step of the selection, the criterion "likely to present a significant radiological risk in case of a fire" is applied. Significant risk is meant to be a hazard for which arrangements for preparedness and response for a nuclear or radiological emergency are established following the safety analysis required to the facility, according to Requirement 4 of the IAEA's GSR-Part 7 [2].

In the case of the Vandellós 1 NPP, the plant has been in permanent shutdown and decommissioned following the fire that occurred on October 19th, 1989. It is now owned by the national waste disposal company, ENRESA. The spent fuel has been sent to France for reprocessing and interim storage. Decommissioning work is no longer performed at the facility, the decommissioning phase having already been completed by January 2005, signalling the starting date of the current latency period. In its present stage, the graphite-gas reactor structure has been removed, all non-fixed contamination has already been withdrawn or confined in fireproof containers and the activities for waste storage and conditioning prior to its final disposal have been completed. Therefore the radiological risk derived from a fire at the facility is considered negligible whereby Vandellós 1 is not suitable to be included in the scope of this TPR.

Concerning other installations, the fuel cycle facility (FCF) at Juzbado (a fuel fabrication plant) was initially proposed for exclusion from the exercise. The rationale behind this decision was the very low consequences of a fire as detailed in the facility's On-site Emergency Plan, which considers the inventory and physico-chemical form of the radiological material in the factory (non-irradiated uranium oxide powder or pellets) and its storage and handling.

Nevertheless, following the discussions held during the review and plenary meetings by the ENSREG Board, Spain has finally decided to include Juzbado as a FCF in the list of qualified facilities.

As a result of the previous analysis, the final list of qualifying installations in Spain is as follows:

Name	Type	License status	License holder
CN Almaraz 1	NPP – W-PWR	In operation	CNAT
CN Almaraz 2	NPP – W-PWR	In operation	CNAT
CN Ascó 1	NPP – W-PWR	In operation	ANAV
CN Ascó 2	NPP – W-PWR	In operation	ANAV
CN Cofrentes	NPP - GE-BWR	In operation	Iberdrola
CN Santa María de Garoña	NPP - GE-BWR	Shutdown (reactor) Operation (SFSF)	Nuclenor

CN Trillo 1	NPP – KWU-PWR	In operation	CNAT
CN Vandellós 2	NPP – W-PWR	In operation	ANAV
CN José Cabrera	NPP – W-PWR	In decommissioning	Enresa

It must be recalled that the SFSF associated to nuclear power plants has already been included and will be documented specifically in the mother NPP analyses and will therefore not be analysed separately.

The same will apply to the on-site waste management facilities, as has been highlighted by the reviewers' board of ENSREG in their meeting sessions.

01.1.2 National selection of installations for TPR II and justification

The third and last step involves the application of a sampling approach considering (1) that the sample shall be representative of the various types of installations and technologies, and that (2) the candidate facilities should be selected considering similarities with regard to the implemented fire safety concept.

The sampling of candidate installations proposed to be contributed by Spain in the TPR II on fire protection is, according to the Appendix to this document:

Name	Type	License status	License holder
CN Almaraz candidate unit	NPP – W-PWR	In operation	CNAT
CN Cofrentes	NPP - GE-BWR	In operation	Iberdrola
CN Vandellós 2	NPP – W-PWR	In operation	ANAV
FC Juzbado	Fuel fabrication	In operation	Enusa

It must be mentioned in this section that the observed differences and specificities of the represented installations from the candidate ones will be highlighted in the corresponding sections of the NAR, in which the candidate facility will be analysed in detail when applicable and relevant for the analysis.

01.1.3 Key parameters per installation

As detailed above, the following nuclear facilities have been included in the scope of this report:

- Almaraz Nuclear Power Plant (PWR-Westinghouse).
- Vandellós II Nuclear Power Plant (PWR-Westinghouse).
- Cofrentes Nuclear Power Plant (BWR-General Electric).
- Juzbado fuel fabrication.

This section includes a general description of each of these facilities.

Almaraz Nuclear Power Plant (two PWR-Westinghouse units).

The Almaraz nuclear power plant is owned by the companies Iberdrola Generación S.A., Endesa Generación S.A. and Gas Natural SDG S.A.

Two Westinghouse-designed three-loop Pressurised Water Reactors (PWR) of nominal thermal power 2956.6 MWt (Unit I) and 2955.8 MWt (Unit II) operate at the site. Both units share some areas and equipment, which is why this facility has been conservatively selected as a candidate over Ascó NPP, whose two units are completely independent.

Unit I reached first criticality on 5 April 1981, and commercial operation on 1 September 1983. Unit II reached initial criticality on 19 September 1983 and commercial operation on 1 July 1984.

Radiological risks at the plant originate mainly from the two reactors and the two fuel pools and to a lesser extent from the on-site Independent Spent Fuel Storage Installation (ISFSI).

In the vicinity of Almaraz NPP there is no other facility that could impact the plant or vice versa, as documented in chapter 2 of the Safety Analysis Report (SAR).

<u>Vandellós II Nuclear Power Plant (PWR-Westinghouse).</u>

The Vandellós II nuclear power plant is owned by the electricity companies Endesa Generación S.A. (72%) and Iberdrola Generación S.A.U. (28%).

The site operates a single Westinghouse-designed three-loop Pressurised Water Reactor (PWR) of nominal thermal power 2940.6 MWt.

The first criticality took place on 13 November 1987 and the commercial operation declaration on 8 March 1988.

The radiological risks at the plant originate in the reactor and the fuel pool.

In the vicinity of Vandellós NPP there is no other installation that could set an impact on the plant safety or vice versa. Nearby are the Vandellós I NPP (currently in latency period after decommissioning) and a combined-cycle thermal power plant. Chapter 2 of the Vandellós NPP SAR includes an analysis of the impact of all facilities located within a radius of less than 8 km and of the impact of transport by road, rail and the pipeline transport of flammable gases, concluding that the results obtained are enveloped by those considered in the design.

<u>Cofrentes Nuclear Power Plant (BWR-General Electric).</u>

The Cofrentes nuclear power plant is 100% owned by the electricity company Iberdrola Generación S.A.U.

The site operates a single BWR-6 reactor designed and supplied by General Electric (GE) with a thermal output currently licensed at 3237 MWt.

The reactor's first criticality was in August 1984 and commercial operation started in March 1985.

Radiological risks at the plant originate mainly from the reactor and the fuel pool and, to a lesser extent, from the on-site Independent Spent Fuel Storage Installation (ISFSI).

There are no other facilities in the vicinity of Cofrentes NPP that could impact the plant or vice versa, as documented in chapter 2 of the SAR.

<u>Juzbado Fuel Factory</u>

This fuel assembly factory is located in a piece of land owned by Enusa in the province of Salamanca, in the municipality of Juzbado. It performs the operations necessary to fabricate fuel elements from enriched uranium oxide and gadolinium oxide powder. Prior to the reception of the uranium oxide at the mill, there is a chemical process of transformation of enriched uranium hexafluoride into enriched uranium oxide, which is carried out in facilities outside Spain.

The purpose of the installation, classified as a nuclear facility with a licensed manufacturing capacity of 500 tonnes of uranium per year, is to fabricate fuel elements of uranium oxide and, in certain cases, of a mixture of uranium oxide and gadolinium oxide, with a maximum enrichment in uranium-235 of 5% by weight, for use in pressurised light water and boiling light water nuclear reactors.

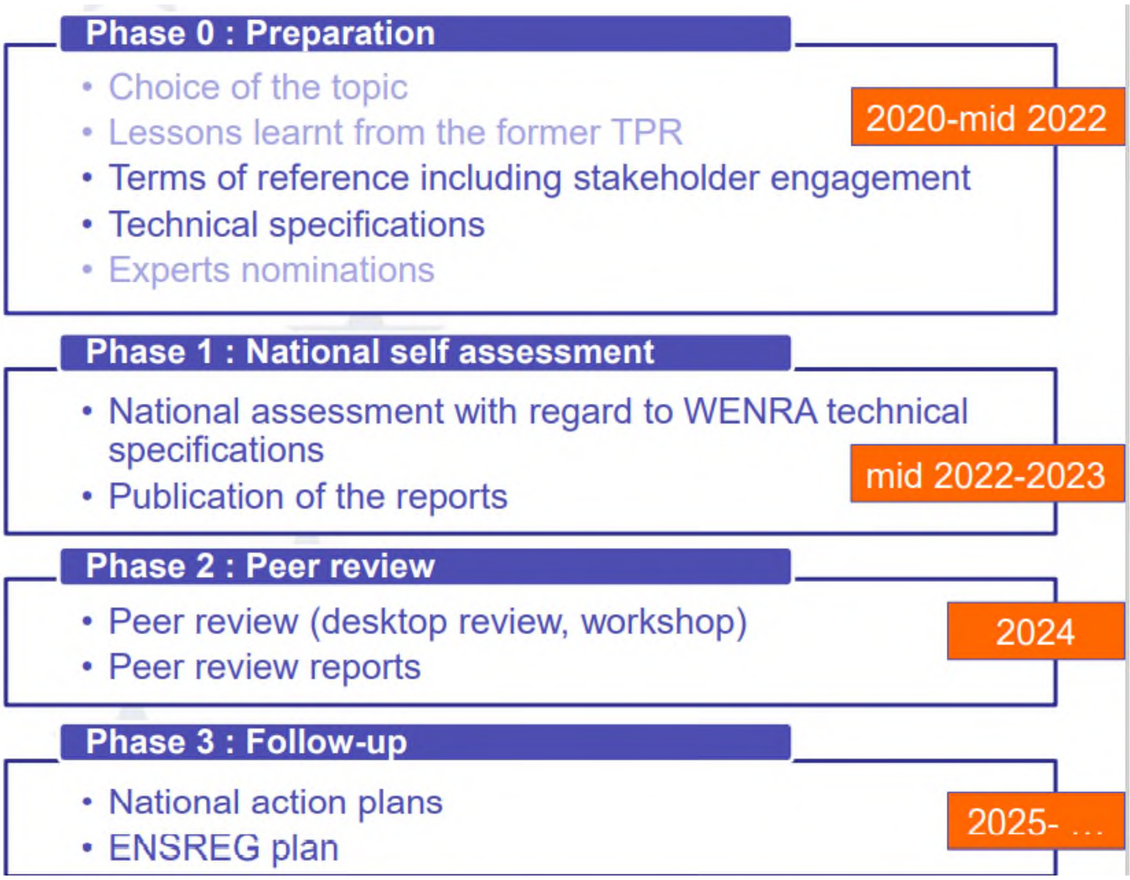
The process has two clearly separate stages. In the first, the ceramic process, uranium oxide powder or uranium oxide powder with gadolinium oxide is sintered to produce high-density pellets. The second stage, the mechanical process, comprises activities ranging from the loading of the fuel pellets into rods and their subsequent sealing, to the assembly of the fuel pellets into the final fuel elements. Its construction authorisation was granted on 12 December 1980, and started operation on 14 January 1985. The latest operating and manufacturing authorisation was granted on 5 July 2016 and is valid until 5 July 2026.

The greatest radiological risk at the plant lies in the ceramic area, the only area of the plant where uranium oxides in non-encapsulated form are handled.

In the vicinity of the Juzbado factory there are no other installations that could have an impact on the power plant or vice versa. Although there is a biogas plant built and initially operated by Enusa in the vicinity, according to the analysis carried out by the licensee at that time, it does not have any impact on the Factory.

01.1.4 Approach to development of the NAR for the national selection

In 2020 the European Nuclear Safety Regulators Group (ENSREG) identified fire protection as a topic for the second thematic peer review, to be implemented in the phases shown in the figure below.



Additionally, in this TPR it was decided to include all facilities subject to the Nuclear Safety Directive in the scope. However, due to the scope that the inclusion of all the facilities would entail, it was decided to make a selection of the facilities that could contribute most to the exercise and to justify this in each NAR. The selection of Spanish facilities is documented in section 01.1.2 above and the Appendix to this document.

In accordance with its participation as a member of WENRA in the above-mentioned thematic peer review, the Nuclear Safety Council (CSN) has established a process for the execution of Phase 1 (National Assessment Report, NAR).

Prior to the start of the development of the report, the CSN convened a sectoral meeting to explain the background to the WENRA project in question. The final content of the technical specification was also explained [2].

WENRA identified the following topics for which it requests, specifically and in a detailed manner, the in-depth analyses carried out and methodologies implemented, the description of the active systems and passive barriers installed, the organisation proposed to deal with potential fires that could occur in the facilities and finally the lessons learned over time:

- Fire Safety Analyses (Chapter 02)
- Fire protection concept and its implementation (Chapter 03)
    - Fire prevention (Chapter 03.1)
    - Active fire protection (Chapter 03.2)

- Passive fire protection (Chapter 03.3)

Annex 2 of the technical specification [2] details the content to be included in the national report to be submitted to WENRA for the assessments to be carried out from 2024 onwards.

In accordance with the applicability of the previous chapters to each facility, the CSN established deadlines (July 2022-June 2023) by which each of the Spanish nuclear power plants should have drafts available for comments in response to the technical specification [2], and should have been reviewed by the CSN, in order to be able to finalise the national report during the month of July 2023.

In order to carry out a structured plan and meet the deadlines set by the CSN, a working group was set up, led by the nuclear forum and a licensing representative for all the plants, and made up of technical representatives from each site. This group held regular meetings to review the documents as they were developed. In addition, given the participation of the Juzbado factory in this exercise, Juzbado was invited to the project launch meeting and to the first monitoring meeting, and subsequently a schedule of meetings was followed in parallel to those held with the nuclear power plants.

The NAR preparation process therefore began with the CSN requesting that the facilities within the scope prepare a report on each of them in response to the aforementioned specification [2]. This request materialised at the launch meeting.

In this way, the licensee of each of the nuclear power plants included in the scope, as well as the licensee of the Juzbado fuel manufacturing facility, have carried out a detailed analysis of their fire analysis, fire prevention measures, active detection and extinguishing systems, passive fire protection systems and fire response organisation, and their subsequent submission to the CSN, in accordance with the requirements established in the WENRA specification [2].

During this process, the CSN has held several meetings with the licensees of the Spanish nuclear power plants to guide the process and development of their reports.

On the basis of the reports submitted by the licensees, the CSN has drawn up the National Assessment Report, which will be subject to peer review by the European countries.

01.2 National Regulatory Framework

Law 15/1980 [9], creating the Nuclear Safety Council, explicitly states the faculty of the CSN at proposing and reviewing regulations, as well as elaborating and approving different kinds of mandatory rules related to nuclear and radioactive installations and to the activities associated with nuclear safety and radiological protection. In that sense, Law 15/1980 assigns to the CSN the function of proposing the necessary regulations on nuclear safety and radiation protection, as well as their reviews, for final approval. Furthermore, this article states that the CSN has the legal capacity to issue Instructions of the CSN (legally binding), Circulars, and Safety Guides on technical issues concerning nuclear installations and radioactive facilities and the activities related to nuclear safety and radiation protection (under these terms, transport, emergency and security are also included). Therefore, the CSN elaborates rules (Instructions of the CSN and Safety Guides) which will become part of the Regulatory Framework on the subject under the scope of the rule.

The Board of the CSN set up a Regulation Commission in charge of promoting, supervising and coordinating the activity related to regulation development. The members of this commission consist of two Commissioners (acting as President and Vice-president of the Commission) and other members from both Technical Directorates and Secretariat. Besides CSN membership, the competent Ministry is represented in the Regulation Commission as well so that this Commission serves as a channel for coordinating and monitoring the activities regarding regulations and guides.

The CSN provides, within this legal framework, processes for establishing or adopting, promoting and amending regulations and guides. These processes involve compulsory consultation with interested parties and the general public in the development of regulations and guides, taking into account internationally agreed standards and the feedback of relevant experience. Moreover, technological advances, research and development work, relevant operational lessons learned, and institutional knowledge are valuable tools in reviewing regulations and guides. The consideration of different kinds of foreign regulations (IAEA, NEA, Europe, etc) is considered a strength, and it is important to mention that the CSN Creation Law includes provisions focused on foreign relationships that contains international agreements on the CSN´s responsibilities.

01.2.1 National regulatory requirements and standards

In Spain, the regulatory framework establishes the principles, requirements and associated criteria for safety upon which the regulatory judgements, decisions and actions are based. This framework has a hierarchical structure, as shown in next figure, starting with International Treaties (Conventions), then following top to bottom with Laws, mandatory regulations and Instructions, and ending with Guides that contain acceptable technical approaches to comply with the regulations. Moreover, the competent Ministry and the CSN establish Limits and Conditions applicable to the license granted, and Complementary Technical Instructions for each installation, as a way to establish technical requirements about specific matters not included in other regulations.

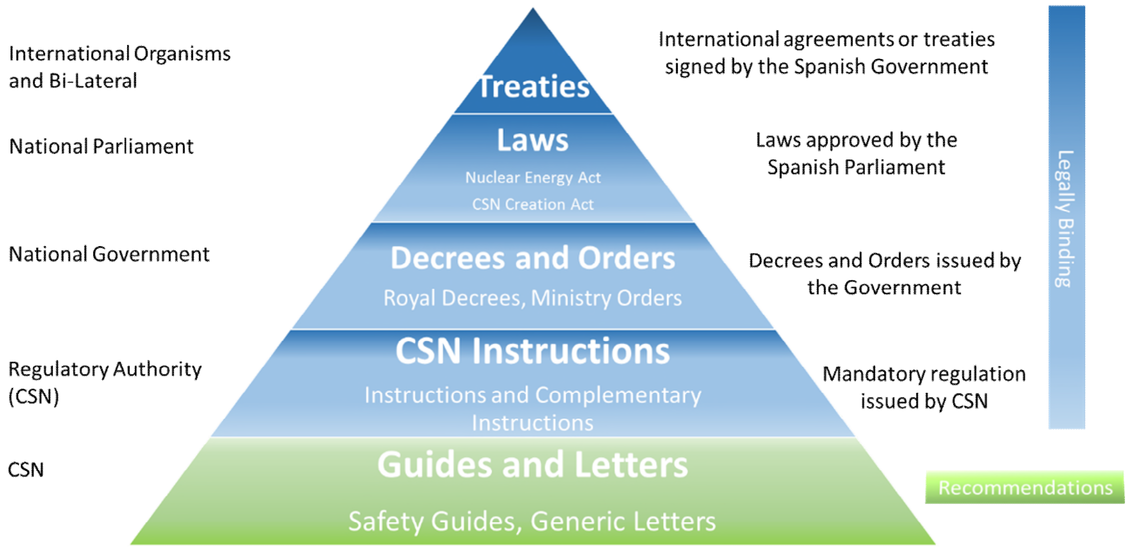


Figure 7 Hierarchical pyramid of nuclear regulation in Spain

There are two main laws serving as the framework for the regulatory requirements and conditions:

- Law 25/1964, of 29 April 1964, on Nuclear Energy, [10]

- Law 15/1980, of 22 April 1980, creating the Nuclear Safety Council [9].

The following Royal Decrees are also a relevant part of the Spanish nuclear regulatory framework:

- Royal Decree 1836/1999, of 3 December, approving the Regulation on Nuclear and Radioactive Facilities [11];

- Royal Decree 146/2004, of 25 June, approving the basic Nuclear Emergency Plan [12].

- Royal Decree 1440/2010, of 5 November, approving the Statute of the Nuclear Safety Council [13].

- Royal Decree 1400/2018, of 23 November, approving the Regulation on nuclear safety in nuclear facilities [14].

- Royal Decree 1029/2022, of 20 December, which approves the Regulation on Sanitary Protection against risks derived from the exposition to Ionising Radiations [15];

So far, there are 45 Instructions of the CSN; these legally binding documents develop Laws and Royal Decrees on nuclear safety, radiation protection, waste management, security and transport. In addition, there are more than 70 Safety Guides on different topics, such as power reactors and nuclear power plants, fuel cycle installations, radiation protection, environmental radiological control, radioactive installation and devices, radioactive waste management, transport, security, natural radiation, etc. All Instructions of the CSN are available in English at the CSN website (https://www.csn.es/en/informacion-general2).

Fire protection requirements are introduced in Royal Decree 1400/2018 [14] approving the Regulation on nuclear safety in nuclear facilities. This regulation was issued incorporating Directive 2014/87/Euratom [1], and includes between its 36 articles, the following ones which are relevant to the present report.

Article 2, sets the scope of application including Nuclear Power Plants, Nuclear fuel enrichment facilities and storage facilities.

Article 6, stablishes the safety objective for nuclear facilities of preventing accidents and mitigate their consequences in case they occur, and avoid radioactive releases.

Article 11, which states that the principle of In-depth defence must be applied to achieve the safety objective in Article 6. This principle includes: minimizing deviations from normal operation, detecting and controlling those deviations, providing necessary SSC and procedures to restore safe conditions, reducing probabilities of serious conditions and releases and mitigating radiological consequences that may occur as a result of an accident.

Article 12 describes the content and requirements of the safety assessments that proves that the facility meets Article 6.

Article 13 related to periodic safety review states the need to re-evaluate the nuclear safety of the facility at least once every 10 years and introduce, based on the results, improvements reasonably feasible related to their safety importance.

Article 20. Internal hazards (which include fires), requires the licensee to justify that the facility is designed to deal with internal hazards, adopt the principle of defence in depth and comply with the safety objective.

Additionally the CSN issued several Instructions which include several of the requirements related to the analysis to be included in this report as detailed in the following paragraphs.

- Instruction IS-25, of 9 June 2010, on criteria and requirements on the performance of probabilistic safety assessments and their applications for nuclear power plants [16], requires in article 3.1 to perform PSAs with a scope of level 1 and 2, including internal and external events, both at power operation and other modes of operation. In other words, licensees have to perform PSAs in which all possible internal and external events in all modes of operation of the nuclear reactor are analysed, also taking into account other sources of radioactivity that might give rise to source terms similar to the reactor core, in particular the spent fuel pool.

- Instruction IS-26, of 16 June 2010, on basic nuclear safety requirements applicable to nuclear installations [17], includes in its articles 5.22, 5.23 and 5.24 the need to: maintain the safety functions in case of a fire; include three protection levels: prevention, detection, alarm and extinguishing systems, and confinement measures through fire barriers; arrange SSC such that they are separated by fire barriers and if not possible a combination of active and passive methods should fulfil the safety function.

- Instruction IS-27, revision 1, of 14 June 2017, on general nuclear power plant design criteria [18], includes in Criterion 3 “Fire protection” four requirements related to the localisation of safety related SSC, the use of non-flammable heat resistant materials, fire detection and extinguishing systems, and protective measures to limit the propagation of fires.

- Instruction IS-29, of 13 October 2010, on safety criteria at spent fuel and high-level radioactive waste storage facilities [19], requires in article 3.5.3 that the design of facilities must provide necessary measures to reduce the risk of and limit the damage due to fires by means of protection levels based on prevention; detection, alarm, firefighting and confinement of fires. Additional requirements are indicated in articles 4.1 related to activities and operations, 4.9 focused on operating procedures and 5.1.y with requirements on the fire protection program.

- Instruction IS-30, revision 2, of 16 November 2016, on requirements of the fire protection programme at nuclear power plants [4], is the national regulation that requires nuclear power station license holders to setup and maintain a fire protection program at their facilities. The requirements included in this IS will be developed in more detail bellow due to the relevance to this report.

The CSN, according to the Law 15/1980, has also issued Complementary Technical Instructions (CTI) which are also technical requirements directed to license holders in order to cover additional topics to the license limits and conditions. In relation to Fire protection, there are several CTI that have been issued with similar requirements to all licensees on the following issues:

- Fire brigade physical aptitude requirements in NPP issued on 13 March 2020 [20].

- Inclusion of certain elements of the fire protection program in the safety analysis and specific modifications to the fire protection program that require the CSN authorisation in NPP issued on 11 June 2018 [21].

- Roving fire watch requirements in NPP issued on 18 December 2020 [22].

- After Fukushima, CSN issued four Complementary Instructions to all the NPP: CTI 1, CTI 2, CTI 3 and CTI 4. CTI 1 and 3 specifically related to Fukushima events in which a fire may be caused by a natural phenomenon either directly of after an explosion and CTI 2 and 4 covering the loss of major areas (covering man-made hazards beyond design bases) being a large fire one of the enveloping scenarios. Similar CTI with an adapted scope to NPP CTI 1 and 3 were also issued to Juzbado FCF [23].

Additionally, the Nuclear Safety Directorate can issue Technical Instructions (TI) as a result of CSN council's agreement approved on 24 February 2010 (BOE number 77, 30 March 2010) to delegate on either Nuclear Safety or Radiation Protection Directorates the issuance of TI in case of urgency. According to this delegation, the following TI have been issued in relation to Fire Protection:

- CNS-IT-DSN-11-07 issued on 16 April 2011, to Juzbado that requires corrective actions as a result of the deviations detected during the inspection on the Fire protection system [24].

- TI issued to all NPP on 13 May 2010 to require the inclusion of a completion time to recover the operability of fire protection systems and the improvement of the fire barriers inspection requirements in the Technical Specifications or in the Technical Requirements Manual (TRM) where applicable [25].

- IT/ALM/02/45 issued to Almaraz to include additional improvements in the fire protections systems of two fire areas as a result of an inspection [26].

Finally, the Nuclear Safety Council has issued several Safety guides that include recommendations on a valid alternative to meet the requirements included in the different instructions. The following guides include aspects related to Fire protection.

- SG 1.10, revision 2, of 30 May 2017, on periodic safety reviews in NPP [27], includes in its Appendix I a guide for the revision of the different safety factors. In the 7th factor, "risk analysis", the guide states that the objective of the revision of this factor is to determine the adequacy of the plant to cope with internal and external hazards (including fires in the scope), taking into account the design, site characteristics, the current and expected status of safety-relevant SSC, as well as the analytical methods, standards and knowledge used.

- SG 1.15, revision 1, of 25 January 2017, on updates and maintenance of PSA [28], include an acceptable alternative for the maintenance and updates of the fire PSA level 1 and level 2 after every cycle and during periodic safety reviews.

- SG 1.19, of 19 January 2011, on fire protection program requirements [29] include acceptable means to meet the requirements related to the fire protection program detailed in IS-30.

<u>IS-30 on requirements of the fire protection programme at nuclear power plants [4].</u>

This instruction, as stated in the previous paragraph constitutes the national regulation that requires nuclear power station license holders to setup and maintain a fire protection programme at their facilities. This fire protection programme includes all the features regarding fire protection (prevention, detection, extinction, firefighting) and analysis performed to ensure that the safe shutdown is achieved and maintained in case of any postulated fire event at any fire area of the facility, including the main control room. This capacity includes the adequate confinement of radioactive materials so that the likelihood of offsite releases of radioactive materials is minimised.

For some time, the CSN has required the nuclear power plant licensees to implement a fire protection programme in keeping with the requirements demanded of US plants and with the licensing conditions for fire protection applied to each plant in particular. Pursuant to the provisions of Article 8.3 of the Regulation on Nuclear and Radioactive Facilities, (Royal Decree 1836/1999, of 3 December, modified by Royal Decree 35/2008, of 18 January), and further to the need to incorporate these requirements into the Spanish legal framework, Instruction IS-30 dealing with the requirements of the fire protection program at nuclear power plants (Official State Gazette “BOE” No. 40 of 16 February 2011) was approved on 19 January, 2011.

In drawing up this Council Instruction, consideration was given to the work performed by the Western European Nuclear Regulators’ Association (WENRA) taking into account the «reference levels» issued by the association.

Specifically, in its chapter S (Protection against internal fires) the WENRA reference levels document sets out the basic applicable requirements which, in the terminology traditionally used within the Spanish documentary and legal framework, are known as «Fire Protection at nuclear power plants».

In order to give consistency to the standards development process undertaken by the CSN as a result of this harmonisation effort, it was considered necessary to draw up a Council Instruction contemplating the aforementioned requirements, this giving rise to approval of the said Instruction IS-30, of 19 January 2011. Subsequently, in view of the experience gleaned from application, the need to regulate the different specific characteristics of both the design and the original licensing basis of the system for fire protection of each of the different Spanish nuclear power plants and the evolution of the fire protection regulations, revision 1 of Instruction IS-30 of 21 February 2013 was approved. Finally, the current version of the IS-30 was issued in order to clarify and facilitate the practical application of the term «exemption», splitting the term coined in revision 1 into two new terms, exemption and equivalent measures, which fit perfectly into the regulatory framework governing nuclear safety and radiological protection. Revision 2 of the Instruction, approved by the Council on 16 November 2016, came into force the day after its publication in the “Official State Gazette” (Wednesday 30 November 2016).

Purpose and scope of application.

The purpose of this Council Instruction is requiring nuclear power station license holders to implement a fire protection programme and defining the criteria that must be fulfilled by such programme. This Instruction shall apply to the licensees of all Spanish nuclear power plants with an operating license.

The Nuclear Safety Council's criteria for fire protection at nuclear power plants.

The fire protection objectives must be met by any license holder under the scope of the Instruction under the principle of defence-in-depth in fire protection, namely implementing measures to prevent a fire before it starts, to detect, control and extinguish it as soon as possible in case it occurs, and to prevent the spread thereof to other areas that might affect safety.

On the other hand, by means of confinement in fire areas, it must be ensured that a fire that cannot be extinguished will not damage at least one of the redundant safe-shutdown trains such that the power plant may achieve and maintain such safe shutdown and the likelihood of offsite radioactive releases is minimised.

Safe shutdown capacity.

A fire risk analysis that proves that fire safety objectives are fulfilled, design bases are complied with, active and passive fire protection systems have been properly designed and administrative controls have been properly implemented must be conducted and kept up to date. This analysis must prove that the possible consequences and effects of both the intentional and spurious actuation of fire extinction systems has been taken into consideration.

On the other hand, a safe-shutdown analysis must demonstrate, from the identification of the redundant safe-shutdown trains considered in the facility that, under a postulated fire in any fire area of the plant, damages to systems are limited so that one train of the systems needed to achieve and maintain safe-shutdown conditions from the control room or from the panel for remote shutdown in case of a fire is undamaged by the fire; and the systems needed to achieve and maintain cold shutdown from the control room or from the panel for remote shutdown in case of a fire can be repaired within the 72 hours following the start of the fire.

The use of operator manual actions in case of a fire is an acceptable alternative that shall require a regulatory approval by the CSN.

The control room must be provided with an alternative or dedicated shutdown capability, independent from the cables, systems and components located therein. The analysis of deterministic safe shutdown capacity in case of fire in this area or other fire areas leading to control room abandonment must be performed under specific boundary conditions, because of the unique configurations of these areas where all the redundant trains of all systems are present.

A valid alternative to meet these requirements is to follow a "risk-informed, performance-based" methodology previously accepted by the CSN.

Additional requirements.

The Instruction also establishes additional requirements to fire protection systems in areas important to safety at the facility as well as to the quality assurance programme applicable to their design, acquisition, assembly, testing and the administrative controls.

Procedures must also be established to control and minimise the amount of combustible material and ignition sources that might affect equipment important to safety.

Effective firefighting capability is also under the scope of the Instruction IS-30, which establishes specific requirements onto fire brigade organisation and co-ordination, composition, duties, physical conditions, training and available resources.

Regulatory supervision of the fire protection programme at nuclear power plants in Spain.

The former set of analysis, procedures and documents constitute the Fire Protection Program of the facility and any change in them that could impair the capacity in fulfilling the objectives of fire protection must be approved by CSN. With this aim, a Complementary Technical Instruction was issued by the CSN last June 2018 to all holders of an operating license in Spain to set the conditions for the regulatory control of this Fire Protection Program and its changes caused by either physical or document modifications.

01.2.2 Implementation/Application of international standards and guidance.

As introduced at the beginning of chapter 01.2, The Law 15/1980, creating the Nuclear Safety Council [9], explicitly states the faculty of the CSN at proposing and reviewing regulations, as well as elaborating and approving different kinds of mandatory rules related to nuclear and radioactive installations and to the activities associated with nuclear safety and radiological protection. In that sense, Law 15/1980 assigns to the CSN the function of proposing the necessary regulations on nuclear safety and radiation protection, as well as their reviews, for final approval. These processes involve compulsory consultation with interested parties and the general public in the development of regulations and guides, taking into account internationally agreed standards and the feedback of relevant experience. Moreover, technological advances, research and development work, relevant operational lessons learned, and institutional knowledge are valuable tools in reviewing regulations and guides. The consideration of different kinds of foreign regulations (IAEA, NEA, Europe, etc) is considered a strength, and it is important to mention that the CSN Creation Law includes provisions focused on foreign relationships that contains international agreements on the CSN´s responsibilities.

The process carried out in the development of regulations and guides and the incorporation of updated international standards and guidance is documented in the justification included in the publication of different standards as for example (including only those explicitly mentioned in this NAR):

- Directive 2014/87/EURATOM [1] was incorporated in Royal Decree 1400/2018 [14].
- IAEA's highest regulatory-level documents served as a basis for IS-26 [17].
- WENRA reference levels [30] served as a basis for IS-25 [16], IS-26 [17], IS-27 [18], IS-29 [19] and IS-30 [4].
- The joint convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [31] was taken into account in IS-29 [19].
- IAEA SSG-25 [32] was taken into account when developing SG 1.10 [27].
- 10 CFR 50 Appendix R [6], 10 CFR 50.48 *Fire Protection* [33], NUREG 0800 9.5-1 *Fire Protection Programme and associated BTP* [7] and RG 1.189, rev 1, *Fire Protection for Nuclear Power Plants* [34] were taken into account when developing IS-30 and SG 1.19 [29].

Additionally all Royal Decrees issued are communicated to the Commission of the European Union during its processing as a project, in accordance with the provisions of Article 33 of the Treaty establishing the European Atomic Energy Community (EURATOM) [35].

The monitoring and analysis of operating experience, both internal and external, is one of the most important sources of information and feedback for learning and improving the safety and reliability of nuclear facilities. It is essential to systematically collect and analyse the information generated during the various phases of the life of a facility, from construction to operation, the definitive shutdown and decommissioning. Not only are occurrences within the plant itself analysed but also within all those that could have an effect on it, to determine whether or not a certain type of failure is possible and, if it is, how to prevent its appearance by modifying the design of the plant or the operating procedures.

Each licensee must provide the CSN with an annual report on the specific operating experience of each plant according to the conditions of each operating permit. These reports are included in the oversight process of each facility and are used as basic information for the inspections by the CSN on operating experience.

As a specific milestone and as set by the regulations of the CSN, nuclear facilities are obliged to undertake a periodic safety review, at least once every 10 years.

A periodic safety review is the process of conducting additional analyses and checks that complement the nuclear safety assessments that take place regularly in a nuclear power plant, providing a global and integrated vision of its various nuclear safety aspects.

After the review, the nuclear safety of the facility is assessed on the basis of the results on the subjects within its scope over a sufficiently long period of time. The scope of the periodic safety review also includes the assessment of programmes under way to improve safety in the facility or the establishment of new programmes, if necessary. One of the most important aspects of this process is the analysis of the updated regulations to check whether new requirements that may apply to the facility have been included. After assessing the results of the periodic safety review carried out by the facilities, the CSN sets additional safety requirements for the licensees if it considers this necessary.

The objectives of a Periodic Safety Review (PSR) include:

- Analysing the facility’s performance in various aspects of nuclear safety over a sufficiently long period of time to be able to identify trends.
- Checking the suitability of the system used to analyse the various aspects of nuclear safety in the facility, documented in the periodic reports.
- Identifying the possible existence of cumulative effects that could negatively affect the facility’s nuclear safety.
- Analysing the facility’s situation with regard to international regulations and the regulations of the project origin country.
- Analysing the facility’s situation in the light of technological progress that could have taken place over the time period covered by the review.

Finally, the functioning of nuclear facilities is supervised and controlled through various mechanisms. The most direct one is based on inspections by the CSN, more than 100 per year, designed to check compliance with the specific nuclear safety and radiological protection requirements.

The inspections provide the necessary information for checking compliance with the relevant legislation currently in force, the Council's instructions and the specific conditions imposed in the regulatory authorisations, licenses or permits. The inspection is carried out by a qualified person, officially accredited by the CSN for this. The results of the inspections are included in a single document called the Inspection Record.

The CSN has a resident inspector in each nuclear power plant to monitor daily activity in such power plants and to supervise compliance with the Official Operating Documents.

In the case of functioning nuclear power plants, the Integrated Nuclear Power Plant Supervision System is applied. This Supervision System includes the inspections in the Base Inspection Programme (BIP) which are systematic control inspections. There are also additional, supplementary or reactive inspections triggered by findings encountered in the previous ones or by specific events that may take place in NPP, which are the occasional control inspections.

There are equivalent integrated supervision systems, applied to Juzbado but adapted to their specific characteristics, and which also have their own BIP.

The biannual BIP inspections cover aspects such as design modifications, component design bases, compliance with monitoring requirements, operating experience, protection against severe weather conditions and floods, fire protection, final heat sink, personnel training, in-service inspection, maintenance management, environmental radiation monitoring programmes, waste management, reloads planning, radiological monitoring of workers, radiological protection instrumentation, emergency preparedness and response, inspections related to the physical protection of the facility, etc. The inspections related to Fire protection and PSA are carried out following the procedures: PT.IV.225 revision 1, *Inspection on PSA maintenance and updates* [36]; PT.IV.87 revision 1, *Inspection on Fire and explosions protection in Juzbado* [37]; PT.IV.204 revision 1, *Fire protection* [38] and PT.IV.205 revision 2, *Fire protection inspections carried out by the resident inspector* [39].

The monitoring of reportable events that occur in nuclear power plants through the Incidents Review Panel also forms part of the supervision and control process carried out by the CSN, as does the monitoring of the operating experience and the review of periodic reports sent by the licensees as base documents for preparing the inspections to comply with the conditions set out in their authorisations.

02 Fire Safety Analyses

02.1 Nuclear Power Plants

02.1.1 Types and scope of the fire safety analyses

In relation to Fire Safety Analysis, the WENRA reference levels SV 6.1, SV 6.2 and E 6.1 are applicable to nuclear power plants.

In Spain, the WENRA reference levels for fire protection are reflected in the national standard for nuclear power plants in IS-30 Rev.2. In particular, the Articles dedicated to fire analysis requirements correspond to paragraph 3.3 of IS-30 Rev.2, 3.3.1 to 3.3.6.

These Articles contain requirements on the scope and purpose of risk and safe shutdown analysis in case of fire, which must be deterministic and completed with a Level 1 at power Fire Probabilistic Safety Analysis (Fire PSA). It also sets out requirements on fire risk analysis for plants that opt for a risk-informed and performance-based approach.

The scope of deterministic analyses should cover, inter alia, the following aspects:

- Demonstration of compliance with fire safety objectives, with the design basis for Fire Protection (FP) systems and that administrative controls are appropriate.
- Safe Shutdown Analysis at power and in other modes of operation (see section 02.1.2.1.2 for other modes of operation).
- Analysis of radioactive releases.
- Combination of events. According to this requirement, in order to address the combination of events, Spanish plants have analysed, in accordance with Articles 3.3.4 and 3.4.2 of IS-30, in the context of the flooding analysis, that the capacity of SSCs important for safety are not affected and, in accordance with Article 3.4.8, a seismic FP subsystem has been set up.

The scope of the probabilistic analyses should cover the level 1 at power fire PSA required by IS-30 as well as the rest of the fire PSAs derived from IS-25 (level 2 at power and level 1 and level 2 at low power and shutdown). The fire PSA can be used to comply with risk-informed alternatives in plants transitioning to this methodology.

According to Article 3.2.8, IS-30 includes the possibility of using NFPA 805 as an alternative methodology to the requirements of Articles 3.2.3 to 3.2.7, or others, upon request and regulatory approval by the CSN.

In accordance with this Article, Almaraz NPP has changed its licensing basis to a risk-informed and performance-based methodology and has therefore used the NFPA-805 methodology to justify compliance with the above Articles.

02.1.2 Key assumptions and methodologies

02.1.2.1 Deterministic evaluation

Fire Hazard Analyses (FHA) must demonstrate that fire safety objectives are met, that the design basis is complied with, that active and passive fire protection systems are appropriately designed and that administrative controls are in place.

This analysis is developed in a deterministic way (considering the loss of all equipment in the area where the fire is postulated) covering as a minimum:

- Consideration of a single fire and its spread, where there is fixed and transient fuel used in normal operations (power, refuelling, maintenance) up to a barrier, which, if not adequately justified, should be three hours fire resistant.
- Consideration of the combination of a fire with other initiating events caused by the fire (e.g. loss of external electrical power).
- Consideration of loss of external electrical power for those fire areas containing equipment with alternative or dedicated shutdown capability in case a fire in another fire area has affected redundant trains for safe shutdown.
- Analysis of associated circuits that may adversely affect safe shutdown.
- Identification of safety relevant Structures, Systems and Components (SSCs) in the field of fire protection. Such safety relevant SSCs shall include, as a minimum:
    - SSCs required to reach and maintain the safe shutdown condition in the event of fire, as well as those which may adversely affect the ability to do so
    - SSCs performing safety functions or those that may impede or influence the performance of such functions.
    - SSCs whose malfunction could lead to an external radioactive release.

The objective of the FHA is to demonstrate that safe shutdown capability is maintained and that there are no radioactive releases to the environment.

02.1.2.1.1 Safe power shutdown analysis

The analysis of the safe shutdown capability, in case of fire, starts from the identification of the safe shutdown equipment that may be affected by a fire in each fire area. The methodology is common to all Spanish plants and follows the guidelines of document NEI-00-01 *Guidance for Post-Fire Safe-Shutdown Circuit Analyses* Rev.2 [40].

The Safe Power Shutdown Analysis postulates a single fire occurring at 100% power, affecting all equipment located in the fire area. Under these boundary conditions the analysis must demonstrate that the safety functions detailed below can be met in order to ensure that hot standby (Mode 3) in PWR or hot shutdown in BWR can be maintained and have the capability to reach cold shutdown within 72 hours.

The following describes the method for fulfilling the main safety functions for the PWR reactor to reach and maintain hot standby:

- Reactivity Control: For hot standby, the insertion of rods will be sufficient to keep the reactor subcritical. As the plant is kept in hot standby, there is no need for boration.
- Inventory control: To keep the inventory under control it is necessary to maintain the level in the pressuriser. This requires the availability to inject borated water as needed and the maintenance of its integrity.

Replenishment capacity is available by injection into the reactor coolant system (RCS or “primary circuit”) from the refuelling water storage tank with a charge pump, with two possible injection paths: normal and emergency.

To maintain the integrity of the primary circuit, it is necessary to ensure the integrity of the reactor coolant pump seals and to prevent leakage from spurious openings of the RCS vent valves, pressuriser relief valves and residual heat removal system suction valves.

- Temperature Control: In order to keep the primary circuit temperature under control, it is necessary to extract enough heat for the reactor to reach and maintain hot standby. This temperature control will be achieved by natural circulation and heat removal through the steam generators. To fulfil the temperature control function, only the following is required:
  - Steam isolation of the three steam generators.
  - The availability of one of the three steam generators with a sufficient water level to extract heat from the reactor. This implies:
    - the availability of auxiliary feed water feeding that steam generator,
    - the availability of steam relief from the same generator,
    - the isolation of the purge of that generator, except at Ascó NPP where this is not necessary, according to the analyses performed for MSO 34.
  - According to the above, the systems required for the temperature control function for hot standby are:
    - Auxiliary feed water system and essential service water system, to feed the steam generator.
    - Main steam system, for steam relief and steam isolation functions.
    - Steam generator blowdown systems, for the steam generator blowdown isolation function, with the exception of Ascó NPP as mentioned above.
- Pressure Control: The pressure control function in the RCS can be performed by cooling (pressure reduction), and by supplying load flow (pressure increase).

  To achieve the pressure reduction by cooling the RCS, the heat sink function (temperature control) is used, and to achieve the pressure increase, injection from the refuelling water supply tank (inventory control) is used.
- Process monitoring: Successful safe shutdown requires maintaining the ability to monitor the following variables: reactor coolant temperature (cold branches and hot branches), pressuriser pressure and level, steam generator pressure and level, neutron flux monitoring, level of tanks required for safe shutdown, and principal operating variables of system required for safe shutdown.

- Support systems: The supporting systems (electrical, cooling and ventilation) are necessary for the front-end systems equipment required for safe shutdown to perform their function.

Additional requirements to reach and maintain cold shutdown are:

- Reactivity Control: Boring is necessary to maintain the shutdown margin. Boration is carried out with the charging pumps from the refueling water storage tank (RWST).

- Temperature Control: The residual heat removal system is necessary. The operation of one train is sufficient for the fulfilment of this function.

Flow diagrams, single-line diagrams, wiring diagrams and detailed wiring diagrams of the affected systems have been used to identify the dependencies (support equipment).

The main safety functions for achieving and maintaining hot shutdown in the BWR are described below. These functions have been defined by NEI Guide 00-01 [40]:

- Reactivity Control: Requires the combined operation of the control rod drive and reactor protection systems, or control rod drive and redundant reactivity control system, or boron injection through the stand-by liquid control system.

  The reactivity control function is considered to be fulfilled, if the reactor scram is successfully achieved by the rapid insertion of the control rods. For this function, the system pumps do not need to be operated, the pressure of the nitrogen accumulators of the HCUs is sufficient for the insertion of the rods.

- Pressure Control is required at any time during the process to reach safe shutdown, and mainly in the immediate aftermath of the reactor scram, during which coolant is injected with the high pressure systems (RCIC and HPCS). The pressure increase due to the steam flow generated in the reactor by the residual heat, and by the injection of high pressure coolant, causes the cycling (opening and closing) of the SRVs with the reactor isolated.

  It is considered that, even in the event that fire could prevent the automatic opening of the pressure relief/safety valves in their pressure relief function, they would still open when their safety function setpoint is reached, so that pressure control is never prevented by fire.

- Inventory control: This is done through plant systems that have the capacity to supply water to the reactor and maintain the level to achieve and maintain hot shutdown. This function includes any system that meets the suction NPSH of the coolant reservoirs for injection into both the vessel and the suppression pool.

  Various high, medium and low pressure systems are available to perform this safety function. The high pressure systems are HPCS (High Pressure Core Spray) and RCIC (Reactor Core Isolation Cooling). The medium and low pressure injection systems are LPCS (Low Pressure Core Spray), LPCI (Low Pressure Core Injection).

- Residual Heat Removal Function: Its main purpose is to remove the decay heat generated in the core after reactor scram. In most of the heat removal paths of the reactor coolant system, the joint action of an injection system and the opening of relief/safety valves discharging to the suppression pool takes place, so that the residual heat removal function must be completed by the removal of heat from the containment.

The systems that extract heat from the reactor are those that are capable of injecting water into the vessel; of which there are high pressure systems (RCIC and HPCS) and low pressure systems (LPCS and LPCI).

Systems that directly perform the above functions are considered front-end systems. The operation of those support systems necessary for the operation of the front-end systems must be ensured. Support functions include: power supply and system control, component cooling and component lubrication.

During the safe shutdown process, the instrumentation that allows the monitoring of the plant status and the performance of the safe shutdown systems must remain undamaged.

- Process variable monitoring function of systems performing the above functions: These variables are those that guide the operating procedures up to cold shutdown in the event of a fire, i.e. those that serve to operate the systems that fulfil the defined front-end functions: reactor level and pressure instrumentation, suppression pool level and temperature instrumentation, primary containment pressure instrumentation, levels of the tanks required for coolant replenishment (upper pool, UHS and condensate storage tank) and the variables that indicate the operation of the front-end systems that perform the safe shutdown functions, such as pressure and flow instrumentation in the lines of these systems (RCIC, HPCS, LPCS, LPCI, essential service water system, etc.).

The identification of the safe shutdown equipment in each fire area is done by determining the safe shutdown SSC present in the fire area as well as the cables that pass through that fire area and are related to safe-shutdown SSC present in either the same or other fire areas.

In the Safe Shutdown analysis it is assumed that all SSCs in the fire area or with cables in the fire area will be affected by the fire, losing their functionality or generating the most unfavourable possible failure mode.

Based on the identification of potentially affected equipment in each fire area, the ability to perform the safety functions with equipment not affected by the fire is analysed.

The identification of possible failures in equipment and associated cables takes into account the following cable failure modes: open circuit, short-circuits to earth and short-circuits between conductors. In this respect, short circuits between conductors in the same cable (intra-cable) are considered, and the possibility of a short circuit occurring with conductors in another cable in the same tray (inter-cable) is also taken into account.

The compliance criteria in accordance with IS-30 require that, in fire areas outside containment where all redundant safe-shutdown trains coincide, in order to ensure a train with systems necessary to reach safe shutdown free of fire damage, one of the separation methods specified in Article 3.2.5.1 must be met.

The barriers credited in the safe shutdown analyses strictly comply with the requirements of IS-30.

IS-30 allows other measures equivalent to the above, provided that they have been favourably assessed by the CSN.

For areas within non-inerted containments, additional separation options are considered in Article 3.2.5.2 of IS-30.

Although fire or failure of the fire protection system concurrent with design basis accidents or the most severe natural phenomenon is not postulated, Article 3.4.8 of IS-30 requires a seismic extinguishing subsystem available under the safe shutdown earthquake (SSE) event.

02.1.2.1.2 Safe shutdown in other modes of operation

The general industry approach to assess risk conditions during shutdown involves qualitative and/or quantitative assessments and is based on the NUMARC 9106 *Guidelines for Industry Actions to Assess Shutdown Management* [41] and in Spain, additionally, in the *Guía Genérica de Seguridad en Parada* UNESA CEN-30. Rev. 0. March 2011 [42].

Within the scope of application of this generic guide, the possible impact of the fire on the RHR and CVCS functions was analysed, and, as a result of the analyses carried out, compensatory measures were established in the operational states where it was determined necessary.

For plants that have changed their licensing basis to a risk-informed and performance-based methodology, the strategy for control/protection of equipment during other modes of operation is a combination of the normal fire protection and risk-informed defence-in-depth actions based on the availability of systems and equipment necessary to address the "Key Safety Functions" (KSF) and whether or not the plant is in "High Risk Evolutions" (HRE).

The KSFs are those already indicated in the safe power shutdown analysis: reactivity control, inventory control, pressure control and temperature control. In addition, measures for monitoring the process and to check the compliance with the KSFs are established, and the availability of corresponding support systems is required. Compliance with the KSFs is analysed in the different Plant Operational States (POS) focusing on those POS that constitute HRE which are previously identified.

The POS are defined on the basis of the low power and shutdown PSA and are plant-specific configurations in which the risk of the plant is analysed. These same POS are used in the analysis of safe shutdown in case of fire in states other than power operation.

The aim is to ensure that contingency plans are in place when the plant is in an HRE and there is a risk of losing a KSF due to fire. During these shutdown modes where the risk is intrinsically high, additional controls or measures are assessed and implemented. Normal risk management controls and fire prevention/protection procedures shall be used during low risk periods.

During POS defined as a High Risk Environment (HRE), the criterion is to establish contingency measures in those fire areas where losses of the analysed functions may occur, carrying out combinations of the options listed below in order to reduce the fire risk, depending on the importance of the potential damage:

- Prohibition or limitation of hot work in the area during periods of increased vulnerability.

- Verification of the operability of detection and/or extinguishing in vulnerable areas.

- Prohibition or limitation of combustible materials in the area during periods of increased vulnerability.

- Changes in plant configuration (e.g.: removal of the power supply to a piece of equipment once it is in its desired position).

- Implementation of additional fire brigade watches at regular intervals or other compensatory measures (e.g. installation of surveillance cameras) during periods of increased vulnerability.

- Use of recovery actions to mitigate potential KSF losses.

- Identification and monitoring of ignition sources on site to determine possible "fire precursors" (e.g. temperature of equipment).

- Rescheduling of work to a period of lower risk or greater defence in depth.

Analyses currently carried out in accordance with NUMARC 9106 [41] for the development of shutdown plans and programmes ensure that KSFs are met during shutdowns. In addition, during outage planning, specific potential configurations are reviewed to determine their impact on plant risk and, if any KSFs in High Risk Evolutions (HRE) could be affected, the necessary contingency plans/actions are developed. These plans and actions result in the implementation of more stringent requirements than those required by the Technical Specifications for plant operation.

The plant operational states (POS) considered for the selection of equipment and cables can be divided into the following groups:

- POS where steam generators are available as an alternative means of residual heat removal.

- POS where the vessel lid is raised and the level in the RCS is close to the half-loop. Also included in this group are those POS where water is available in the steam generators but closure of the PORVs and the various open vents of the RCS is required. In these POS, steam generators cannot be used to extract residual heat from the core.

- POS where the spent fuel is discharged and fresh fuel is loaded into the reactor vessel. The plant is in Mode 6 "Refuelling", with the reactor cavity flooded.

The time available to insulate the primary and thus have the capacity to remove residual heat through the steam generators is given by the time before reaching boiling of the RCS (if the containment is open) or before core uncovery (if the containment is closed).

02.1.2.1.3 Radioactive Releases in the Event of Fire

For Spanish plants, Article 3.2.10 of IS-30 Rev. 2 is applicable. The analysis relating to ventilation systems and the non-release of radioactive fumes is included in section 3.3.2.2, considering the applicable guidelines, in accordance with SG 1.19 section 8.13.4.

In order to minimise the possibility of the generation of radioactive fumes, specific measures are in place to protect materials potentially containing radioactivity, such as spent ion exchange resins and filters, as set out in section 3.1.1 of design considerations for fire prevention, in accordance with the guidelines of SG 1.19 paragraph 11.4.

In accordance with section 8.1.14 of SG 1.19, separate drainage collection systems are available for buildings in radiological areas in which the drainage may be contaminated, with suitable treatment according to their quality. For tanks and pipes containing radioactive effluents, rupture as a result of fire (or extinguishing activities) is not considered to be expected.

For plants that have changed their licensing basis to a risk-informed and performance-based methodology, in accordance with FAQ-09-0056 [43] of NFPA-805, the analysis has been performed by fire areas, identifying the equipment whose malfunctioning in the event of a fire could lead to a radioactive release and taking into account both the systems existing in the area (effluent collection, ventilation, etc.) and the performance of the FP brigade.

As recommended in SG 1.19, the training of the FP brigade includes, among others, knowledge of the ventilation systems, risk analysis, radiation levels, organisation of the intervention, precautions to be taken into account in the event of fire, etc., for the different areas and zones of the plant.

On the basis of the information contained in the Pre Fire Plans (PFP), the fire zones with the possibility of radiological risk are determined. For fire areas with any potential radiological risk, existing engineering controls on liquid and gaseous effluents resulting from the fire and extinguishing activities are assessed to ensure that fumes are filtered before being released to the outside and that water used in the extinguishing activities is confined. For those areas that do not have the means to retain effluent, the contamination levels should be verified as sufficiently low so that an uncontrolled release does not exceed the limits of the Technical Specifications for plant operation or the Offsite Dose Calculation Manual.

RP staff, in Controlled Area emergencies, are called in with the First Intervention Team. Its action is presumed before starting any intervention in a Controlled Area and it advises the Brigade on the radiological situation of the area at all times. The Brigade does not intervene until the area is measured and validated by RP staff.

02.1.2.2 Probabilistic Assessment

02.1.2.2.1 Level 1 PSA

In accordance with Article 3.3.5 of IS-30, the fire risk analysis shall be completed by a Fire Level 1 probabilistic safety analysis at power.

Fire PSAs at the Spanish plants are performed following the guidelines of the document NUREG/CR-6850 *EPRI/NRC-RES Fire PRA Methodology for Nuclear Power Facilities* September 2005 [44].

The different phases for the implementation of the fire PSA are explained below.

1. Screening Analysis

A qualitative and quantitative screening is made to conservatively determine which fire zones, in the event of a fire, may contribute significantly to the core damage frequency.

In the first stage of the analysis, it is conservatively assumed that all equipment and components present in the fire zone where the fire occurs are affected immediately and in the worst possible way, and the possible propagation of the thermal effects of the fire to immediately adjacent areas is also considered.

In the screening analysis, the effects of the fire on the plant were assessed by determining the initiating events that could cause the fire, as well as the mitigation systems affected.

This analysis does not take into account the propagation of fire from the containment building to other buildings or the fire propagation from other buildings to the containment building, due to the special design and surveillance conditions of the containment building and its penetrations.

Based on the results obtained in the analyses described below, a number of fire zones are excluded from further detailed analysis, as the risk is considered to be non-existent or very low.

- Qualitative Analysis

  According to NUREG/CR-6850 [44], fire zones that do not contain equipment cables required for the mitigation of transients or accidents that may lead to core damage can be excluded from the detailed analysis.

- Quantitative Analysis

  A quantitative analysis of the fire zones is carried out assuming conservative criteria, as described in the previous paragraphs, to determine those in which the impact of the risk is practically negligible.

  Once the Core Damage Frequencies (CDF) of the Fire Zones are obtained, the criteria for excluding zones from the detailed analysis, according to NUREG/CR-6850, are as follows:

  - For each fire zone, CDF < 1.00E-07/R-y.
  - The sum of all core damage frequencies of screened fire zones < 0.1 x Internal Events CDF.

2. Detailed Analysis

The methodology of the detailed analysis, contained in NUREG/CR-6850, considers each potential fire origin, with its individual fire frequency, the specific characteristics in terms of initial damage, propagation, etc.

The detailed analysis takes into account for each fire source the ignition, growth and propagation characteristics in order to assess the time available to extinguish it. The affected cables and equipments are defined from each fire source and scenario. The probability of damage to the equipment affected by the fire is defined as the probability of failure to detect and extinguish the fire, depending on the systems and time available to extinguish it.

The analysis of fire growth and propagation from the different fire sources identified in each fire zone takes into account the characteristics of the different types of fire sources in terms of heat release rate and the physical layout of the source with respect to the equipment and trays located in its vicinity.

In general terms, the contribution to the CDF of a given fire scenario defined by a fire origin and certain targets that can be damaged in case the fire reaches them, in case of failure to extinguish the fire in the time available, can be defined as the product of the following factors:

- Fire frequency.
- For transient fires: fraction of area in which the analysed scenario may occur
- For hot work fires: cable weighting factor.
- Severity factor, which corresponds to the probability that a fire presents certain specific conditions that influence its growth rate, level of energy and duration so as to damage the targets.
- Probability of failure of available detection and extinguishing systems in the considered progression time.
- Conditional probability of core damage with the assumed damages in the scenario.

Additionally, for the fire areas included in the screening and detailed analyses, the consequences of possible fire propagation to adjacent areas are analysed, following the methodology of NUREG/CR-6850.

- In case the area to which the fire spreads does not contain cables or equipment credited in the fire PSA, the propagation is considered negligible.
- If the source area does not contain cables or equipment credited in the fire PSA, and if the propagation frequency is lower than the fire frequencies in adjacent areas, the propagation is also considered negligible. In some cases, propagation from areas without cables or equipment credited in the fire PSA and with very low fire frequency are directly excluded from the analysis.
- If the damage in the propagated area does not result in an increase of the assumed damages in the area of fire origin, the propagation is also considered negligible.

Finally, the fire level 1 PSA analysis, includes an uncertainty and sensitivity analysis.

02.1.2.2.2 Level 2 PSA

IS-25 on criteria and requirements on the performance of probabilistic safety analyses and their applications to nuclear power plants requires a full scope PSA, including a Level 2 fire PSA.

The main objectives of this analysis correspond to those defining a plant safety programme, and are as follows:

- Identification of the sequences of initiating events analysed in the Fire PSA that are most likely to give rise to significant radioactive releases outside the plant.
- Identification of potential vulnerabilities of the plant to cope with the sequences identified in the previous point.

- Identification of possible improvements, if necessary, in the design, procedures or practices, which could reduce this vulnerability.

The general methodology is in accordance with the requirements included in the Generic Letter 88-20 [45]. In addition, in the case of PWR plants, the Basic Guidelines for the development of Fire Individual Plant Examination (IPE) in Spanish PWR plants (Rev. 1), drawn up by the Spanish PWR owners' group, have also been used.

In the Level 2 fire PSA, core damage sequences and their possible progression to large releases and large early releases due to containment failure and bypass (containment isolation failure) are analysed.

In the accidental sequences, the effectiveness of the hydrogen recombiners and the filtered containment venting system during fire scenarios is analysed, as well as the containment isolation, its structural condition, the time in which core damage occurs and the possible retention of activity in the water inside the containment.

Uncertainty and sensitivity analyses are also carried out in the framework of the Level 2 fire PSA.

02.1.2.2.3 Low Power and Shutdown PSA (LPSD PSA)

As above, compliance with IS-25 requires a Level 1 and 2 LPSD PSA.

An internal fire, occurring during shutdown or low power operations, may be due to equipment malfunction or activities and transient combustibles, more frequent during shutdown.

The methodology of NUREG/CR-7114 [48], which is supported by NUREG/CR-6850 [44], is applied.

Fire frequencies are estimated on the basis of the operational experience of the plants, as was done for the at-power fire PSA, and using the same database. Recalculations shall only be performed for those ignition sources that vary substantially from the at-power fire frequencies.

In addition, the LPSD fire PSA has the following special features:

- The goal of the at-power PSA is to ensure stable and safe condition within 24 hours of the accident. However, LPSD PSA fires occur when the plant is already shut down, invalidating some of the considerations used for at-power PSA. For example, during an outage, the designated safe shutdown train may be undergoing maintenance, eliminating the benefits for the use of such a system by at-power fire PSA.

- The importance of the actions taken by the operator will increase, as there are fewer automatic responses from the plant, but human reliability methodologies tend to give credit only to actions that are proceduralised or can be considered as acquired operator skills.

The scenarios for the LPSD fire PSA need to consider the requirements of the fire programme during shutdown, i.e. whether it maintains the characteristics of: fire brigades, transient combustible controls, hot work permits (although the number of permits granted increases during the shutdown) and the availability and testing of fire protection systems.

02.1.3 Fire phenomena analyses: overview of models, data and consequences

The most significant fire-related phenomenological aspects considered in the analyses are listed below.

02.1.3.1 Associated circuits

The associated circuit analysis is applicable to both the deterministic safe shutdown analysis and the fire PSA.

Associated circuits in the field of fire protection are safety-related and non-safety-related electrical circuits which, due to a fire, may adversely affect the safe shutdown. Their definition is included in IS-30.

With regard to possible spurious operations, flow diagrams are used to identify components whose spurious actuation due to a fire may prevent the performance of the assigned safety or support functions. These possible spurious actuation correspond to valves and pumps, etc. and their failure mode is identified.

Additionally, instrumentation related to automatic actuations whose associated cables may give rise to spurious actuations of fire analyses SSCs is identified.

02.1.3.2 Multiple spurious operations

The multiple spurious operations (MSOs) analysis is applicable to both deterministic safe shutdown analysis and fire PSA.

A fire-induced spurious performance is an event in which the fire causes damage to cables such that a particular component goes into an undesired state, which prevents or impairs the performance of one or more safety functions.

Since the fire may affect numerous cables, it is possible to consider the occurrence of more than one spurious actuation during the progression of the fire.

The following cases are included in the analysis of multiple spurious actions:

- Spurious actions within the same train or redundancy of a system. In this case the consideration of multiple spurious actions makes no difference as long as the end result is the failure of such a train or redundancy.
- Spurious performances on different trains or redundancies. In this case the consideration of more than one spurious performance results in the consideration of the failure of the affected trains or redundancies.
- Spurious actions in different systems that perform or may perform the same function. In this case the consideration of more than one spurious performance results in the consideration of failure in alternative systems for the same function.
- Spurious actions in different systems or components resulting in a situation not previously considered. In this case the result is a different scenario that may be more severe than the scenario(s) originally considered.

NEI-00-01 Revision 2 [40], presents a list of MSO scenarios that basically fall into some of the above groups.

Based on the initial list contained in this reference, the following steps have been followed for the identification and analysis of potential MSOs that could occur as a consequence of a fire:

1) Identification of applicable MSOs. For the identification of applicable MSOs, the generic list included in Appendix G of the NEI 0001 has been used as a starting point, the affected cables have been reviewed for each fire area and from this information the potential MSOs applicable in each fire area have been obtained.

2) Conducting a panel of experts to analyse specific aspects of the plant that need to be taken into account for the MSO analysis.

3) Analysis of the consequences of the occurrence of MSO in deterministic and probabilistic analysis.

4) Resolution of deviations. In plants with a deterministic licensing basis, deviations from the safe shutdown capability have been solved by implementing design modifications (rerouting, installation of passive protections) or by using Operator Manual Actions (OMAs). These OMAs are proceduralised, have been demonstrated to be feasible and reliable in accordance with NUREG-1852 Demonstrating the Feasibility and Reliability of Operator Manual Actions in Response to Fire [49] and have a regulatory approval by the CSN, in accordance with section 3.2.9 of IS-30 Rev.2, in order to be credited for the fulfilment of the functions required for safe shutdown.

   For plants that have changed their licensing basis to NFPA-805 [5] the deviations have been considered as VFDR (Variance From Deterministic Requirements) and evaluated according to NFPA-805 Chapter 4, SG 1.14 [46] and RG 1.174 [47].

02.1.3.3 Human reliability in case of fire

The human reliability analysis is carried out within the framework of probabilistic analyses based on the NUREG-1921 document [50] and the internal events PSA. The purpose of this analysis is to identify and define the human actions required in the event of fire, document their analysis and the assignment of values to the probabilities of human failure. The results of this analysis are incorporated in the Fire PSA.

Among the Human Reliability analyses carried out, the following human actions should be highlighted:

1. Human actions in response to the fire

In the deterministic safe shutdown analysis in case of fire, OMAs credited to fulfil the safety functions, as described in the previous section, are analysed.

In the case of fire PSAs it is necessary to model specific human actions in the event of a fire, starting from the analysis of the cables that would be affected by a fire at a given origin.

Firstly, the cables that are affected by a fire and the equipment associated with them are identified, analysing whether such equipment is associated with equipment modelled in the Fire PSA.

This identification takes place at different levels:

1) Cables that may affect equipment related to initiating events identified in the PSA.

2) The second step is the identification of cables that may affect mitigation equipment considered in the PSA.

3) The third step is the identification of cables that may affect equipment (instruments) necessary for the performance of operator actions modelled in the PSA.

4) The fourth step is the identification of cables that may affect equipment/instruments that are not assigned to a basic event and need to be analysed in detail because of their potential impact on human actions.

In relation to the above, no operator action other than those set out in the existing procedures have been identified.

2. Unwanted operator responses to spurious alarms and indications included in procedures.

According to the general systematics for the realisation of PSAs, the actions of the Operation shift are identified primarily through sequence analysis and review of plant procedures. In the particular field of human reliability analysis in case of fire, the methodology contemplates the review of three types of procedures: emergency operating procedures (EOPs), alarm book and fire procedures, understood as those procedures (apart from EOPs and/or abnormal response procedures) that the Operation shift uses to respond to a fire in any area of the plant (NUREG-1921).

The process for identifying and defining these types of human actions is as follows:

1) Review of responses to alarms. Taking all control room alarms as a starting point, a systematic review of equipment or system alarms modelled in the PSA is performed to identify operator responses that may complicate the plant situation. For the analysis of this type of human action, the following has been taken into account:

   - CRITERION 1. The first level of screening has been to discard those alarms that would in any case not affect equipment directly or indirectly modelled in the PSA.

   - CRITERION 2. The second level consists of alarms with multiple channels or alternative parameters to identify the actual cause of the event, which are screened according to the NUREG-1921 criteria [50].

   - CRITERION 3. The third level of screening is the so-called selective analysis, which consists of those alarms that, by means of a small analysis or directly from the reading of the action required by the alarm, can be discarded as a possible origin of an incorrect action by the operator, either because it would not occur or because if it did occur it would not impact the control of the plant.

   - CRITERION 4. Finally, the fourth level corresponds to the detailed analysis carried out for the remaining alarms not screened in the previous steps, to assess the impact on the plant evolution of an incorrect response by the operator as a result of a spurious actuation.

   Additionally, Operation performs or participates in the analysis of spurious activation of alarms of equipment or systems considered in the PSA. The following premises have been taken into account in order to rule out shift actuations in response to the spurious activation of alarm that would not impact the plant evolution:

- If the spuriously activated alarm has automatic actuations associated with other instrumentation, the fact that these actuations did not occur can be interpreted as confirmation of a spurious activation of the alarm. However, allowance has been made for the possibility that the source of the spurious signal may give rise to both the alarm and other subsequent actions. In other words, the very origin of the spurious activation of the alarm can also trigger automatic actions.

- It is assessed whether the Operation shift would be able to carry out effective additional checks to identify a possible spurious activation, being able to rule out these cases from the instrumentation available in the Control Room or with the help of the Support staff. Likewise, Operation is actively involved in the process of consequence analysis in response to possible spurious alarms, both in the analysis itself and in the review and validation of the conclusions drawn.

2) Review of procedural steps (normal, abnormal and emergency)

A systematic review of the steps of the operating procedures (normal, abnormal and emergency) is performed to identify possible operator actions in case of instrumentation spurious indication that may complicate the plant situation.

3. Human actions of the Fixed Extinguishing Systems

The Fire PSA evaluates the non-suppression probability in the relevant fire zones using NUREG/CR-6850 curves.

4. Human actions in case of abandonment of the Control Room

In general, there are two criteria for control room abandonment: loss of habitability of the control room (due to smoke, heat…) and loss of control from the main control room.

In the event of a control room abandonment, the human reliability analysis focuses on identifying the actions to be taken to proceed to mitigate the accident from the alternative shutdown panel, using the available fire mitigation procedures.

02.1.3.4 Propagation analysis

The Fire PSA includes the study of the progression and development of fires in the selected fire zones for each of the sources considered.

The objective is to determine the times at which targets are damaged due to fires at the various origins. This time relates to the time available for extinguishing and the potential burned trays for each source will serve as a basis for determining the extent of damage and therefore which equipment could be affected by the fire.

The work carried out for the fire propagation calculations in the selected areas is as follows:

- Calculation of the flame height.
- Calculation of the plume centerline temperature of a fire.

- Calculation of the ceiling jet temperature and height.
- Calculation of the hot gas layer temperature and height.
- Calculation of the radiant heat flux to a target.

The scope of the calculations, as well as the methodology used, is determined by NUREG-1805, *Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program (FDT's, Fire Dynamic Tools)* [51], by NUREG/CR-6850 and by NUREG-1934, *Nuclear Power Plant Fire Modeling Analysis Guidelines (NPP FIRE MAG)* [52].

02.1.3.5 Analysis with *Fire Dynamics Simulator* (FDS)

In addition to the propagation calculations indicated in the previous section, FDS calculations have been performed at the Almaraz, Ascó and Vandellós nuclear power plants for certain locations and scenarios considered to be of special relevance.

02.1.4 Main results / dominant events (licensee's experience)

02.1.4.1 Almaraz NPP analysis

Almaraz NPP requested the adoption of the probabilistic and performance-based fire protection licensing basis (according to Article 2.3.8 of IS-30). According to Chapter 4 of NFPA 805 (Ed. 2001), the following main activities have been carried out with the aim of implementing this standard:

- A deterministic analysis of fires at power and in other modes of operation. If the deterministic requirements are met, the risk criteria are considered to be satisfied and do not require further analysis.
- A probabilistic fire analysis (level 1 and 2).
- Cable identification and location.
- Engineering Analysis. Areas with exemption and unacceptable risk.
- Modifications in areas with unacceptable risk.
- Assessment of radioactive releases.

Activities began in 2007 and culminated in approval by the CSN in 2020, together with the renewal of the Operating Permit.

NEI 04-02, *Guidance for Implementing a Risk-Informed, Performance Based Fire Protection Program* [53], issued to help plants transition from their current licensing basis to a new licensing basis based on NFPA 805, was used as project guidance. This guidance was endorsed by the NRC with RG 1.205, *Risk-Informed, Performance-Based Fire Protection for Existing Light Water Nuclear Power Plants* [54].

The results of the compliance assessment at Almaraz NPP are presented below.

02.1.4.1.1 Deterministic Evaluation

Safe shutdown analysis

The criteria of the analysis to be performed are similar whether or not the plants have transitioned to NFPA-805, except for the nuclear safety goal (safe and stable condition) of the plant.

For pressurised water reactors, with the fuel inside the vessel and the vessel head on, the safe and stable condition is defined as the ability to maintain the $K_{eff} < 0.99$, with the coolant temperature at or below that defined for the hot standby mode (1.6.56 of NFPA 805).

According to NFPA 805, the objective of nuclear safety requires "...reasonable assurance that a fire during any mode of operation and plant configuration will not prevent the plant from achieving and maintaining the fuel in a safe and stable condition" without specific reference to an operating time or the time to deal with an event. In order for the plant to be in a safe and stable condition, it may not be necessary to reach Cold Shutdown as required in Article 3.2.4 of IS-30. Therefore, the plant can remain at or below the temperature defined by the Hot Standby mode of operation.

As a differential element in the fulfilment of safety functions, at Almaraz NPP, credit has been given to steam isolation to consumers, as a reinforcement of the main steam isolation.

As a result of the deterministic analysis carried out according to the criteria described above (section 2.1.2.1), some areas, where the criteria of NEI-00-01 Rev. 2 [40] are not met, have been identified in the following buildings: containment, safeguards, auxiliary, electrical and essential services intake structure.

Additionally, as a result of the safe shutdown analysis, the shutdown paths chosen to comply with NEI-00-01 Rev. 2 have been identified for the areas that do not meet the criteria of NEI-00-01 Rev. 2 (Section 3.3). According to this procedure, it is possible to identify the equipment that fails to meet the deterministic criteria in each zone. These zones have been assessed from a probabilistic point of view, as described in the corresponding section, and the increase in total plant CDF due to these deviations (VFDR) with regard to deterministic compliance is acceptable, although in some cases design modifications were required.

In relation to the analysis in the fuel building, the focus is on the assessment of the cooling capacity of the spent fuel assemblies stored in the pool in case of fire. The existing cooling and water supply alternatives are evaluated and it is concluded that the only fire area where water supply capacity could be lost due to the loss of the three FP pumps is one cable room. This scenario has been solved crediting the use of the procedure POA-1-SC-4 Operation from the Alternative Shutdown Panel for widespread fires in the control room or the cable room, which includes the possibility of cooling the pool with the SW system from this panel.

Low power and shutdown deterministic analysis

In addition to what is indicated in the corresponding part of section 02.1.2.1.2, for plants transitioning to NFPA-805, NEI 04-02 and FAQ-07-0040 *Non-Power Operations Clarifications* [55] are also applicable.

A documented low power and shutdown deterministic analysis is available. As in the safe shutdown analysis (at-power), it identifies in each zone the equipment that may be affected in order to maintain the key safety functions.

The analysis has focused on the operation of the plant in modes 4, 5 and 6, distinguishing between safety functions that can be credited during high-risk POS and non-high-risk POS.

As a result of this analysis, some fire areas and zones have been defined in which the RHR system and/or process monitoring (temperature instrumentation) cannot be credited from a deterministic point of view, during high risk evolutions (HRE), in the Containment, Safeguards, Auxiliary and Electrical buildings. In these areas, design modifications have been implemented and/or compensatory and contingency measures have been put in place.

With regard to the key safety functions, the evaluation of the POS defined in FAQ 07-0040, revision 5, as well as the criteria established in the pilot plants (Oconee and Shearon Harris), has led to the exclusion of the containment integrity safety function from the analysis.

The application of the above FAQ in the definition of HRE and the consequent selection of equipment and cables in the resulting POS is based on the consideration of the following criteria:

- The fuel is in the vessel

  AND

- The time to boil is less than 2 hours

  OR

- The plant is in a low reactor coolant system inventory condition.

Additionally, it should be noted that, at Almaraz NPP, when equipment related to the fulfilment of a KSF is taken out of service during a HRE, its impact is assessed based on the status of the KSF equipment and the conclusions of the low power and shutdown analysis, in order to develop or revise the necessary contingency plans/actions.

02.1.4.1.2 Probabilistic assessment

In accordance with the NFPA-805 methodology, the corresponding probabilistic assessment has been carried out at Almaraz NPP, and the corresponding PSA studies have been performed, with the particularities and results shown below.

As part of the transition project, a Peer Review on the fire PSA methodology was carried out at Almaraz NPP. No deviations were identified during this Peer Review.

Level 1 Fire PSA

1. Screening Analysis

- Qualitative Analysis

  The fuel building has been excluded as there is no equipment required for the mitigation of transients or accidents that could lead to a core damage situation, and furthermore, this building has no communication with other buildings.

  Taking into account what is reflected in Almaraz's Fire Database, fire zones that do not have equipment cables credited for the mitigation of transients or accidents have been eliminated from the detailed analysis.

The 4DG building has been eliminated as it is an independent building separate from the rest of the buildings in which there are cables that only affect the 4DG, which does not produce a reactor trip due to a fire.

The application of the above criteria results in the elimination of 29 fire zones in the qualitative analysis phase.

There are however some areas which, although they may not contain equipment cables required for the mitigation of transients or accidents that could lead to a core damage situation, a fire in these areas may result in a plant trip. These areas are analysed quantitatively.

Propagation between certain areas (containment and transformer outdoor areas) is reasonably ruled out.

- Quantitative Analysis

  The 46 areas excluded in the selective analysis, based on quantitative criteria, meet the criteria for exclusion from the detailed analysis:

  - The total CDF of the screened areas amounts to 3.56 E-07/R-y < 4.39 E-07/R-y (0.1 x CDF internal events)
  - For each fire zone, CDF < 1.00E-07/R-y.

2. Detailed Analysis

As a result of the qualitative and quantitative analysis, a detailed analysis is carried out in 77 fire zones.

The objective is to determine the impact on the risk increase as a consequence of not strictly complying with the deterministic criteria of section 4.2.3 of NFPA 805, i.e. the risk as a consequence of Variances from deterministic requirements (VFDR). This increased risk is established based on the results of the detailed fire PSA, with respect to the core damage frequency (CDF) and the large early release frequency (LERF).

Risk assessments should be quantitatively estimated for acceptability by determining the ΔCDF and ΔLERF using the criteria set out in RG 1.174 and RG 1.205, Rev. 1.

VFDRs are identified from the safe shutdown analyses of the plant. A VFDR is considered if any safety function cannot be guaranteed due to the failure of the mitigation system trains as a consequence of the fire, considering the total loss of the equipment and cables in the analysed fire area. These VFDRs are assessed with the Fire PSA to calculate the increased risk.

The total CDF of the Fire PSA is currently 3.02E-5/year, according to the current review of the Licensing Report and its supporting documentation.

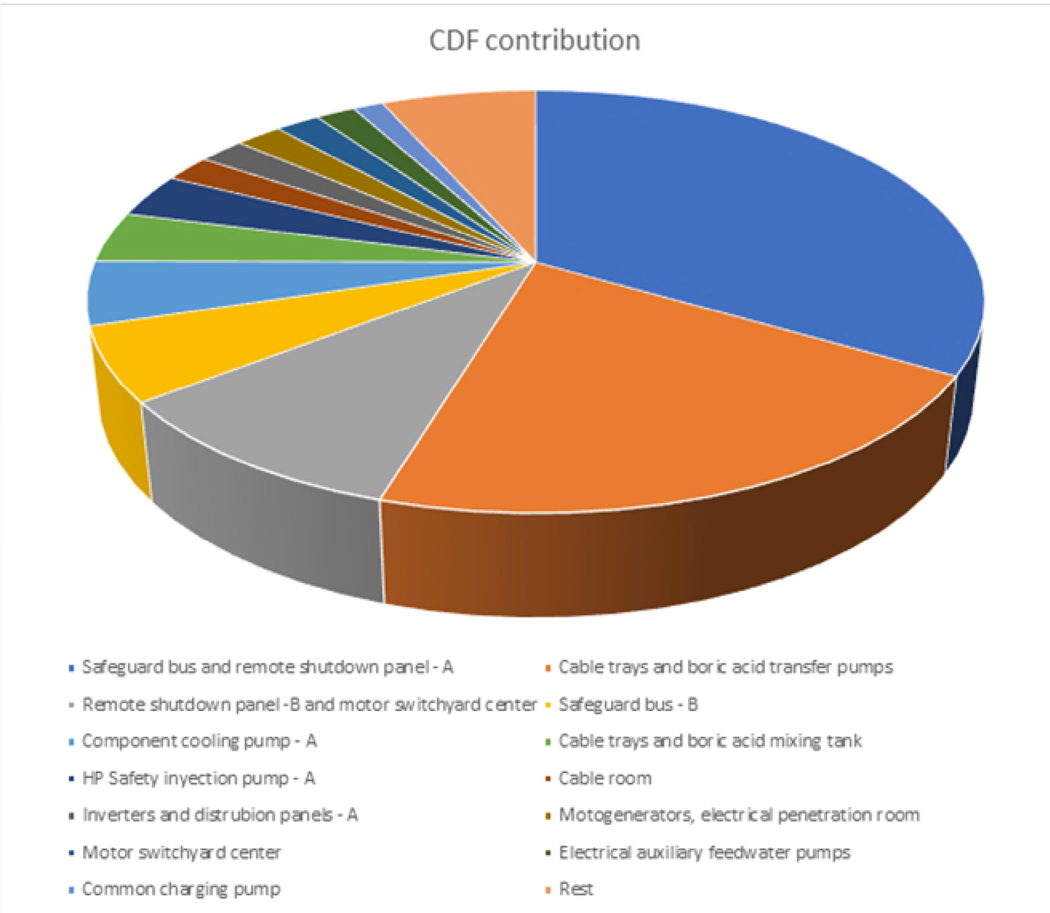
It has been estimated that the consideration in the PSA of the design modifications (DM) implemented in recent years will lead to a reduction in the CDF of around 50%. This reduction of the CDF will be reflected in the ongoing update of the NFPA 805 documentation.

The most significant modifications implemented have been a consequence of the application of defence in depth criteria, the improvement of I&C information to operators and the elimination of some LOCA and HEAF scenarios:

- Routing of H_2 lines.
- Improvement of procedures (control of combustibles and hot works Pre-Fire Plans and an auxiliary fire procedure)
- Replacement of Hemyc-type ceramic blankets installed in accordance with GL-2006-03 and IN 2005-07 in certain fire zones.
- Installation of RCP passive seals, together with their automatic trip.
- Protection of trays, conduits and cable rerouting of the pressuriser PORVs, RCPs thermal barrier and CCW system cables.

Once these DMs have been implemented, the increase in the resulting CDF, with respect to considering compliance with the deterministic criteria, is 7.11E-6/R-y, meeting the requirements of RG 1.174.

The following figure represents the contribution to the CDF of the risk associated with the different fire areas:



Level 2 Fire PSA

As part of the transition methodology, it is necessary to develop a Level 2 fire PSA, as outlined in the relevant part of section 02.1.2.2.

- LERF increase

To determine the increase in LERF as a consequence of not strictly complying with the deterministic criteria of section 4.2.3 of NFPA 805, the results of the Level 2 Fire PSA are used as a starting point.

The source term category (STC) contributing to the LERF are: induced steam generator tube rupture (SGTR) (STC 22), containment isolation failure (STC 20), early containment failure, DCH (STC 3) and alpha mode (STC 1).

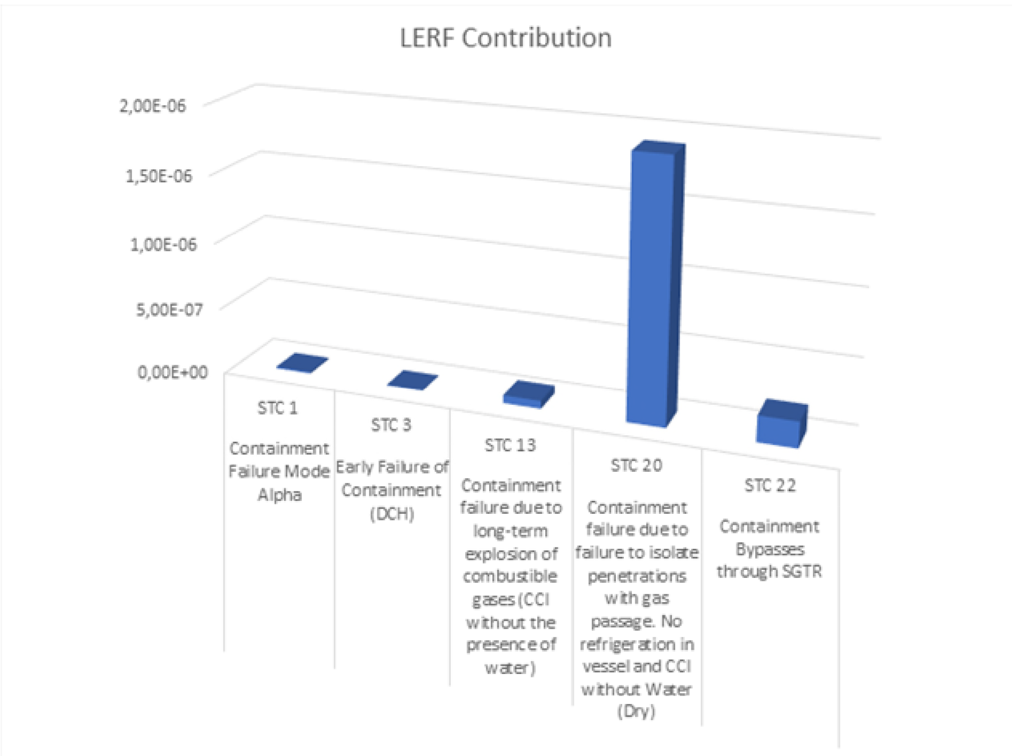
The categories of release of induced SGTR, DCH and alpha mode, are developed based on models explicitly considered in the Level 2 PSA.

The LERF value in the current Level 2 Fire PSA at Almaraz NPP is 2.18E-06/year, which represents 6.34% of the CDF of the Level 1 Fire PSA.

The current LERF increase of Almaraz NPP due to not strictly complying with the deterministic criteria of NFPA Section 4.2.3, defined as indicated in Appendix B of NUREG/CR-6595 [56], is 3.47E-07/R-y, which is well within the permitted limit of 1.00E-6/R-y in Region II of RG 1.174. This check has been carried out both per fire area and for the total LERF increase.

The above values will be improved in the next edition of the Level 2 Fire PSA by incorporating the design modifications outlined in the previous section. The LERF increase is expected to be reduced from 3.47E-07/R-y to 8.31E-08/R-y.

Next figure shows the contribution to the LERF:



Low power and shutdown PSA

The LPSD PSA of Almaraz NPP has been developed according to the requirements explained in the corresponding part of section 2.1.2.2.3, not being related to the NFPA-805 transition.

Based on the Fire PSA, the Level 1 and Level 2 LPSD PSA has been addressed. Its most relevant results are:

Total CDF of the LPSD Fire PSA is 1.7E-05/R-y and the LERF is 1.61E-06/R-y. By building, the largest contributor to the CDF (56%) is the electrical building, followed by the safeguards building (21%). In terms of LERF, the most contributing buildings coincide with the above (82.5% and 11%, respectively).

These results are considered acceptable, in accordance with CSN SG 1.14 and RG 1.174.

02.1.4.1.3 Associated circuits and MSO

These analyses have been documented at Almaraz NPP, following the methodology described in Sections 02.1.3.1 and 02.1.3.2. These analyses are taken into account, both in the deterministic safety analysis and the fire PSA, therefore they are included in the results, and have also been considered in the establishment of the improvement measures implemented (cited in the PSA section).

02.1.4.1.4 Human Reliability Analysis

At Almaraz NPP the corresponding Human Reliability analysis has been carried out and documented, as explained in section 02.1.3.3.

With respect to non-suppression probabilities, the Almaraz NPP Fire PSA calculates the non-suppression probability by modelling the human actions needed for the manual actuation of fixed systems in the corresponding fire zones, and by using the non-suppression NUREG/CR-6850 curves.

Additionally, an analysis was performed of the generic emergency response guidelines, finding no steps containing logical decisions that could result in unintended operator actions as a result of a fire-induced single instrument failure (NUREG-1921 analysis requirement). This is because the decisions in such guidelines are based on indications of a sufficient diversity and/or redundancy that spurious fire-induced indications in a single instrument will not cause operators to take actions that worsen the accident response.

These conclusions can be extrapolated to the Almaraz NPP EOP.

The analysis has been extended to AOP expected to be followed during certain fire scenarios, although this extension of scope is not required in NUREG-1921 which limits the scope to EOPs. The human actions identified in this analysis are included in the Fire PSA model, with their specific considerations (feasibility, quantitative, dependency and sensitivity/uncertainty analysis).

Apart from the above, in order to analyse the correct use of the EOPs in the event of equipment and instrumentation failure due to a fire, it was considered appropriate to develop specific fire scenarios for analysis and periodic training in the simulator. This activity led to the conclusion that EOPs are adequate procedures for the management of the fire scenarios that may occur in the plant. In addition, a specific auxiliary support procedure has been developed.

Improvements associated with this section include the development of the auxiliary fire procedure, as well as the implementation of specific fire sheets on the operation support screens.

02.1.4.1.5 FDS Analysis

*As indicated in section 02.1.3.5, the FDS a*nalyses performed in the context of the Almaraz NPP NFPA 805 transition project should be highlighted. The purpose of these calculations was to assess the temperature rise, heat flux and potential propagation in case of fire in cable trays located in rooms considered to be of special relevance.

These calculations have been developed for the train A and B safeguards switch rooms located in the Electrical Building. Significant effort has been devoted to this work, given the complexity and level of detail of the calculations and modelling.

The postulated fire in each area is caused by a high-energy arcing fault affecting a number of switch cabinets and cable trays located within the boundaries of the zone of influence (ZOI).

As a result of this analysis, it was found that HGLT (hot gas layer temperature) does not occur in a large fire caused by high energy arcing faults, however, specific improvements have been implemented in the safeguard bus-bar rooms of both trains (routing/protection of PORV cables) to prevent scenarios of conditional probability of core damage equal to 1.

02.1.4.1.6 Radioactive release analysis

In all potentially radiologically hazardous fire areas of the nuclear island buildings, liquid and gaseous effluents resulting from the fire and the extinguishing activities are confined and filtered, respectively, before release to the outside. The liquid effluents are channelled through the drainage network to different tanks which are fitted with level alarms. The gaseous effluents are discharged, filtered, through the chimney of the auxiliary building or the fuel storage building, where radiation monitoring screens are available.

From the analysis carried out, the conclusion is that fumes and water generated by firefighting activities will be confined within the buildings, or if not, the radiological risk is negligible because the risk of fire is extremely low and the equipment is stored without radioactive surface contamination, as required by revision 2 of FAQ 09-0056 [43]. Due to this conclusion, it has not been necessary to consider additional means.

Additionally, improvements (detection and collection of drainage resulting from possible actuation of the FP brigade) have been implemented in some buildings defined as waste areas and where staff traffic is low.

In conclusion, it can be stated that radioactive releases to unrestricted areas due to the direct effects of firefighting activities are as low as reasonably achievable and do not exceed the limits of the Release Specifications contained in the Offsite Dose Calculation Manual.

02.1.4.1.7 Other analyses

The results of other FP-related analyses performed by Almaraz NPP are presented below.

Analysis of the actuation of pre-action or automatic FP systems

In the event of the actuation of pre-action or automatic systems, the impact on the plant risk is analysed for each of the following buildings: Unit I safeguard, Unit II safeguard, auxiliary and purge treatment, electrical and controlled access tunnels.

The actuation of such systems result in water releases that generate lower flood levels than those resulting from the deterministic flooding analysis except for the cases shown below.

In the Unit I and Unit II Safeguarding Building, after comparing the levels obtained in the deterministic flooding analysis with the once obtained from the actuation of the FP system, the level obtained is only exceeded in one case but it does not exceed the critical level of the room (240 mm).

In the Electrical Building of Unit I, the resulting level from the actuation of the FP systems is higher than the one obtained in the deterministic flooding analysis in the DGs 1 and 3 rooms, in two cable rooms, in two staircases and in one corridor.

Only the level in the emergency diesel rooms (critical level = 250 mm) is considered relevant. In the rest of the rooms, although the results are higher than those of the deterministic flooding analysis, they are of no consequence.

In accordance with the *Flooding protection Manual*, there is sufficient time to prevent the flooding level reach the critical height in both emergency diesel generator rooms.

In the Electrical Building at Unit II, a level higher than the level given in the flooding deterministic analysis for the electrical building is reached in the DG 2 room.

The level obtained is slightly higher than in the flooding deterministic evaluation, which already exceeded the critical level, although this was justified by the fact that, as only diesel generator 2 (train A) was affected, it would be acceptable for the operation of the plant.

In addition, the potential damage caused by water spraying as a result of spurious operation of the pre-action or automatic fire protection systems in buildings with fire protection systems has also been analysed.

The different rooms that could be affected have been identified. All rooms with pre-action or automatic systems have been analysed within the scope of the deterministic spray damage analysis resulting from cracks or pipe breaks in these rooms, so the analysis of spray damage due to the actuation of the FP system would be covered by the deterministic spray analysis.

Analysis of ISFSI Container Fires

The consequences of a fire resulting from an aircraft impact (worst case scenario) have been analysed by calculating the temperature increase in the ISFSI containers.

The analysis was carried out in two steps:

- Simulation of the fire, using the FDS code, to obtain the net heat flux absorbed by the containers.
- Calculation, by means of the FLUENT code, of the temperature increase produced in the containers by the absorption of the heat flux calculated in the previous step.

Taking into account the environmental conditions of the site, two fire scenarios have been simulated, corresponding to two different wind conditions, concluding that the one with the higher wind speed is more unfavourable, leading to a greater heat flux towards the container.

The temperature reached in the shielding material would be higher than the operating temperature of the shielding material, but not of the aluminium structures of which it is composed.

The maximum temperature in the shielding material is reached at the end of the fire, 3350 s after the start of the fire. The maximum temperature in the fuel is reached 24 h after the start of the fire.

The maximum temperature reached in the fuel element is far from the maximum permissible temperature.

In view of the above results, and taking into account the conservatism considered in this study (very high wind speed throughout the duration of the fire, no credit given to the perimeter wall protecting the slab, container at its maximum residual storage capacity, etc.), the result obtained in the simulated scenario is considered acceptable. The maximum temperatures reached by the fuel element are well below the maximum permissible temperatures and only part of the shielding material could be compromised, while the temperature of the structures is considered acceptable.

The conclusion obtained is that the Almaraz NPP analyses are covered by the Cask Storage Safety Analysis in the different phases of the fire, and that there is no risk of reaching the maximum permitted temperatures in the fuel assemblies stored.

Fire analysis in the fuel storage building

The Fire Analysis in the fuel storage building is focused on the assessment of the cooling capacity of the spent fuel assemblies stored in the pool in case of fire. These analyses include the components required to fulfil the spent fuel pool cooling function of the spent fuel pool cooling system: the two pumps and the valves associated with the component cooling system.

In case of failure of the fuel pool cooling system, different alternatives for cooling and diverse means to make up pool inventory are available.

The deterministic analysis carried out was focused on determining whether any of the pumps required for cooling and/or inventory makeup are available in all the zones/areas of the plant. Based on the FP pumps, which would allow to make up inventory, the following conclusions can be drawn:

- The only area that houses cables from the 3 FP pumps is a specific cable room). The area where the cables of two of the pumps meet is at least 8 metres away from the area where the other pump could be lost. However, this justification is not considered valid from a deterministic point of view as there is intermediate combustibles between the two regions. In the event that the fire occurs in this cable room and affects the 3 pumps, the procedure POA-1-SC-4 "operation from the Alternative Shutdown Panel due to widespread fire in the control room or cable room", would allow cooling the pool with the SW system from this panel.

- In every other zone and area, at least one FP pump is kept free from fire damage from a deterministic point of view.

As a consequence, it is concluded that a fire does not compromise the cooling and/or fuel pool inventory makeup in any area or zone of the plant.

At Ascó NPP, the fuel building is included in the safe shutdown analysis in case of fire as an additional fire area within the scope of the analysis according to the methodology of NEI-00-01 Rev.2 [40], which does not include the functions related to the cooling of the pool as necessary for the safe shutdown.

However, the analysis of the cooling function of the spent fuel pool is included in the deterministic analysis of fires under shutdown conditions.

The function requires the operation of a cooling pump and a heat exchanger.

The alternative cooling of the spent fuel pit is based on the inventory makeup, with multiple alternatives being contemplated for its implementation, all of which are included in the procedure for the spent fuel pool Loss-of-cooling events.

In accordance with NRC FAQ 07-0040, taking into account the time to boil and the different means of inventory makeup, the analysis concludes that the cooling function of the spent fuel pool is not considered to be risk significant. The plant configuration in the high-risk EOPs ensures that the cooling function of the spent fuel pool is fulfilled during the EOPs, so no equipment is required for this function and no detailed analysis of the cooling system cable routes is required.

Additionally, according to IS-25, there is a Level 1 spent fuel pool PSA in which the fuel damage frequency is determined. However, this PSA does not include fire as an initiating event.

02.1.4.2 Vandellós NPP analysis

02.1.4.2.1 Deterministic evaluation

Safe power shutdown analysis

As a result of the deterministic analysis performed in accordance with the methodology described in NEI-00-01 Rev. 2, fire areas were identified that, in order to comply with the separation criteria, required design modifications to be made (installation of passive protections or a combination of passive protections with automatic detection and suppression systems) or the modification/generation of operating procedures for the performance of operator manual actions (OMAs) which, once validated and implemented, were submitted to the CSN for its regulatory approval.

Two sets of OMAs are available:

1. OMAs required for safe shutdown in the event of a control room fire. They were included in a section of procedure POF-115, Shutdown from the remote shutdown panel, currently under revision 21.

2. OMAs required for safe shutdown in case of fire in fire areas other than the control room. A specific procedure, POF-327 Operator's manual actions in fires located outside the control room, was generated and is currently under revision 3.

In both cases, the regulatory approval process of the OMAs included the following steps:

- Identification of deviations from safe shutdown capability generally due to multiple spurious operations (MSOs) derived from the analysis carried out according to NEI-00-01 Rev.2;

- Definition of the operator manual actions to be implemented locally to resolve the above deviations and drafting of a procedure;

- Determination of the available time for the OMAs by thermo-hydraulic calculations;

- Validations of OMAs to verify their feasibility and reliability according to NUREG-1852 [49]. During this process it is verified that OMAs are feasible by checking the availability of the necessary personnel and tools, that there is adequate access for carrying out the actions while taking into account the conditions expected during the fire (lighting, environmental conditions, etc.) and that they can be carried out within the available time. The time calculated taking into account, the fire growth time (Tc) plus the sum of the diagnosis time and the execution time (T1) should be less than the available time (Td). Additionally, it is verified that OMAs are reliable by allowing extra time for uncertainties, for which an additional margin for uncertainties (T2) equal to the sum of the diagnosis time plus the execution time is generally considered.

  OMA feasible: $(Tc + T1) < Td$ where $T1 = Tdiagnosis + Texecution$

  OMA reliable: $(Tc+T1+T2) < Td$ where $T2=T1$

In addition, for three fire areas with deviations related to R180 fire barriers, a regulatory approval of equivalent compliance measures has been requested in accordance with Article 3.2.5.1.d of IS-30.

- In the fire area corresponding to the main steam relief valves, the application has relied on FDS calculations to rule out the propagation through penetrations used by three armoured trays, so that the separation between the areas corresponding to each of the three main steam relief valves can be considered equivalent to three-hour fire barriers. In addition, fire-stops have been installed on these trays.

- The fire area corresponding to the condensate water tank in outdoor areas and without fire combustibles and ignition sources was not favourably approved and a modification was required to separate the redundant train level instruments and their electrical conduits by means of a R180 barrier. The RWST is also affected by a similar design modification.

- In the fire area corresponding to the containment, a request was made on the basis of the characteristics of the containment building itself, with separating walls and intermediate separations. The CSN considered that the design was aligned with the guides in SG 1.19.

This ensures that, in the event of a widespread fire in any fire area, a train will remain available to achieve and maintain safe shutdown (mode 3) and, within 72 hours following the onset of the fire, recover all the equipment and systems required to achieve and maintain cold shutdown.

The strategy for the fulfilment of the safety functions in each fire area is set out in the Fire Hazard Analysis, included as Appendix 9.5B to the Safety Analysis Report.

Low power and shutdown deterministic analysis

The availability of the RHR and CVCS systems has been analysed i and it has been determined in which fire areas a complete loss of one of them could occur in the event of a fire during low power and shutdown.

As a result of the analysis, defence in depth measures have been established to reduce the fire risk during the high risk POS (POS 11 and POS 12). These measures consist of not granting Fire Risk Work Permits (FRWPs), in certain fire areas during these POS. This measure was included in procedure PCI-15 Rev.13 as well as in procedure PA-126.

02.1.4.2.2 Probabilistic Safety Analysis

The Vandellós II NPP has the following analysis: level 1 and level 2 Fire PSA and level 1 and level 2 LPSD Fire PSA.

The particularities and results of each of them are discussed below.

Level 1 Fire PSA

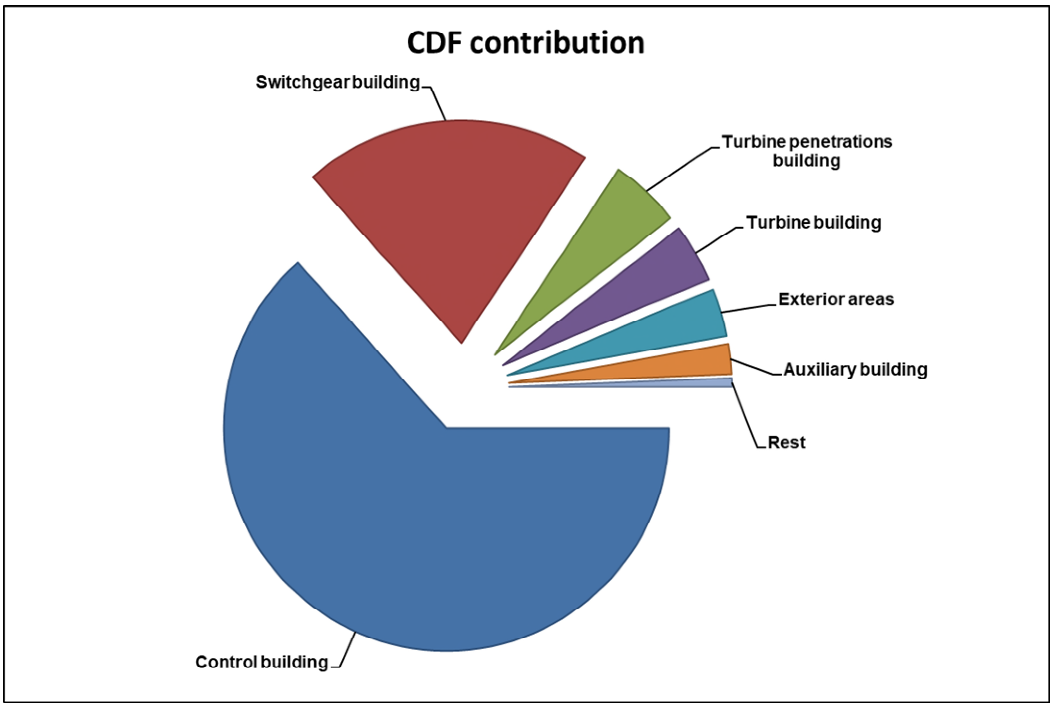
The documents indicated in the generic part of the report (NUREG/CR-6850, NUREG-1921 and NUREG-1805) have been used as methodological references and, additionally:

- propagation calculations have been performed on the basis of the NUREG-1934 *Nuclear Power Plant Fire Modelling Analysis Guidelines (NPP FIRE MAG*) [52].
- the fire frequency calculations have been performed on the basis of NUREG-2169 *Nuclear Power Plant Fire Ignition Frequency and Non-Suppression Probability Estimation Using the Updated Fire Events Database* [57].
- as stated in NUREG-1921, EPRI's *HRA Calculator* software [50] has been used for the human reliability analysis

Furthermore, the development of the PSA is consistent with ASME/ANS RA-Sa-2009 [58] meeting the requirements for "Capability Category II".

The Level 1 Fire PSA results obtained a CDF of 1.54E-5/R-y, with the control building being the largest contributor to the risk (63.37%) followed by the switchgear building (20.99%). Regarding fire areas, the largest contributor is the control room (36.67%).

The following figure shows the contribution to the CDF of the different buildings:

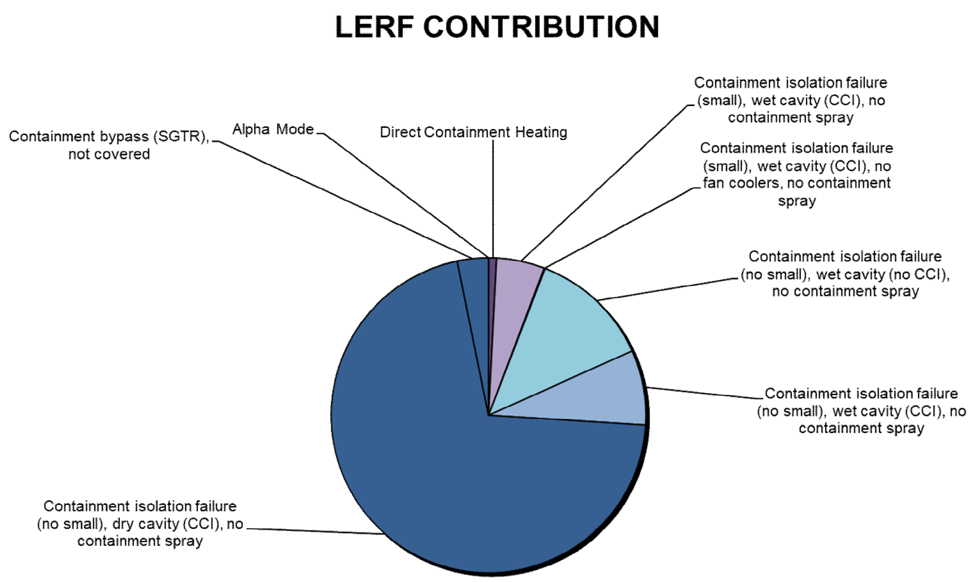


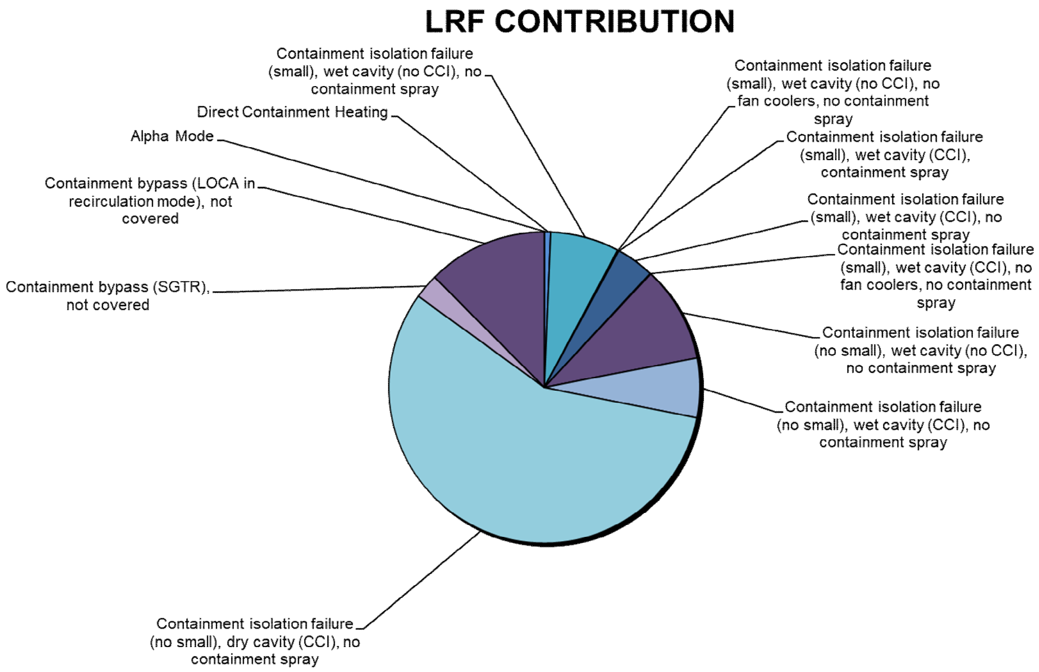
Level 2 Fire PSA

A noteworthy aspect of this PSA is that it incorporates the design modifications and strategies derived from the results of the stress tests carried out after the Fukushima accident, i.e. the installation of the filtered containment venting system, the autocatalytic passive hydrogen recombiners, and the implementation of the reactor cavity flooding strategy.

The Level 2 Fire PSA results obtained a LERF of 1.50E-6/R-y and a LRF of 1.87E-6/R-y, with the control building being the largest contributor to the risk (63.37%) followed by the switchgear building (20.99%).

The following figure represents the contribution to the LERF and LRF of the different source term categories:





Level 1 LPSD Fire PSA

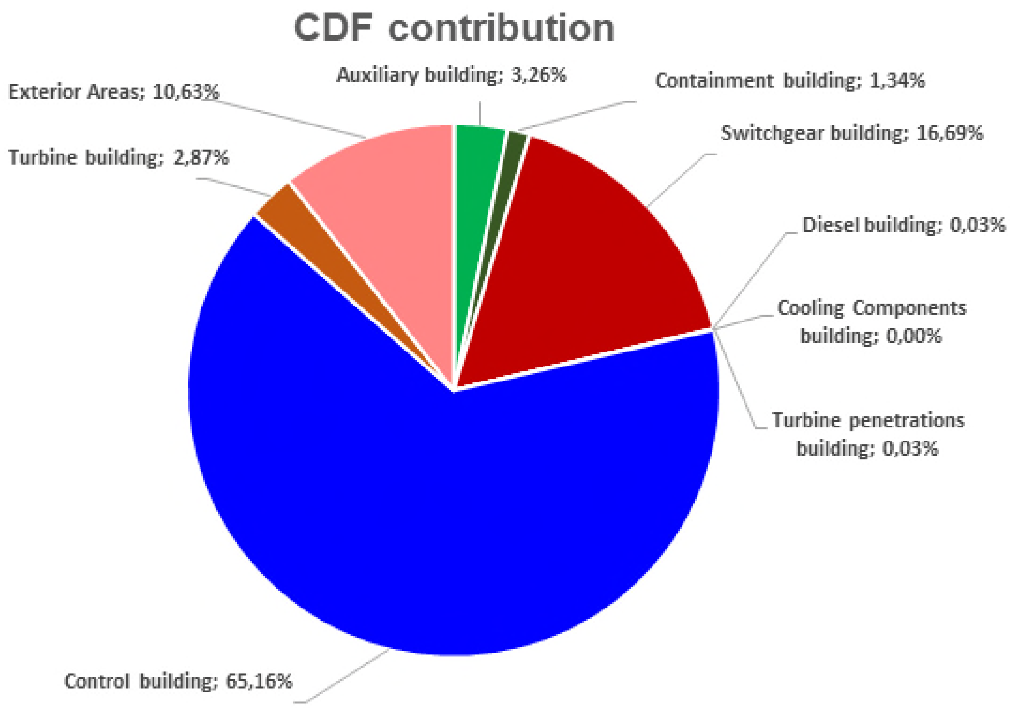
The Level 1 LPSD Fire PSA results in a CDF of 2.62E-05/R-y, with the electrical switchgear building being the largest contributor to the risk followed by the containment building and outdoor areas. Regarding fire areas, the largest contributor is the control room.

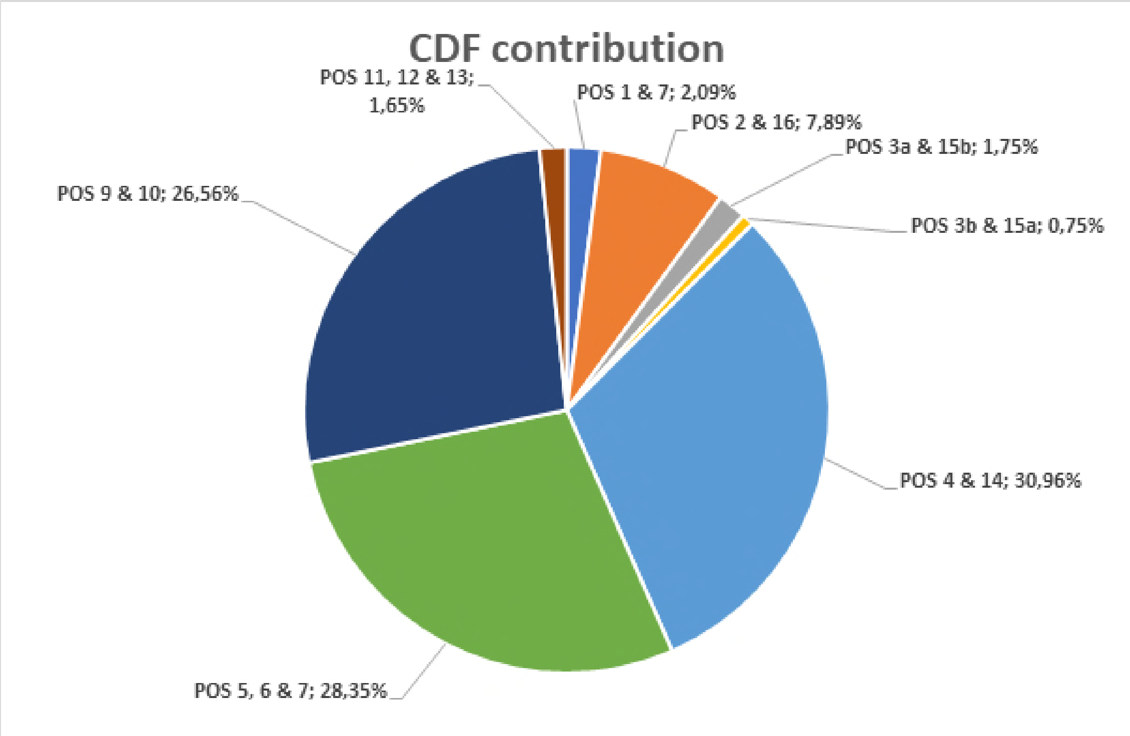
With regard to the risk value obtained, this is a first-of-its-kind analysis and has therefore been carried out with a high degree of conservatism, so that there is much room for improvement by considering more detailed scenario analyses, the use of different and more realistic calculation methodologies and the detailed analyses of fire-specific human actions.

The POS have been grouped for the Level 1 LPSD Fire PSA as follows:

- Group 1 - POS 1 and 17 (mode 1 other than power operation and mode 2).
- Group 2 - POS 2 and 16 (mode 3).
- Group 3 - POS 3a and 15b (mode 4 cooling with steam generators).
- Group 4 - POS 3b and 15a (mode 4 cooling with the RHR).
- Group 5 - POS 4 and 14 (mode 5).
- Group 6 - POS 5, 6 and 7 (reactor vessel flange level with spent fuel).
- Group 7 - POS 9 and 10 (reactor vessel flange level with fresh fuel).
- Group 8 - POS 11, 12 and 13 (mid-loop).

The following figures show the contribution to the FDN of the different buildings and of each POS group:



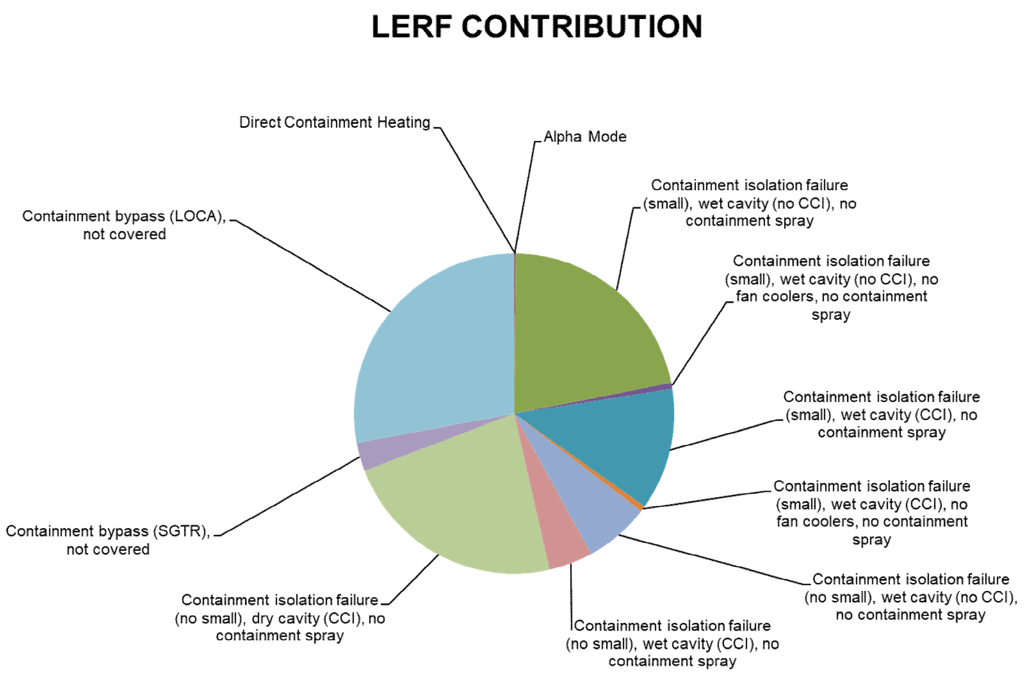


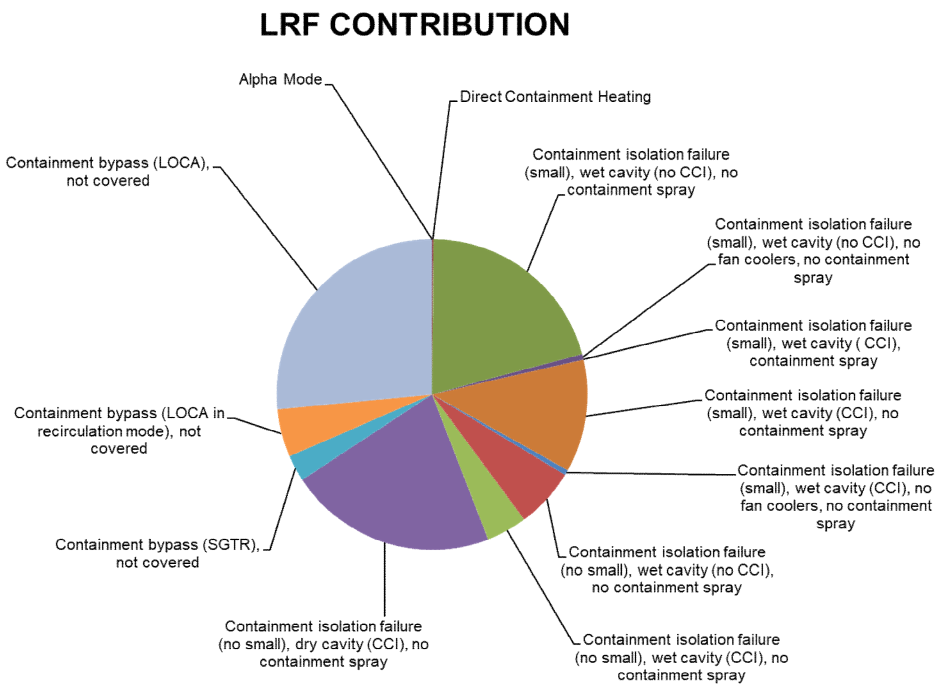
Level 2 LPSD Fire PSA

Like the at-power analysis, this PSA incorporates the design modifications and strategies derived from the results of the post-Fukushima stress tests described above.

The Level 2 LPSD Fire PSA results in a LERF of 5.19E-6/R-y and a LRF of 5.46E-6/R-y, with the control building being the largest contributor to risk.

The following figure represents the contribution to the LERF and LRF of the different source term categories:





02.1.4.2.3 Radioactive release analysis

In accordance with Article 3.2.10 of IS-30, it has been verified that all buildings containing radioactive materials are of concrete construction. Buildings are divided into fire areas delineated by fire resistant barriers as indicated in the FHA (Appendix 9.5B to the SAR).

Ventilation systems in buildings that are part of the controlled area (auxiliary, containment, fuel, components and radioactive waste) are fitted with radiation monitors to prevent the discharge of potentially radioactive fumes without the consent of the radiation protection service. A more detailed analysis of ventilation systems is included in section 03.3.1.2.

02.1.4.2.4 Fire analysis at the ISFSI

Not applicable to Vandellós since there is not an ISFSI at the site.

Trillo NPP (ISFSI)

The spent fuel storage casks have been evaluated against a hypothetical long duration fire accident according to the applicable transport mode hypothetical fire accident standard (10CFR71 and IAEA SSR-6 postulating a temperature of 800ºC for 30 minutes), proving their integrity in the event of the postulated fire accident.

With regard to the consideration of external fires with impact in the storage building, it is not foreseen that such events could affect its safety functions, given that its location in the Plant is far away from the possible storage of combustible material, and that the enclosure of the building itself provides adequate protection for the stored containers.

However, the three external hydrants around the building are available, in addition to the extensive damage mitigation measures, which would allow controlling any external fire that might affect the building.

Having ruled out an external fire, the possibility that internal fires could lead to the dispersion of radioactive materials both inside and outside the building is analysed, and has therefore been taken into account in a risk analysis.

In order to prevent both the outbreak of fire and its subsequent propagation, the accumulation of combustible materials inside the building is prevented, so that there are fire sources. Both in the container storage area and in the rest of the building, the occurrence of a fire is not considered feasible. According to the Fire Risk Analysis, all the areas inside the building have zero fire load.

Measures have been foreseen in the design to ensure having zero fire load (design of electrical systems, steel tube cable routing and use of appropriate construction materials). Possible combustibles in the area are encapsulated in such a way that prevent their spread. In addition, the building crane is parked outside the container storage area.

For all these reasons, it is considered that fires are adequately prevented in the area, in spite of which, there are means of detection (two detector lines, FACP and local and control room alarms) and suppression (fire extinguisher trolley, portable extinguishers and FHC) to mitigate their consequences.

02.1.4.2.5 Spent fuel pool analysis

At Vandellós NPP, the fire area of the spent fuel pool is included in the fire safe shutdown analysis as an additional fire area in the scope of the analysis in accordance with the methodology of NEI-00-01 Rev.2, which does not include the fuel pool cooling functions as necessary for safe shutdown.

With regard to the spent fuel pool cooling function, the SSCs of the fuel pool cooling system are safety-related and therefore important for safety from a FP point of view and their protection is required by IS-30. These SSCs are subject to Articles 3.4.1 and 3.4.2 for detection and suppression respectively and the cables are subject to the protection requirements of Article 3.4.13 Annex A7.

At Vandellós the extraction of residual heat in the spent fuel pool is carried out by means of one of the two redundant trains of the spent fuel pool cooling and cleanup system, the equipment of each redundant train being located in different fire areas separated by R180 barriers, as described in the fire hazard analysis (FHA).

In addition, multiple alternatives are available to guarantee the water inventory in the pool and its cooling.

Despite not having a specific document containing the analysis of compliance with the function in the event of fire, it is considered that this is guaranteed, since there are numerous alternatives available for fuel pool inventory makeup, as is included in the following procedures: Failure of the spent fuel pool cooling and Cooling and alternative spent fuel pool inventory makeup, and the availability of sufficient time for the performance of manual actions, as a result of which, in accordance with FAQ 07-0040 of the NRC, a detailed analysis of the cables is not required.

At Trillo NPP, the cooling of the spent fuel pool is considered a safety function. The safe shutdown analysis includes consideration of compliance with this function.

In the worst case scenario, a pool cooling pump would be available which, through its associated residual heat exchanger, is able to maintain both the core and the fuel pool at a temperature below 90°C in the alternating cooling mode.

The procedure "Spent Fuel pool cooling disturbance" provides instructions to make up inventory using different alternatives (demineralised water system and fire protection and seismic fire protection systems) which ensures that the safety function is fulfilled.

Additionally, according to IS-25, there is a spent fuel pool level 1 PSA available, in which the FDF is determined. However, this PSA does not include fire as an initiating event.

02.1.4.2.6 Flooding analysis due to FP systems piping breaks or actuation of automatic or manual FP systems

In accordance with Article 3.4.2 of IS-30, the FP system components have been designed such that their failure or inadvertent operation does not cause loss of function of safety-related SSCs in accordance with GDC-3 of IS-27. These design bases are set out in section 1.4 of the FHA (Appendix 9.5B).

In the FHA, the availability of drains or the strategy for water evacuation if the previous are not available, is recorded for each fire area.

The current deterministic flooding analysis considers the performance of the automatic FP systems, the performance of the FP Brigade and postulated piping breaks, and evaluates that, taking into consideration the existing drains and protections (seals, dampers, doors, ...) it is guaranteed that the safety functions are fulfilled and that the safe shutdown can be reached taking into account the flooding levels reached and the spray damage.

Finally, in relation to the FP system piping breaks, this is analysed together with the rest of the plant's systems in section 3.6 of the SAR. This analysis postulates the circumferential rupture of the fire protection system, being seismic class 2, even though it is of moderate energy. The effect of these ruptures is discussed in Appendix 3A.2.4.2 and section 3.6.2.1 of the SAR. In accordance with the CTI CSN/ITC/SG/VA2/20/06 [59] requiring the adaptation of the internal flooding analyses to BTP 3-3 and 3-4 [60], the modification has been made taking into account the FP system pipe breaks and its effects, including circumferential breaks, spraying, loss of external power supply and the occurrence of a seism.

02.1.4.3 Cofrentes NPP analysis

02.1.4.3.1 Deterministic evaluation

Cofrentes NPP complies with point 3.3.2 of IS-30 through the following documents:

- *Safe Shutdown Analysis.* Analysis by fire area to verify compliance with the system protection criteria necessary to achieve and maintain safe shutdown and cold shutdown capability in the event of a postulated fire in any fire area of the plant.
- *Identification of SSCs important for safety in case of fire*. Compliance with section 3.3.2-5 of IS-30.
- *Definition of the safe shutdown paths in case of fire*.

The deterministic analysis has been performed according to the methodology described in NEI 00-01 Rev. 2 [40]. The fire areas that have required administrative controls, design modifications or regulatory approval by the CSN are identified below.

Administrative controls

The likelihood of MSO 5g Non-synchronous paralleling - inadvertent cross tie breaker operation between opposite divisions (e.g., 4160V, 480V) of Div 1(2) EDGs through Spurious Operation of 480V Breakers or the Divisional Cross-Tie through 4160V Maintenance Tie Breakers in table G-1 of NEI 00-01- is addressed by establishing administrative controls over the affected breakers in three procedures.

Regulatory approval accepted by the CSN as equivalent compliance with IS-30 revision 2, by letter CSN/C/SG/COF/17/03 [61]:

- The AU-01 fire area has a regulatory approval for 4 doors and for the separations between the AU-01-East area zones (Division I) and the AU-01-West area zones (Division II). The design modifications (DM) SCP-5985 and OCP-5302 have been carried out for improvements to the existing passive protections.
- In AU-02 and SE-08 areas, the CSN-C-DT-95-535 (6/09/1995) [62] letter of compliance to Appendix R to 10CFR50 has been considered, having improved the existing passive protections (conduit &B2961, and DM: SCP-5985 and OCP-5302).
- In areaSE-06, the letter CSN-C-DT-94-444 (25/05/1994) Modifications and compensatory measures related to Appendix R to 10CFR50 [63] has been considered. The improvement of the existing passive protections has been carried out with DMs: SCP-5984, SCP 5985 and OCP-5302.

- In area EF-04 the configuration is accepted by CSN-C-DT-99-753 (10/11/1999) *Cofrentes NPP. FP system. Compliance with GL.86.10 Supplement 1* [64] and CSN-C-DT-94-444 [63].
- In CO-01 and DR-02 areas, the equivalent measure included in the CSN-C-DT-96-103 (12/02/1996) *Cofrentes NPP. FP system. Compliance with Appendix R to 10CFR 50. Proposals for improvements* GENUC-CSN-C-99 letter [65], is considered.

Taking into account the above, the results of the analyses are as follows:

- Safe shutdown: Safe shutdown paths are kept intact in case of fire.
- Cold shutdown: With the systems intact with which safe shutdown is achieved, cold shutdown conditions would be reached and maintained.
- Other modes of operation: The safe shutdown paths are maintained.

02.1.4.3.2 Probabilistic safety analysis

Fire PSAs at Cofrentes NPP are: Level 1 and Level 2 Fire PSA and Level 1 LPSD Fire PSA.

The Level 2 LPSD Fire PSA is scheduled for release by the end of 2024, as indicated in the letter (1799983304467) of 20 December 2017 [66], which refers to the planning of PSA developments in compliance with Instruction IS-25.

The methodology and results obtained in each of the above-mentioned analysis are described below.

Level 1 Fire PSA

The Level 1 Fire PSA evaluates the contribution of fire-induced accident sequences against the total core damage frequency. The analysis considers the probability of fire occurrence in each area of the plant and its propagation and subsequent impact on plant systems, taking into account the damage induced to the equipment and their associated cables.

The methodology used follows the methodology in NUREG/CR-6850, *Fire PRA Methodology for Nuclear Power Facilities*. September 2005 and NUREG/CR-6850, Supplement 1, *Fire Probabilistic Risk Assessment Methods Enhancements*. September 2010 [67].

The analysis is carried out in two stages: a screening analysis and a detailed analysis.

The screening analysis corresponds to tasks 1 to 7 of NUREG/CR-6850 as well as the applicable addenda of supplement 1. This analysis is performed for buildings where a fire could impact equipment involved in the normal and emergency operation of the plant, and aims to identify potentially significant fire areas and scenarios through qualitative and quantitative screening.

The detailed analysis corresponds to tasks 6 and 8 to 15 of NUREG/CR-6850 as well as the applicable addenda of Supplement 1.

This analysis comprises, for the areas/zones selected in the screening analysis, the following activities:

- Identification of fire origins and estimation of fire frequencies based on Appendix G to NUREG/CR-6850.

- Definition of the stages of fire growth.

- Deterministic or probabilistic analysis of the time to reach each stage. The deterministic model developed in Magic, or the semi-empirical equations in NUREG-1805 *Fire Dynamics Tools (FDTs) Quantitative Fire Hazard Analysis Methods for the U.S. Nuclear Regulatory Commission Fire Protection Inspection Programme*. December, 2004 [51], are used to determine the time available for fire suppression before the fire reaches each growth stage.

- Probabilistic analysis of fire detection and suppression systems.

- Assessment of fire propagation to other areas or zones.

- Quantification of the frequencies of fire-induced accident sequences.

After quantification of the analysed areas, a fire CDF of 1.71E-05/R-y was obtained. The CDFs obtained for each area and the most significant fire scenarios were as follows:

- Auxiliary Building. ECCS and RWCU systems, area: 5,42E 07/R-y.

- Auxiliary Building. Div. I cable and busbars rooms: 2.90E 06/R-y.

- Auxiliary Building. Div. II cable and busbars rooms. 5.61E 06/R-y.

- Services Building. Div. II and III cable room: 5.05E 06/R-y.

- Main Control Room: 9.65E 08/R-y.

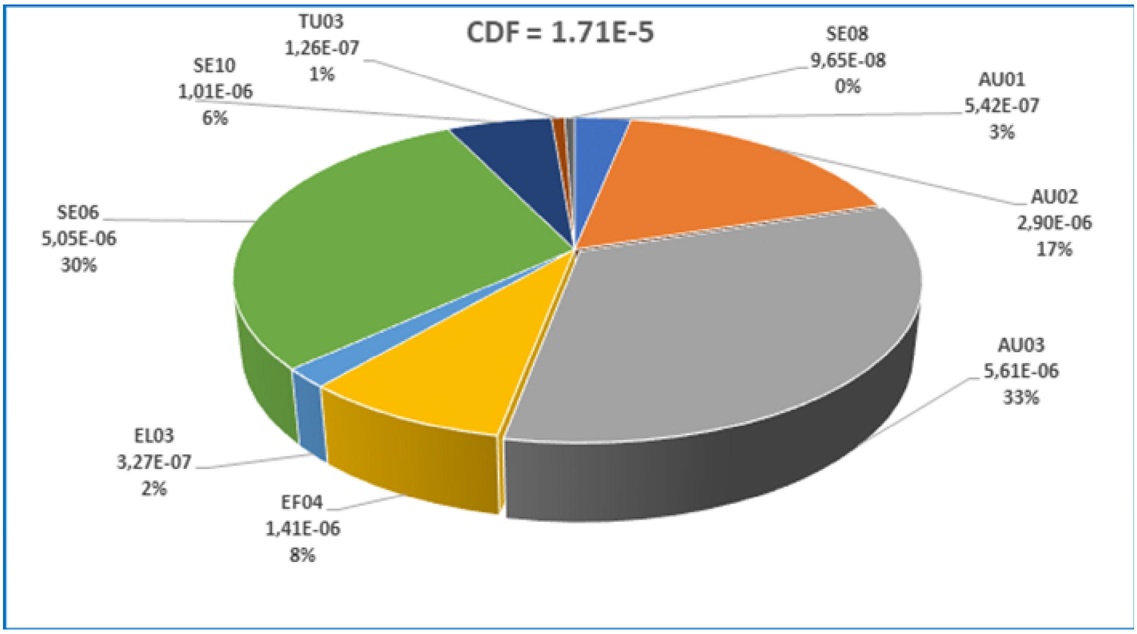
- Services Building. Div. I cable room: 1.01E 06/R-y.

- Fuel Building. Spent Fuel pools: 1.41E 06/R-y.

- Electrical Building specific area: 3.27E-07/R-y.

- Turbine Building. Generator: 1.26E 07/R-y.

The following figure represents the contribution to the CDF of the areas that have been included in the detailed analysis:



Additionally, a multi-compartment analysis has been carried out, following section 11.5.4 of NUREG/CR 6850, and no significant risk situations have been identified due to the propagation between fire areas through potential existing communications (sealed penetrations, fire doors, fire dampers, etc.).

Level 2 Fire PSA

The results show a contribution to the total LERF of 1.05E-6/R-y (3.10 %), and a contribution to the total LRF of 6.58E-6/R-y (19.38 %).

The largest contributors to the LERF are:

- STC-19 (1.19 %): sequence with failed vessel, early containment failure and dry well bypass. The representative extended fire sequence is a total loss of feedwater, with scram. High pressure systems and vessel depressurisation fail. Late water supply from external sources is not available, containment is initially isolated, and containment spray and containment venting are available.

- STC-22 (0.45 %): sequence with failed vessel, early containment failure and dry well bypass. The representative extended fire sequence is a main steam isolation with scram, with successful vessel depressurisation, but cooling failure with high and low pressure systems. The sequence has availability of late water supply from external sources, isolated containment and available containment venting.

- STC-10 (0.43%): sequence with failed vessel and containment failure (isolation failure) and early dry well bypass. The representative extended fire sequence is an SBO with reactor scram with failure of the high pressure systems and failure in the vessel depressurisation. Late water supply from external sources is not possible, containment is not isolated due to the SBO and containment venting is available.

The major contributors to LRF are the same as in LERF explained in the previous point, in addition to:

- STC-13 (14.93 %): sequence with failed vessel and early containment failure (isolation failure) and late dry well bypass. The representative extended fire sequence is a SBO with reactor scram with failure of the high pressure systems and successful vessel depressurisation. There is failure of late water supply from external sources, the containment is not isolated due to the SBO and venting is available.

- STC-27 (0.52 %): sequence with failed vessel, early containment failure and late dry well bypass. The representative extended fire sequence is a total loss of feedwater, with reactor scram. High pressure systems and vessel depressurisation fail. Late water supply from external sources is not available, containment is initially isolated, and containment spray and containment venting are available.

Level 1 LPSD Fire PSA

The Level 1 LPSD Fire PSA estimates the Core Damage Frequency (CDF) of the fuel in the vessel in fire scenarios when the plant is in operating modes other than at-power. The methodology followed is based on the general lines and criteria described in NUREG/CR 7114 *A Framework for Low Power/Shutdown fire PRA*, September, 2013 [54] and, in the case of the Human Reliability task, in the NUREG-1921 *EPRI/NRC-RES Fire Human Reliability Analysis Guidelines. Final Report*, July 2012 [50].

After quantification of the analysed areas, a fire CDF of 3.82E-06 /R-y has been obtained. The CDFs obtained for each area are as follows:

- Services Building. Div. II and III cable room: 1.31E 06/R-y.

- Auxiliary Building. Div. II cable and busbars rooms: 6.98E 07/R-y

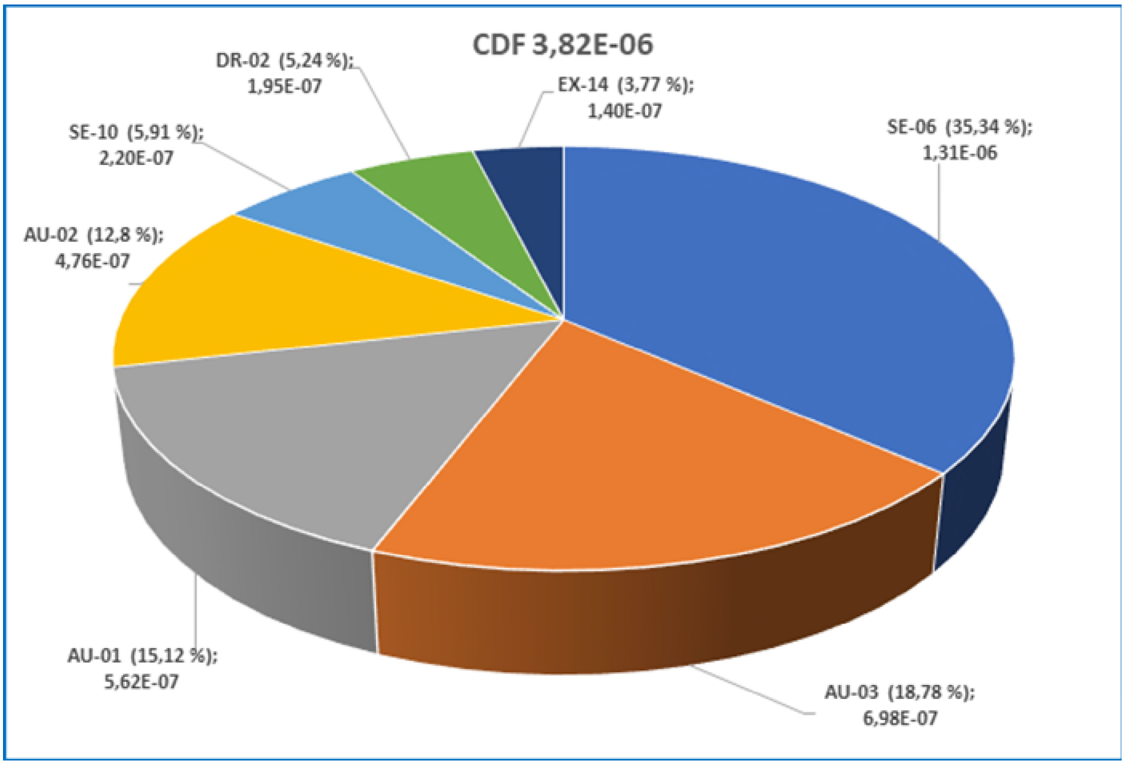
- Auxiliary Building. ECCS and RWCU systems room: 5,627E 07/R-y.

- Auxiliary Building. Div. I cable and busbars rooms): 4,76E 07/R-y.

- Services Building. Div. I cable room: 2,20E 07/R-y.

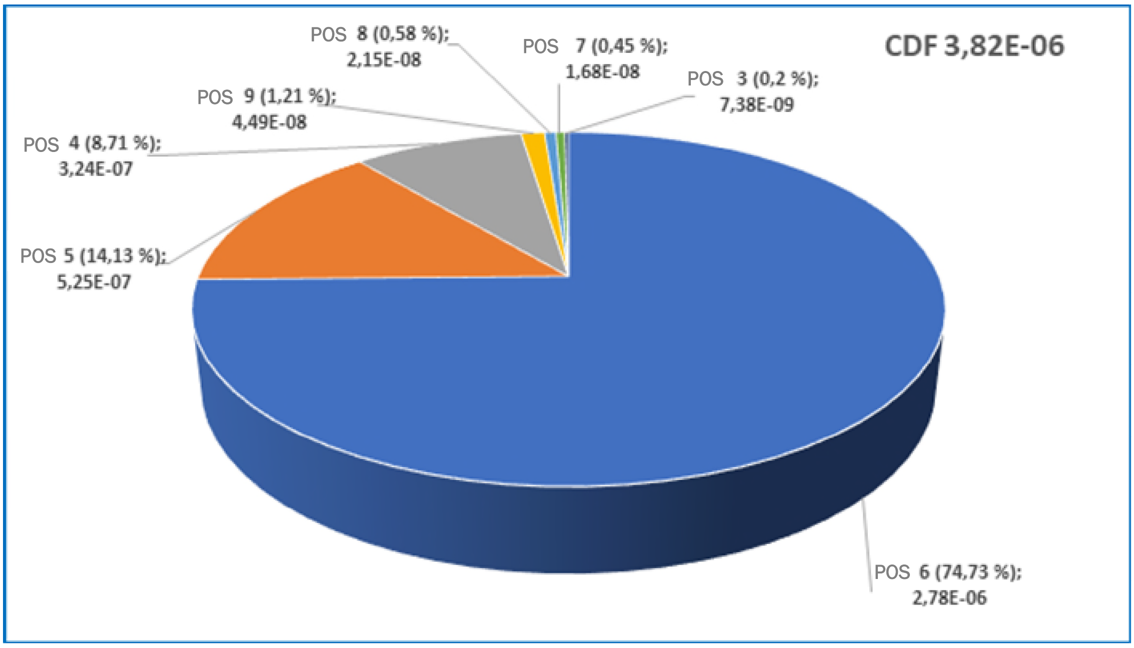
- Drywell: 1.95E-07/R-y.

- ESW pump room in the UHS: 1.40E-07/R-y.



The distribution of the CDF by POS is as follows:

- POS 6 (Refuelling. Flooded cavity): 2.78E-06/R-y.
- POS 5 (Water level < 7 metres above the vessel flange. Operating Condition 5, Refuelling): 5.25E-07/R-y.
- POS 4 (Cold shutdown): 3.24E-07/R-y.
- POS 9 (Hydrostatic test): 4.49E-08/R-y.
- POS 8 (Cold shutdown after reloading): 2.15E-08/R-y.
- POS 7 (Water level < 7 metres above the vessel flange. Operating Condition 5, Refuelling): 1.68E-07/R-y.
- POS 3 (Hot Shutdown): 7.38E-09/R-y.



02.1.4.3.3 Analysis of associated circuits and multiple spurious operations

At Cofrentes NPP these analyses, developed in accordance with methodology NEI 00-01, Rev. 2, are taken into account in both the deterministic safe shutdown analysis and the probabilistic analysis, and are therefore incorporated in the results.

02.1.4.3.4 Radioactive release analysis

In all potentially radiologically hazardous fire areas of the nuclear island buildings, liquid and gaseous effluents resulting from fire and suppression activities are confined and filtered before being released.

The liquid effluents, after passing through the dilution and retardation system consisting of 5 tanks, are released through the discharge channel.

Radiation monitors located in the liquid effluent discharge are fitted with a gamma-ray scintillation detector. These radiation monitors have automatic actuations and/or alarms with indication in the Control Room in order to comply with the concentration and dose limits established in the corresponding controls.

The gaseous effluents are discharged, filtered, through the chimney of the radioactive gas disposal system, where radiation monitors are in place. These monitors have indicators and alarms in the control room.

The procedure regulating the control, monitoring and surveillance of these potential pathways is the PA PR-19 Programme for the Control of Radioactive Effluents released from Significant, Non-Significant and Potential Pathways.

The Offsite Dose Calculation Manual is available, and it establishes the Discharge Specification limits.

02.1.4.3.5 Fire analysis at the ISFSI

The fire analysis of the ISFSI is included in the tables of FHA, as well as the rest of the fire zones of the plant.

In addition, an analysis of the design of the container is carried out in its safety analysis. The design of the container allows its storage on an unprotected outdoor slab during its design life. Therefore, it is designed to withstand normal, abnormal, and postulated natural phenomena and accident conditions during storage.

Chapter 12 of the container Safety Analysis assesses the effects of the postulated abnormal and accident conditions, including those caused by natural phenomena. For each postulated event, the cause of the event, means of detection, consequences and corrective actions are discussed and evaluated. The assessment of the consequences of each design event includes the structural thermal, shielding, criticality, confinement and radiation protection assessment of the system, as applicable.

Sections 18.8.1 and 18.8.2 of the SAR summarise the assessment of abnormal conditions and accidents considered in the container Safety Analysis, taking into account the specific risks of the Cofrentes NPP ISFSI site.

Fire is one of the accidents considered. Both the external fire risk and the specific risk associated with the ISFSI facility is low, the main risk being that associated with a possible fire during the handling and transport of the containers.

The Container Safety Analysis postulates a design basis fire engulfing the container due to spillage and ignition of fuel from the transport vehicle. The surfaces of the container are considered to receive incident radiation and heat flux from the fire.

A transient state analysis is performed for the duration of the fire with a post-fire period of 19 hours, sufficient time to reach the maximum temperatures. The results show that the containment meets the requirements on the stress limits under those accident conditions.

The possibility of forest fires in the vicinity of the ISFSI is very low and there is a procedure in place for dealing with fires in the vicinity of the ISFSI site. A forest fire in the perimeter close to the ISFSI facility is an unlikely event and is covered by the fire accident considered in the design of the container.

02.1.4.3.6 Flooding analysis due to FP systems piping breaks or actuation of automatic or manual FP systems

According to Article 3.4.2 of IS-30, the components of the FP system have been designed such that their failure or inadvertent operation does not cause loss of function of safety-related SSCs.

In areas with water suppression systems, and with SSCs in the same or in adjacent areas, that may be damaged by the possible flooding caused by the actuation of the suppression system,, protections have been installed to prevent water from reaching such equipment.

Several cases can be identified:

- Areas that do not contain SSCs and in which the combustible material contained therein is mostly liquid. The area is considered as a bucket to control possible fuel spills. The drain is covered with a removable plug. And the levels of access doors and other openings are raised in order to contain the maximum discharge of the water suppression system.

- Areas that do not contain SSCs that may be damaged by water, but in which the discharge of the water from the suppression system may cause flooding in adjacent areas. Walls are installed in the communication paths between areas to contain the maximum amount of water and to protect the SSCs contained in the adjacent areas.

- Areas containing SSCs other than fire risk equipment, which may be damaged by the flooding resulting from the actuation of the suppression system. (These are usually electrical panels with connection terminals close to the ground which can cause short circuits). The equipment is located over pedestals or isolated by surrounding retaining walls.

The performance of the Fire Protection System is analysed in the study Evaluation of drainage capacity vs. FP flow rates, in which it is guaranteed that the safety functions are fulfilled, and that the safe shutdown can be achieved taking into account the flooding levels that may be reached.

In addition, through the internal flooding analysis, it is analysed that the FP pipe breaks do not affect the safe shutdown capability.

Finally, the Flooding protection manual lists for each flooding area the availability of drains and other protections credited in the deterministic and probabilistic analyses.

02.1.4.3.7 Assessment of the cooling capacity of the spent fuel pool in case of fire

Cofrentes NPP spent fuel pool fire area is included within the scope of the fire safe shutdown analysis as an additional fire area, , in accordance with the methodology of NEI 00-01 Rev.2, which does not include the spent fuel pool cooling function as required for safe shutdown.

The safe shutdown analysis indicates that no equipment necessary for the reactor safe shutdown is located in the area of the fuel storage pools. Division I cables run in the eastern part of the area and Division II cables run in the western part. Although there are losses in this area, multiple safe shutdown paths are still available.

No additional risk situations have been identified as a result of associated circuit analysis. Therefore:

- Safe shutdown: A fire in the pool area would not prevent the safe shutdown

- Cold shutdown: Cold shutdown conditions would be reached and maintained

Low power and shutdown modes: Safe shutdown paths are also maintained.

Additionally, according to IS-25, a level 1 PSA is available for the spent fuel pool in which the FDF is determined. However, this PSA does not include fire as an initiating event.

As regards the spent fuel pool cooling function, the SSCs of the fuel pool cooling system are safety related and therefore important for safety from a FP point of view and their protection is required by IS-30. These SSCs are subject to Articles 3.4.1 and 3.4.2 for detection and suppression respectively and the cables are subject to the protection requirements of Article 3.4.13 Annex A7.The cooling function is considered to be ensured since numerous alternatives are available to provide water to the fuel pool through different plant systems, as well as through portable equipment, as described in the Extensive Damage Mitigation Guidelines (EDMG), which are instructions to be used when everything described in the

EOP/SAG and SBO instructions is not sufficient to manage the accident. These guides provide alternative solutions or support to the procedures.

The EDMG related to the fuel pools is Water supply to the fuel building pools supported by portable equipment. The fuel pool inventory makeup can be carried out using the condensate distribution system, the essential service water system and the fire protection system.

The "Fuel pool cooling system failure" procedure is also available. This procedure is designed to be used in case of loss of cooling, which will be accompanied by a decrease in the spent fuel pool level, with an increase in temperature and dose due to the loss of shielding in the area. Alternative systems for spent fuel pool inventory makeup are listed in Annex 1 of the document. And in Annex 2 the location of the material necessary to carry out the different strategies.

02.1.5 Periodic review and management of changes

In accordance with CSN Safety Guide 1.10 Rev. 2 (SG 1.10) [27], endorsed by the Spanish NPP's Operating Permits, as well as with IS-26 [17], a Periodic Safety Review must be carried out at least once every 10 years.

SG 1.10 takes the IAEA SSG 25 [68] on PSR as a reference and establishes the PSR process as an operator self-assessment in which compliance with the criteria established by Safety Factors (SFs) is analysed. For each of these SFs, standards (new or existing as licensing bases) as well as industry best practices against which to assess compliance, are defined. As a product of this self-assessment, Strengths and Potential areas for Improvement are identified and, based on the latter, the PSR improvement plan is developed.

FP issues are assessed in different SFs: SF1 (plant design, design modifications), SF2 (current condition of SSCs important for safety, reliability and monitoring), SF7 (risk analysis, FP manual, deterministic analysis, compliance with the LB, IS-30 and Fire PSA), and SF13 (emergency plans, interaction with OSEP initiating events due to fire).

In addition, in accordance with the IS-21 on requirements applicable to modifications at nuclear power plants, the licensees of the Spanish plants must assess, for all design modifications (DM), the impact on the FHA and on the PSA. During the DM design phase, care should be taken to ensure that FHA are not negatively impacted so that compliance with both deterministic and probabilistic criteria is maintained. This is verified in the Preliminary Analysis or in the Safety Assessment of the modification where, in the event that the DM has an impact on these risk analyses, it will be concluded that it is necessary to obtain the required approval for its implementation.

Finally, the FHA, is included in the safety analysis report (SAR), so that all the DMs that may affect it have to have a SAR change proposal where they incorporate the modifications to be introduced in the FHA and the SAR. These modifications are incorporated once the DMs are implemented in the following review of the SAR which is due 6 months after the end of each outage. In addition, the FHA is defined as a document subject to configuration control ensuring that it is always up to date.

02.1.5.1 Almaraz NPP

02.1.5.1.1 Overview of actions

Almaraz NPP carried out its 3rd PSR in 2017-2018 and submitted it to the Administration in support of the Operating Permit renewal application in March 2019. The period assessed was from January 2009 to June 2018.

Derived from the Almaraz NPP PSR, the following results were identified in relation to FP:

- The inclusion of scenarios derived from the transition to NFPA 805 in the simulator exercises is considered a strength.
- The already implemented incorporation of RCP passive seals and automatic trip was committed as an improvement action.

In addition, for those plants that have transitioned to NFPA-805 [5] it is required that the programme documentation established, reviewed or used to support compliance with 10CFR50.48(c) [33] is subject to Almaraz NPP configuration control processes, which meet the requirements of NFPA 805 section 2.7.2 . This includes appropriate procedures and processes to ensure that the impact of changes in the FP program is reviewed.

Specifically for Almaraz NPP, the design modifications will be reviewed to analyse their impact on the fire protection programme documentation using the CNAT and the main supporting engineering procedures. These analyses shall be documented as part of the DM analyses and evaluations and the affected documents shall be identified.

- The basic and supporting documentation associated with 10CFR50.48 (c) compliance shall be updated in accordance with the applicable procedure. That procedure should meet the requirements of the document structure and configuration control, as well as the specific quality plan.
- On the other hand, the assessment of the impact on the FHA, it is carried out at the end of the editing process of the Design Modification Report, in parallel with the performance of the previous analysis or safety assessment, according to established procedures.
- As part of the above process, for those modifications that may have an impact on the analyses that support the licensing basis, an assessment is made to quantify such impact, and in particular for those that may involve an increase in risk, an analysis is carried out to determine the magnitude of such an increase. The risk increase analyses are carried out taking into account the criteria contained in the NEI 04-02 documents as well as in the Regulatory Guides RG 1.205 [54] and RG 1.174 [47].

02.1.5.1.2 Implementation status of modification/changes

The main Design Modifications carried out in the NFPA 805 transition process at Almaraz NPP with the objective of reducing the risk, maintaining the defence in depth criteria and the safety margins to reduce the increases in the CDF and LERF, and to address the existing variances from the deterministic requirements are set out below. All of them are currently in place.

- Rerouting of H_2 lines to eliminate associated risks in auxiliary and safeguards buildings.

- Improvement of procedures (control of combustibles and hot works Pre-Fire Plans and an auxiliary fire procedure)

- Replacement of ceramic blankets with R60 approved protections in certain areas of the safeguards and auxiliary buildings.

- Installation of RCPs passive seals and automatic trip and protection of the I&C cables from the thermal barrier to eliminate RCP seal LOCA scenarios.

- Protection and cable rerouting of the pressuriser PORVs: elimination of scenarios with very low probability of occurrence and acceptable area risk, but with conditional probability of core damage equal to 1.

- Passive protections against loss of both CCW trains: elimination of scenarios where both trains of the component cooling water system were lost.

- Additionally, in relation to the analysis of radioactive releases, detection has been improved in the fire areas located in the controlled area that are not usually visited, taking NFPA 805 into account.

02.1.5.2 Vandellós NPP

02.1.5.2.1 Overview of actions

Vandellós II NPP carried out its 3rd PSR in 2017-2018 and submitted it to the Administration in support of the Operating Permit renewal application in March 2019. The period assessed was from January 2009 to June 2018.

Some of the strengths and areas for improvement identified are set out in the following section.

Derived from the PSR of Vandellós II NPP, the following strengths relating to safety factor 7 were identified in relation to FP:

- Having the FHA included in the SAR and a robust process for updating it.

- Having a forest fire prevention plan.

- Improvements included in plant procedures to avoid unnecessary FP actuations.

- Existence of a chemical substances control procedure inside the power block.

- Analysis of FP system seismic margins carried out as part of the post-Fukushima actions.

- Installation of passive RCP seals with the associated significant reduction in CDF.

- Installation of the technological safeguards cooling water system (EJ) as a final heat sink making the safety SSC cooling independent of the Mediterranean Sea.

In addition, the following areas for improvement were identified:

- No chemical substances control procedure is available for areas outside the power block. Revisions of the applicable procedures were issued including the instructions for surveillance of toxic, asphyxiating, flammable and/or explosive substances in outdoor areas.

- Procedures for actuation on systems in the event of a major fire outside the facility. Revision 4 of the applicable procedure has been issued including actions needed to minimise the impact of fumes.

- Extensive Damage Mitigation Guidelines, whose adoption in the last period together with the development of the Flex Support Guidelines has provided alternatives to prevent core damage or minimise its consequences in events beyond the design basis.

- Other areas for improvement that improve the plant's ability to withstand risks (PSA):

  - Design improvements to deal with Open Phase Conditions events, automating the response to such events.

  - Automatic RCP trip, that prevent human failures while carrying out actions with limited available time to prevent the loss of RCP seal cooling.

  - Absence of methods to cope with a SBO without a rising temperature transient while shutdown. The capacity to power the RHR train A, an EG pump and an EJ pump, from the Alternative Diesel Generator was analysed.

Finally, the comparative analysis of the design and operational practices against the guidelines of RG 1.189 Rev. 3 and SG 1.19 Rev. 0, which are the most up-to-date guidances, should be highlighted. It is worth noting the similarity of positions of SG 1.19 and RG 1.189. As an example, upon completion of the IS-30 alignment plan mentioned above, 85% of the positions in SG 1.19 will be strictly or equivalently complied with. For the remaining ones, areas for improvement have been identified which go beyond the requirements of IS-30 and which will result in an additional improvement of the compliance with the objectives of the aforementioned regulation:

- The analysis of the outdoor areas within the protected area of Vandellós II NPP does not fully follow the recommendations of RG 1.189 Rev. 3, so an analysis was carried out in those areas. In conclusion, no areas have been identified with significant fire loads that could lead to fire exposure of safety relevant SSCs. In areas where there are relevant fire loads, it was verified that SSCs that are safety relevant in the FP domain are not affected.

  For the new fire area EX-15 (RWST enclosure), despite the absence of fire loads or fire ignition sources, a design modification is proposed to separate the redundant trains in accordance with Article 3.2.5 of IS-30, so as to ensure safe shutdown capability in case of fire in the area. This DM will be executed in April 2024, and the licensee has opened meanwhile an abnormal condition.

  For the new areas and zones, the corresponding actions, with deadline on December 2023, have been generated to complete the analyses, to include the results in the FHA and to request regulatory approval to the CSN of the equivalent compliance to IS-30 articles 3.4.1 and 3.4.13. This action was finished finally in December 2022.

- Provisions included in the design of detecting systems for preventing the effects of lightning strikes according to paragraph 4.3 of SG 1.19 and to follow the guidelines of section 4.3 of SG 1.19 have been included in the FHA and in the new appendix for compliance with IS-30 in the SAR.

- The Pre Fire Plan (PFP) does not include the SSCs necessary for safe shutdown that may be affected by the fire, so an action is generated to document in the PFP the SSCs and safety functions necessary for safe shutdown that may be affected by the fire in the area according to section 5.15 of SG 1.19. Performance scheduled for December 2023.

- The Control Room abandonment procedures do not include verification of the habitability of the Control Room after a fire, so an action was issued to revise POF-115 to incorporate the recommendations of section 8.9.4 of SG 1.19 regarding the verifications to be made before returning to the Control Room after its abandonment due to fire.

The Fire Protection Programme is subject to the configuration control processes of Vandellós II NPP, so that modifications to the plant are evaluated and their impact on the analyses and documentation is determined.

As indicated above, the Vandellós II FHA is explicitly included in section 9.5 of the SAR. The analysis of this risk is reviewed in each edition of the SAR, according to the design modifications implemented, as well as additional internal reviews.

According to PG-3.01 and PG-3.05 the applicable processes must include proposals for changes to the SAR arising from modifications to the installation, thus including updates to any of the risk analyses documented therein. Finally, by means of PG-3.05, it is analysed whether changes in operational practices have an impact on the SAR.

02.1.5.2.2 Implementation status of modification/changes

The main design modifications carried out as a result of the FHA carried out for the adaptation to IS-30 are listed below:

- De-energisation of motorised valves during power operation: Residual heat removal inlet isolation valves remain de-energised during power operation.

- Installation of passive protections: Installation of passive protections in the electrical conduits so that a fire in certain area cannot affect the trip of the charging pump aligned to train A preventing the overfilling of the pressuriser. Installation of passive protections in electrical conduits to ensure safe shutdown in case of fire in several fire areas. Separation of redundant train cables and installation of an R180 barrier to separate the auxiliary feed water tank level redundant transmitters in an outside area of the plant. Install fire-stops on cable trays not associated with any train in three enclosures in a specific fire area.

- Detection/suppression installation: Installation of automatic Novec 1230 suppression system in four fire areas with electrical equipment in the Auxiliary building (according to articles 3.2.5 and 3.4.13 Annex A.7 of IS-30).

- Improvement of the electrical independence of the control room in accordance with Article 3.2.12 of IS-30 and GDC-19 of IS-27: Install circuit breakers in remote shutdown circuits with insufficient electrical isolation. New remote shutdown instrumentation loops independent of the control room and replacement of the train

B extended range cabinet and its associated electronics. Modification of certain pumps and motorised valves to prevent the impact of hot-shorts on the safe shutdown in case of fire in the control room. Improvements in cold shutdown valves in the event of multiple spurious operations (MSO) due to fire in the control room.

- Modification of communications through the implementation of the necessary infrastructure to provide indoor radio coverage to all building locations in the power block. These communications are analysed in the context of the OMAs regulatory approval.

- Installation of autonomous blocks with batteries with 8 h of additional autonomy (EJ gallery and areas where OMAs are planned).

All of the above modifications are in place.

As a result of the outdoor area analysis carried out in accordance with RG-1.189, a design modification has been identified to separate the level transmitters and their cables from the RWST by means of R180, for which a DM has been programmed for its implementation in the 2024 spring outage.

In addition, a documentary DM is planned to include in the FHA the new fire areas identified during the analysis of the outside areas, scheduled for December 2023.

02.1.5.3 Cofrentes NPP

02.1.5.3.1 Overview of actions

Cofrentes NPP carried out a review of 15 Safety Factors (SFs) in order to verify the plant's compliance with the applicable standards and propose improvements in the different areas of study. The final PSR report for the new operating permit was submitted on 31 March 2020. These factors include fire in Factor 7.

Following the corresponding evaluation by the CSN, on 17 March 2021, by Order TED/308/2021 [69], Iberdrola Generación Nuclear SAU was granted renewal of the Cofrentes NPP authorisation, valid until 30 November 2030.

In the third periodic safety review, the following strengths were identified in relation to the risk analysis aspects:

- Actions carried out as a result of the Fukushima Stress Tests and the reinforcement measures implemented.

- Seismic FP system capacity exceeding the IS-30 requirements.

And the next area for improvement:

- Inclusion of instrumentation that could be lost in the event of fire in the fire action procedure. Action completed.

The Fire Protection Programme is subject to the Cofrentes NPP configuration control processes, so that modifications to the plant are evaluated and their impact on the analyses and documentation is assessed.

Design modifications are managed on the basis of the PG 05X series procedures for project change orders and project change requests and the administrative procedures for their development.

In accordance with the above-mentioned procedures and guidelines, for each design modification, the impact on the project documentation, including risk analyses, is assessed. Based on this analysis, each project change request or order includes a proposed change to the Cofrentes NPP project documentation that could be affected. Once the modifications have been executed, Cofrentes NPP incorporates and updates the project documentation in accordance with the proposals made.

02.1.5.3.2 Implementation status of modification/changes

In the third periodic safety review in relation to the risk analysis aspects, only the following area for improvement was identified, which has been finalised, so there are no pending modifications.

- Inclusion of instrumentation that could be lost in the event of fire in the procedure IP02 (Fire Action Procedure). Action completed.

02.1.6 Licensee's experience of fire safety analyses

02.1.6.1 Almaraz NPP

02.1.6.1.1 Overview of strengths and weaknesses identified

From the point of view of strengths relating to Fire Protection, the importance of the IS-30 Rev. 2 implementation process and/or the transition to NFPA-805 should be highlighted, both for the modifications made, see section 02.1.8.1.2, and for the process itself, which guarantees an exhaustive analysis of the plant's situation.

Another aspect to highlight related to the transition process to NFPA-805 is the improvement of the existing procedures and the reinforcement of plant configuration control.

Likewise, the exhaustive use of the plant simulator training for both simulation and validation of fire scenarios is considered relevant as the results and conclusions obtained are transferred to the operator training programmes (see Section 02.1.5.4).

It should be pointed out that, as a result of the adaptation process to IS-30, which, as indicated, has meant: the implementation of FP design improvements, the review and updating of the project documentation, and the Spanish plant status control processes, from the point of view of FP, it is considered that there are currently no existing weaknesses in terms of the response to fire scenarios.

Other notable aspects, considered as strengths, are:

1. Peer Review

In accordance with section 4.3 of RG 1.205 [54], Almaraz NPP has carried out a Peer Review of the NFPA-805 Fire Analysis reports.

Almaraz NPP performed a peer review against the requirements of the American Society of Mechanical Engineers (ASME)/American Nuclear Society (ANS) ASME/ANS RA-Sa-2009 PSA standard [63] taking into account the clarifications given by the NRC contained in revision 2 of regulatory guide 1.200 [70]. This peer review was conducted using the process defined by the NEI 07-12 [71].

The Peer Review team reviewed the Almaraz NPP Fire PSA against section 4 of the ASME/ANS PRA standard. The team was composed of experts in the field from companies in the US nuclear industry. The Peer Review was conducted in February 2011.

The Peer Review assessment report concluded that overall, the methodology used is appropriate and sufficient to meet the requirements of the ASME/ANS PRA standard, and that the Almaraz NPP Fire PSA is consistent with the standard and can be used for "risk-informed" applications.

However, some issues were identified concerning the analysis of control room abandonment, the assessment of exposed structural steel and the calculations of the human reliability analysis adjustment factors, as well as some purely documentary issues and the lack of the Large Early Release Frequency analysis at the time of the Peer Review.

These issues are set out in the Peer Review evaluation report and are summarised in 37 "findings" and 14 "suggestions". Almaraz NPP has answered and incorporated all these questions in the current documentation.

Once all the findings and suggestions identified by the peer review have been resolved, it is concluded that the Almaraz NPP Fire PSA complies with at least Capability Category II of the ASME/ANS PRA standard, in all its points.

2. Alternative shutdown panel

Almaraz NPP has made improvements, in both units, to the design of the Alternative Shutdown Panel (ASDP) to guarantee its electrical independence from the control room in accordance with criterion 19 of IS-27 Rev.1, and the requirements of Appendix R to 10CFR50, section IIIG (Fire Protection of Safe Shutdown Capability) and Position c.5.2 of Regulatory Guide 1.189 (Fire Protection for Operating NPP).

3. Flame-retardant cables

The power, control and instrumentation cables were purchased with an appropriate specification requiring the cables to be qualified in accordance with IEEE 383/1974 [72] to demonstrate their ability to perform their function during normal, accident and post-accident environmental operating conditions. This specification includes a requirement for flame resistance testing, in accordance with paragraph 2 of IEEE-383/1974, on representative samples of each manufacturing unit of the cables offered.

An analysis has been carried out taking as a starting point the Fire Analysis Cable Database, which includes all cables considered in the PSA and Fire Safe Shutdown Analysis, and includes all 1E cables, plus train-associated cables and plus control cables (and some non-train cables). This analysis has been documented without having identified any cables with qualification deficiencies.

4. Review by Operation

The Level 1 PSA human reliability analyst has conducted interviews with plant operating personnel to confirm the hypothesis on the plant's response and to help ensure that the human reliability analysis reflects the reality of the plant. Additionally, the way in which the operating shift interacts with the fire brigade has been confirmed.

Shift tasks may vary in a fire and these additional tasks could lead to an increased workload. It is important to confirm that a minimum number of operators and Plant personnel are available to complete the human actions modelled.

The walk-throughs and talk-throughs performed in the Level 1 PSA have provided information on the timing of human actions, as well as insight into the understanding of the plant's response. The time required to complete the human actions has been estimated by walk-throughs and talk-throughs of the procedures or in observations on the simulator with the participation of different shifts to obtain the most realistic and reasonable action times.

5. Almaraz NPP Procedures in case of fire

One of the important aspects related to the Human Reliability task, both because of its potential impact and its significance in dealing with a fire, is the procedures that operators will use in the event of a fire.

Almaraz NPP does not have specific fire procedures that include the strategies that in the event of a fire could help the operator to bring the plant to a safe shutdown. Almaraz directly uses the EOPs as generic procedures for dealing with a fire, without differentiating if the failure of an equipment is due to a fire or to any other cause. The strategies followed are the ones in the Emergency Operating Procedures (EOP) themselves, since in the event of a plant trip (the starting hypothesis of the fire analysis) the operating personnel are obliged to follow them. The Shift Manager is in charge of carrying out the scram and using the EOPs in parallel.

However, Almaraz NPP has developed a procedure that lists the safe shutdown equipment that could be affected in each fire zone, as well as possible strategies to deal with equipment inoperability as a consequence of the fire, including operation from the alternative shutdown panel.

In addition, Almaraz NPP, has carried out a more detailed comparison between North Anna FP procedures (being North Anna, Almaraz’s reference plant), and the procedures that Almaraz shift would use in case of fire to deal with the fire itself and the possible loss or unavailability of equipment as a result of it. The most relevant aspects are outlined below:

- This analysis has been based on the different concepts applied in the two plants when dealing with a fire. North Anna has developed specific fire procedures that prevail over the EOPs in the event of a fire (Fire Contingency Action), while Almaraz deals with a fire following the EOPs as they would during any other accident, having a specific AOP for fires and other AOPs to deal with the equipment failure. These last AOP are not fire specific, in other words, the failure may have been caused or not by fire.

- Based on the analysis performed, it may be concluded that the fire procedures at Almaraz NPP have the same level of detail as those of the reference plant, since these procedures identify the equipment and instrumentation failing in the different fire zones. The fire procedures of Almaraz NPP do not contemplate preventive actions on safety equipment in the event of a fire. On the other hand, at Almaraz NPP the use of EOPs is allowed in parallel with fire procedures. The Shift Manager is in charge of carrying out the scram and using the EOPs in parallel.

In order to demonstrate whether it is feasible to control the plant in a fire scenario, simulations of 5 fire scenarios have been carried out on the simulator to test, demonstrate and justify the feasibility of the simulation, as well as the correct use of the applicable procedures, together with the auxiliary fire procedure. The implementation of each scenario has been observed and documented.

From the simulation it can be concluded that, although the simulator does not have the capacity to simulate a fire directly, it is possible to do so by introducing malfunctions. The operating group correctly used the emergency operating procedures together with the auxiliary fire procedure and brought the plant to a controlled situation.

Other procedures:

In the framework of the NFPA 805 transition project, the following procedures have been generated or revised: *Fire in any area of the plant*; *Evaluation of the critical safety functions during shutdown*; *Labelling of the equipment protected during shutdown; Alternative power supply to discharge valves (CS) due to deterioration of their power supply as a consequence of a hypothetical fire; Replacement of the power supply cables to residual heat removal pumps (RH) due to their deterioration as a consequence of a hypothetical fire; Replacement of the power supply cables to charging pumps (CS) due to their deterioration as a consequence of a hypothetical fire; Emergency termination and recovery*; *Oil leakage and/or fire in the turbine building*; *FP surveillance*.

6. FP seismic system

See section 03.2.1.2.2 in the thematic chapter on active protection.

7. Adaptation to IS-30 Rev. 2

The adaptation to IS-30 Rev. 2 process has meant an exhaustive review of the Fire Protection Programme, requiring in many cases the implementation of improvements to the existing FP design and the improvement of existing documentation and procedures, which on the whole may be considered a strength of the Spanish plants in relation to FP.

8. Instruction IS-25

To comply with IS-25, the PSAs available at the date of its publication have been developed, completing the scope for all possible internal and external events in all modes of operation and considering, in addition, other sources of radioactivity that may give rise to source terms similar to the reactor core. Almaraz NPP has the following analysis: Level 1 and 2 internal events PSA, Level 1 and 2 LPSD internal events PSA, Level 1 and 2 Flooding PSA, Level 1 and 2 LPSD Flooding PSA, Level 1 and 2 Fire PSA, Level 1 and 2 LPSD Fire PSA, Other sources PSA and Other external events PSA.

The PSA must also be maintained and updated, so that at all times this tool is as accurate a representation as possible of the situation in the plant. The implementation of design modifications and the increased availability of operational data and results need to be reflected in the PSA models through regular updates. The timelines available to perform them are set out in SG 1.15, *Updating and Maintaining Probabilistic Safety Assessments* [28].

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

The main findings of the NFPA-805 transition process are summarised below:

- The NFPA-805 transition process has been carried out at Almaraz NPP in accordance with the methodology set out in NEI 04-02, following its application at the pilot plants in the United States, although with shorter timeframes and with certain additional requirements imposed by the CSN.

- During the process, compliance with the Licensing Bases currently in force has been verified, identifying some non-compliances relating to passive protections in cables and doors, notified in ISN-I-09/001, ISN-II-09/001 and their subsequent revisions. These non-compliances have been resolved through some of the design modifications included in the thematic block on passive protection.

- Design modifications implemented to comply with the requirements of NFPA-805 are included in the NFPA-805 Licensing Report. The most relevant ones are listed in the corresponding thematic blocks.

- The variations from the deterministic requirements are also detailed in the NFPA-805 Licensing Report and sufficient justification is provided that the situation at Almaraz NPP is acceptable.

- In the Assessment of Key Safety Functions (KSF) within the LPSD analysis carried out at Almaraz NPP, the Operational States defined as high risk configuration are identified and analysed. As a result of the analysis, contingency plans and/or an analysis to justify that they are not required are developed in areas where the KSF may be impaired.

- The assessment by fire area has concluded that the majority of areas meet the deterministic criteria (52 out of 76) of the NEI 00-01. For fire areas that did not meet the deterministic criteria, a probabilistic assessment has been carried out concluding that the risk is acceptable, according to the criteria of RG 1.174, even without considering the improvements implemented after the analysis.

- According to the results indicated in section 02.1.5.2 (probabilistic assessment), the increase in risk due to non-compliance with points 1.a, 1.b or 1.c of article 3.2.5 of IS 30 Rev. 2 is 7.11E-06 (see section 02.1.5.2.1, results of the detailed analysis), taking into account the improvements implemented as a result of the analysis carried out in the context of the NFPA-805 transition.

02.1.6.2 Vandellós NPP

02.1.6.2.1 Overview of strengths and weaknesses identified

From the point of view of strengths relating to Fire Protection, the importance of the IS-30 Rev. 2 implementation process itself should be highlighted, both for the modifications made and for the process itself, which guarantees an exhaustive analysis of the plant's situation.

It should be pointed out that, as a result of the adaptation process to IS-30, which, as indicated, has meant the implementation of FP design improvements, the review and updating of the project documentation and the Spanish plant status control processes, from the point of view of FP, it is considered that there are currently no existing weaknesses in terms of the response to fire scenarios.

Other notable aspects, considered as strengths, are:

1. Flame-retardant cables

Power, control and instrumentation cables are qualified in accordance with IEEE 383/1974 [70].

2. Vandellós II NPP procedure in the event of fire

Vandellós II NPP has specific fire procedures indicating the local actions to be taken in the event of a fire in certain fire areas. These procedures are complementary to the EOPs and would be used in parallel. They have been validated within the scope of the regulatory approval of the OMAs required for safe shutdown and are procedures for control room fires and for fires in other specific fire areas.

3. Adaptation to IS-30 Rev. 2

The IS-30 Rev. 2 adaptation process has meant an exhaustive review of the Fire Protection Programme, requiring in many cases the implementation of improvements to the existing FP design and the improvement of existing documentation and procedures, which on the whole may be considered a strength of the Spanish plants in relation to FP.

4. IS-25

Compliance with IS-25 has required the development of Level 1 and 2 Fire PSAs and Level 1 and 2 LPSD Fire PSAs.

PSAs must also be maintained and updated, so that at all times this tool is as accurate a representation as possible of the situation in the plant. The implementation of design modifications and the increased availability of operational data and results need to be reflected in the PSA models through regular updates. The timelines available to perform them are set out in SG 1.15, Updating and Maintaining Probabilistic Safety Assessments.

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

Within the scope of the 3rd PSR, an analysis was made of the results obtained from the External Evaluations carried out for the period from 01/01/2009 to 30/06/2018, verifying that the action plans provided had been adequately implemented and that there were no pending aspects to be resolved. Both evaluations by International Organisations and the results of inspections by the CSN were taken into account.

With regard to the former, the relevant results emanating eminently from OSART missions and the corresponding Follow-Ups have been analysed. As a result, an improvement plan has been established in relation to fire load limits, separation of fire areas, work control, detection and emergency response, which has been satisfactorily implemented.

On the other hand, the CSN performs an independent supervision, both through the resident inspections and during the BIP inspections related to Fires, Floods and Severe Weather Conditions. In addition, a significant number of inspections have been carried out during the period, reviewing aspects of Safety Factor 7 related to post-Fukushima actions. From the analysis of the conclusions of these inspections, a significant reduction in both findings and minor deviations has been noted. Such a reduction reflects the continuous improvement of the installation, and the adequacy of the design and practices to address the plant risks.

In addition, specific internal assessments relating to fire risk were reviewed under Safety Factor 7. Throughout the period, the indicators associated with the Fire Protection Programme have been expanded, improving the monitoring of activities. As a general conclusion in relation to self-assessments, it can be stated that this process contributes to the improvement of the programme (in this case the fire protection programme) and were considered a strength in the quality audits carried out during the period.

In relation to Quality Audits, the overall conclusion is that the Fire Protection Programme is properly implemented and ensures that all aspects of fire safety are identified, implemented and subject to adequate inspection controls in accordance with the applicable official documents and associated regulations. Good practices have been identified, including the management of temporary storage areas by means of a computerised system, which verifies that the severity of fire is kept below that specified for the area in the FHA (F/4.07-010/001), considered a strength in the Safety Factor 7 analysis. On the other hand, the audits have served to identify deviations from applicable expectations and areas for improvement. The detailed quality audits that have been carried out including field visits have led to the identification of a large number of areas for improvement in all aspects of the Fire Protection Programme. In general, all the entries to the problem identification and resolution programme (PI&R) generated as a result of these audits are closed after the applicable corrective or improvement actions have been performed.

As a final conclusion, the self-assessment processes and the quality audit programme have contributed to the continuous improvement of the facility.

In relation to the operational experience analysed, the positive aspects that stand out are that the PI&R has provided tools to improve the identification and mitigation of risks associated with the operation of the plant. These include:

- improvements in design in response to events that have occurred, highlighting as an example the waterproofing of the roofs of several buildings; with regard to the risk of fire and flooding,

- with regard to the risk of fire and flooding, which, as a result of various reportable events in 2012 related to plant seals, they were progressively reviewed and a database of passive protections was created;

- in the training sessions, the expectation has been reinforced for any ANAV or collaborating company worker to comply with the requirements of PA-180 by making applications for the authorisation of Chemical Products, identification, use in the plant, etc.

As conclusions derived from the analysis of the IP&R, it can be observed that the different issues raised during the period have been resolved.

02.1.6.3 Cofrentes NPP

02.1.6.3.1 Overview of strengths and weaknesses identified

In the third periodic safety review, the following strengths were identified in relation to the risk analysis:

- Actions carried out as a result of the Fukushima Stress Tests and reinforcement measures.

  As a result of the accident at the Fukushima plant in Japan, and within the framework of the stress tests and analyses of the loss of large areas, Cofrentes NPP proposed and has implemented various actions aimed at reinforcing the robustness of the plant to deal with specific events: loss of the extended power supply, loss of the final heat sink, events beyond the design basis, such as the impact of an aircraft, which could lead to the loss of large areas of the plant.

These actions have involved numerous analyses and assessments; the implementation of design modifications; the acquisition of portable equipment required for use in new mitigation strategies; and improvements in procedures, organisation, training and capabilities.

- Seismic FP system capacity exceeding the requirements of IS-30.

  Section 3.4.8 of IS-30 requires the provision of a seismic suppression subsystem capable of supplying water to the fixed fire hydrants of those fire areas containing equipment necessary to perform the safe shutdown in the event of a safe shutdown earthquake (SSE). Annex A (Requirements for detection and suppression systems) requires that the seismic connection must be capable of providing a flow rate of at least 34 m^3/h.

  The installed FP seismic subsystem has higher capacities than required and has been designed to fulfil its function in the event of an earthquake of an intensity corresponding to a SME (0.3 g) and with the capacity to supply water to the reactor vessel, the suppression pool and the spent fuel storage pools, during a SBO. The tank ensures the water inventory necessary to maintain core cooling in case of a 24 hours SBO.

In the periodic safety review in relation to the risk analysis aspects, a possible improvement already completed was identified to include the instrumentation that could be lost in the event of a fire in the Fire Action Procedure as an operating aid.

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

As a result of the new regulations adaptation processes, as well as improvements derived from external inspections, the following improvements have been carried out in recent years or will be carried out in the future:

1. Improvements derived from the Peer Review

After the 2019 Peer Review the Fire Protection Water System Health report was carried out.

Maintenance work scheduling has been improved in order to group maintenance work orders on the same system, leaving systems inoperable as little as possible, thereby improving plant safety.

2. Improvements resulting from NEIL

The Fire Risk Analysis is revised to incorporate the fire-resistant separation wall between the main and standby transformers, the implementation of which was completed in March 2021.

3. PSR-derived improvements

The Fire Risk Analysis is revised to incorporate the gas suppression system, activated by an incipient detection system, in the control panels of the Diesel generators of the three divisions, the implementation of which was completed in December 2021.

The Fire Action Procedure was modified at the end of 2021 to include instrumentation that could be lost in the event of a fire.

4. Improvements arising from the implementation of the IS-30

As a consequence of the edition of IS 30 and its subsequent revisions, Cofrentes NPP has carried out an exhaustive review of its FP system to comply with the requirements of the aforementioned instruction.

The Fire Risk Analysis was revised to incorporate the following design modifications:

- To comply with 3.2.3, 3.2.4 and 3.2.5 concerning the separation of redundant safe shutdown trains, three modifications were implemented to keep at least one of the trains free of damage. The implementation of these changes was completed in January 2016, February 2016 and March 2016 respectively.

In order to comply with points 3.3.2.1 and 3.3.2.4, relating to the Fire Risk Analysis, the following documents were reviewed and edited:

- Analysis of Capability to Achieve Safe Shutdown in the Event of Fire, Revision 1 and Analysis of Compliance with Appendix R to 10 CFR 50, Revision 4 were revised to take into account associated circuits not considered in the previous analysis. The review of the fire risk analysis included the demonstration of alternative or dedicated shutdown capability for the Control Room with assumptions and criteria given in paragraph 8.8 of SG 1.19.

- Spurious Impact on Control Room Fire Safe Shutdown and Associated Circuit Analysis documents were produced to demonstrate alternative or dedicated shutdown capability for the Control Room with the assumptions and criteria outlined in 8.8 of SG 1.19

In order to comply with point 3.3.2.5 on the identification of safety-related SSCs in the field of FP, the document Identification of safety-related SSCs in the field of fire protection was issued.

In order to comply with points 3.3.3 and 3.3.5 a safe shutdown analysis was developed and collected in the documents Definition of Safe Shutdown paths in Case of Fire and Safe shutdown Analysis by Fire Area.

The following actions arising from the studies of associated circuits and multiple spurious operations were also carried out:

- Adjustment of overcurrent relays in a specific cabinet of the safeguard bars

- Two switches were installed in the MCCs so that the test valves of the HPCS and RCIC can be kept de-energised when the system is not under test and the HPCS OUT OF SERVICE and RCIC SYSTEM OUT OF SERVICE alarm is not present in the control room respectively, and the status lamp for overload or loss of voltage in any MOV of the HPCS /RCIC is not lit.

02.1.7 Regulator's assessment and conclusions on fire safety analyses

From the point of view of the regulatory body, the entry into force of IS-30 has meant an important qualitative leap in the requirements and level of detail of fire safety analysis in nuclear power plants. This has allowed a uniform treatment of the analyses developed in all the plants and the adoption of the methodologies, state of the art, established in one of the reference countries (USA).

As a result, the fire safety analyses are of a high quality standard and have a full scope, including not only the impact of fire on the systems that would be used to cope with the postulated initiating events or accidents, but also the analysis to achieve and maintain safe shutdown considering the impact of fire on the associated circuits and a detailed analysis of the operator actions performed on these systems in case of fire.

In addition, the CSN inspection process includes in its basic inspection plan the performance of an inspection at each facility every 2 years to review the fire protection programme, in accordance with procedure PT.IV.204 revision 1 [38], and another with the same frequency to review the maintenance and updating of the probabilistic safety analyses, in accordance with procedure PT.IV.225 revision 1 [36]. These inspections ensure that the fire risk analyses of the plants are maintained and updated and monitor that the deviations detected are adequately corrected by means of the corrective action programme of each plant.

02.1.7.1 Overview of strengths and weaknesses identified

The regulatory framework established by IS-30 in relation to fire protection is considered to be robust, as it is based on methodologies and references widely contrasted in other countries with a large number of nuclear power plants (the United States and other countries that have adopted the same methodologies).

With regard to the scope and methodologies of safety analysis accepted as applicable, it is considered that the use of NEI 00-01 as a basic reference provides a robust methodology for the identification of the safe shutdown paths in case of fire, taking into account the analysis on associated circuits and multiple spurious operations.

On the other hand, the identification and analysis of the human actions necessary to ensure the success of the safe shutdown in case of fire is another important step in the integrated management of the fire risk from an operational and personnel training point of view.

Finally, the adoption of ASME/ANS RA-Sa-09 as a standard for PSAs in general and for Fire PSAs in particular, has made it possible to establish a unified framework of minimum quality requirements for probabilistic analyses and their successive revisions. These quality standards are, in particular, more demanding for plants that have adopted the risk-informed approach as a licensing basis. The use of the NUREG/CR-6850 methodology in all the fire PSAs of all the Spanish plants guarantees their quality and their adaptation to the most modern and detailed methodologies currently available for the performance of these analyses.

The integration of these three pillars described in the above paragraphs in the analysis methodologies allows for unified and complete criteria in the regulation of fire protection and in the identification of the key points to prioritise areas for improvement.

On the other hand, the dual adoption of both deterministic and probabilistic analyses to justify compliance with fire protection regulations allows for a high degree of confidence in the consistency of these analyses and guarantees that all possible fire scenarios that could potentially occur have been adequately analysed and considered in the establishment of prevention, detection and suppression measures.

Detailed analysis of fire induced failures taking into account the associated circuits and including available instrumentation, has led to further fire analysis in the control room or in other locations which may require a control transfer to the alternative shutdown panel. In some cases this has involved the installation or upgrading of this panel. On the other hand, the implementation of improvements such as the installation of RCPs passive seals or the rerouting of equipment to prevent spurious actuations, as well as the development and validation of the necessary procedures that have been incorporated into the training plans for operating personnel, have had a positive impact on safety.

In addition to the above, the design modifications and improved procedures required to guarantee safe operation in the event of any postulated fire scenario, including scenarios beyond the design basis, have been implemented at the Spanish plants.

As regards possible combinations of events in the case of the Spanish plants, a fire caused by an earthquake has been considered. In this case, the regulations require the availability of a seismically qualified FP system. In addition, for this scenario, the structural analyses of the H_2 lines, in safety-related areas, have been revised to ensure their integrity in the event of an earthquake and therefore eliminate the possibility of explosions in such a situation.

In addition, the combinations of fire and flooding have been reviewed in the flooding analyses to ensure that both the performance of the FP systems and the possible rupture of any of their lines would not lead to damage in SSC that would prevent the safe shutdown of the plant.

Fire scenarios that may affect the cooling safety function of the fuel pool or the ISFSI are expected to have very little risk significance due to the diverse water supply alternatives and the lengthy times available in the first case, and the fire design of the casks themselves in the second case.

02.1.7.2 Lessons learned from inspection and assessment

Monitoring activities have greatly benefited from a comprehensive and consistent regulatory and methodological framework since the entry into force of IS-30.

On the other hand, efficient supervision of analyses at this level of detail has required the constitution of multidisciplinary teams composed of experts in the various areas (risk analysis, systems engineering and operation, electrical engineering, organisation, human factors and training).

In this context, the fire protection inspection procedure, PT.IV.204, is in the process of being revised to formally incorporate the lessons learned from the fire protection inspection process into the current regulatory framework. Additionally, the inspection to review the maintenance and updating of the probabilistic safety analyses following procedure PT.IV.225, reinforces the vigilance on the fire analyses performed under this perspective.

Finally, risk-informed and performance-based analyses have proven to be a fundamental tool for licensing, in particular for plants that have carried out the NFPA 805 transition process and their monitoring is part of the biennial inspection performed under PT.IV.204 and PT.IV.225.

02.1.7.3 Conclusions drawn on the adequacy of the licensee's FSA

As mentioned in the previous sections, the development of Fire Safety Analyses in accordance with the indicated regulatory requirements established by IS-30, is generally considered a major step forward, in order to provide them with a broad and multidisciplinary scope, both from the point of view of regulatory compliance and to identify possible areas for improvement in the regulated installations.

Similarly, the requirement for seismic FP systems in operating power plants and the development of flooding analyses covering both FP actuation and rupture is an indication of the concern for the combination of seismic + fire and fire + flood events and their consideration by current regulations.

Finally, the CSN inspection process, carried out following PT.IV.204 revision 1 and PT.IV.225 revision 1 procedures, guarantees the maintenance and updating of the FHA and PSA of the plants and that the deviations detected during these inspections are suitably corrected by means of the corrective action programme of each plant.

02.2 Fuel Cycle facility – Juzbado

Safety Reference Levels (SRLs) have not yet been developed specifically for fire safety analyses for fuel cycle installations. In order to carry out this analysis, it was suggested in the TS to use the SV 3.1, 3.2 and 3.3, trying to apply them in a graded approach.

It was also suggested to apply, with a graded approach, the SRL E 6.1 which focuses on the combination of events in nuclear power plants

Finally, it was indicated that requirement 22 of IAEA SSR-4 *Safety of Nuclear Fuel Cycle Facilities* [73] should be considered.

At the Juzbado Plant, the Safety Objective, in accordance with Article 6 of Royal Decree 1400/2018 approving the Regulation on nuclear safety at nuclear facilities [14], is:

- *The purpose, design, construction, commissioning, operation and dismantling of nuclear facilities must aim at:*
    - *Preventing accidents and, in the event that they occur, the mitigation of their consequences.*
    - *Avoiding, either due to physical impossibility or by being extremely unlikely with a high level of confidence:*

      1. early radioactive releases that require emergency measures outside the site without sufficient time for their application; 2. major radioactive emissions that require protection measures for the population that must not be limited in duration or area.

In relation to fire protection, the principle of defence in depth is applied, implementing measures to prevent a fire before it starts, measures to detect, control and suppress it as soon as possible and, in the event of a fire, measures to prevent the propagation to other areas.

02.2.1 Types and scope of the fire safety analyses

At the Juzbado facility there are four documents that analyse the fires from different points of view:

- Fire Hazard Analysis
- Explosion Risk Analysis
- Deterministic Accident Analysis (Chapter 10 of the Safety Analysis Report)
- Integrated Safety Analysis (ISA):
- Combination of accidents

02.2.1.1 Fire hazard analysis

The Juzbado facility has a Fire Hazard Analysis, required by industrial regulations, the objective of which is to evaluate the risk of fire, taking into consideration:

- The calculation of intrinsic risk (deterministic method) of fire in all existing installations and buildings within the area under operator's control.
- The constructive characteristics of the installations.
- The fire protection existing means.
- The identification of applicable prevention and protection measures.

This analysis complies with the following regulations and applicable legislation:

- Royal Decree 2267/2004 of 3 December 2004, approving the regulation on fire safety in industrial establishments [74].
- Royal Decree 1942/1993, of 5 November 1993, approving the regulation on fire protection installations [75].
- Royal Decree 279/1991 of 1 March 1991 approving the Basic Building Regulations NBE-CPI/91: Fire protection conditions in buildings [76].
- Royal Decree 314/2006, of 17 March, approving the Technical Building Code (TBC) [77].
- Royal Decree 513/2017, of 22 May, approving the Regulation on fire protection installations [78].

Initially, the document analyses the location of the site, the existing buildings and the detail of the manufacturing processes and categorises the different buildings according to their configuration and location in relation to their surroundings, as well as their intrinsic risk level, taking into account the typologies included in RD 2267/2004:

- Type A: the industrial establishment partially occupies a building that also has other establishments, whether these are for industrial or other uses. Within the Juzbado site, there are no buildings of this typology.

- Type B: The industrial establishment fully occupies a building which is attached to other buildings, or at a distance of three metres or less from one or more buildings. Typology applicable to two auxiliary buildings.

- Type C: The industrial establishment fully occupies a building, or several buildings, which are at a distance of more than three metres from the nearest building. Applicable to nine buildings, the most important of which is the one housing the manufacturing activities.

- Type D: The industrial establishment occupies an open space, which may be partially covered, some of its façades have no side enclosure at all. Within the Juzbado site, there are no buildings of this typology.

- Type E: The industrial establishment occupies an open space, which may be completely covered, some of its façades on the covered part have no side enclosure at all. Applicable to one building within the Juzbado site.

Following this categorisation and in accordance with current regulations, a fire risk assessment is carried out for each of the buildings and each of the fire sectors.

This assessment is carried out by means of mathematical calculations included in Annex I of RD 2267/2004, which take into account the fire load density and the degree of danger of the fuels. Once the assessment of the areas has been finished, the global assessment of the buildings is carried out ending with the global analysis of the installation.

Depending on the numerical value obtained, the intrinsic risk levels are classified according to the following criteria set out in RD 2267/2004:

Intrinsic Risk Levels

	Low		Medium			High		
	1	2	3	4	5	6	7	8
Q_s (MJ/m^2)	$Q_s \leq 425$	$425 < Q_s \leq 850$	$850 < Q_s \leq 1{,}275$	$1{,}275 < Q_s \leq 1{,}700$	$1{,}700 < Q_s \leq 3{,}400$	$3{,}400 < Q_s \leq 6{,}800$	$6{,}800 < Q_s \leq 13{,}600$	$13{,}600 < Q_s$

Juzbado has a total of 12 areas or buildings, which house a total of 38 fire zones, in which the fire load has been calculated and the fire risk level evaluated following the guidelines of RD 2267/2004. Of these 38 fire zones, 22 constitute fire areas. Of the 38 zones, only 2 are of high risk (6). These 2 areas are located in the conventional part of the plant (with no radiological risk).

Once the fire load has been calculated for each of the areas located in the different buildings, the fire load and the total risk level for each building is calculated. It is important to point out that the highest classification of the buildings at the Juzbado factory is HIGH 6, which is present exclusively in a conventional building in which no nuclear material is handled.

Finally, the fire hazard analysis includes the overall intrinsic risk level of the industrial establishment. This is a weighted calculation, based on the existing areas in each building and their existing fire loads, which serves to provide a single value for the whole site. For the Juzbado factory, the intrinsic risk level of the establishment is LOW 2.

Once the fire risk of the different areas has been determined, the constructive requirements of the fire areas of the installation are verified, identifying, that their characteristics comply with the fire resistance requirements derived from the fire load calculations. Within the capacity or fire resistance of the fire areas, the fire barriers existing in each area are also listed in detail, highlighting: walls, doors, dampers in penetrations, seals in pipes and other passing elements between areas, etc.

Another section in the fire hazard analysis includes the evacuation routes, paths and elements available for a possible evacuation in case of fire in each of the 38 delimited areas, which is obtained according to the expected occupancy and the requirements of RD 2267/2004, the NBE-CPI/91 and the TBC Evacuation of occupants.

Once the fire risk and the details of the manufacturing processes at Juzbado have been identified, the fire hazard analysis includes the detection and suppression systems available in each area.

Finally, the fire hazard analysis verifies, using comparative tables, compliance with fire regulations, indicating compliance with the different requirements applicable to each detection and/or suppression system, set out in section 03.2.2.2 Fire suppression provisions of this document.

02.2.1.2 Explosion risk analysis

The Juzbado factory, in addition to the fire hazard analysis, has a document that includes the determination and evaluation of the risk of explosion, as well as the appropriate prevention measures for this risk in each case.

It is a document that includes a deterministic analysis in compliance with the following regulations and legislation:

- Royal Decree 400/1996 (Transposition of Directive 94/9/EC) concerning equipment and protective systems for use in potentially explosive atmospheres [79].
- Royal Decree 681/2003 (Transposition of Directive 99/92/EC) on the protection of the health and safety of workers exposed to risks arising from the presence of explosive atmospheres in the workplace [80].
- Technical guide for the assessment and prevention of risks arising from explosive atmospheres in the workplace, RD.681/2008 of 12 June [81].

Initially, the document lists the industrial buildings at the site, indicating those materials or products that can generate an explosion risk, whether they are liquids, gases or solids.

The following section is the application of the analytical method, based on the Technical Guide [81], to assess the risk and determine the need to apply explosion prevention and protection measures. For the determination of areas susceptible to the formation of explosive atmospheres, the analysis takes into account potential sources and classifies the areas accordingly. These studies include:

- Drawings with the classification of areas with a possible presence of explosive atmospheres.
- Characterisation of prevention and protection measures according to the existing technical requirements.

The criteria for classifying areas are as follows:

- Classification for gases or vapours:
    - Zone 0: permanent presence or for long periods of time of explosive gases or vapours.
    - Zone 1: liable to form under normal working conditions.
    - Zone 2: unlikely to be present for short periods.
- Classification for powders:
    - Area 20: An area in which combustible dust is present or may be present during normal operations, start-up or cleaning, in sufficient quantity to produce an explosive atmosphere. Example: in pulverising mills.
    - Area 21: An area in which a dust cloud or dust layer is likely to form under normal working conditions.
    - Zone 22: explosive powder is unlikely to be present and for short periods.

Once the categorisation of the areas has been completed, an assessment of the areas in terms of the probability of occurrence of explosive atmospheres is developed. The following valuation matrix is used:

		PRESENCE OF EXPLOSIVE ATMOSPHERES		
		ZONE 2 // 22	ZONE 1 // 21	ZONE 0 // 20
PRESENCE OF IGNITION SOURCES	UNLIKELY	UNLIKELY	UNLIKELY	REMOTE
	REMOTE	UNLIKELY	REMOTE	OCCASIONAL
	OCCASIONAL	UNLIKELY	OCCASIONAL	LIKELY
	LIKELY	REMOTE	LIKELY	LIKELY
	FREQUENT	OCCASIONAL	LIKELY	FREQUENT

Finally, an assessment is made of the level of risk in the event of an explosion:

		CONSEQUENCES			
		4 NEGLIGIBLE	3 MINOR	2 MAJOR	1 CATASTROPHIC
PROBABILITY OF EXPLOSION	UNLIKELY	D	C	C	B
	REMOTE	D	C	B	A
	OCCASIONAL	D	B	B	A
	LIKELY	C	B	A	A
	FREQUENT	C	A	A	A

Where:

- D TOLERABLE. There is no need to improve preventive action. However, more cost-effective solutions or improvements that do not entail a major economic burden should be considered. Periodic checks are required to ensure that the effectiveness of the control measures is maintained.

- C MODERATE. Efforts must be made to reduce risk, and the precise investments must be determined. Measures to reduce the risk should be implemented within a certain period. When moderate risk is associated with worse consequences, further action will be required to establish more precisely the probability of damage as a basis for determining the need for improved control measures.

- B IMPORTANT. Work should not be started until the risk has been reduced. Considerable resources may be required to reduce the risk. When the risk corresponds to a job that is being carried out, the problem must be remedied in less time than the moderate risks.

- A INTOLERABLE. Work should not be started or continued until the risk is reduced. If it is not possible to reduce the risk, even with unlimited resources, work should be prohibited.

As a conclusion of the analysis carried out, Juzbado has 8 areas with explosion risk, 4 of which are level C. The rest are level D.

Finally, to close the explosion analysis document, improvements of a technical, administrative or organisational nature are proposed in those areas where applicable, giving rise to design, procedural or organisational modifications at the facility. It also includes recommendations to be made in order to continue maintaining the facility in good condition and improving it. These include:

- Technical measures: Use of robust elements suitable in each case to prevent the escape of flammable substances, whether solid, liquid or gaseous; provision of inerting lines; provision of safety systems to shut off the supply of the flammable substance (interlocks).

- Organisational measures: Training and information to workers; lists of mobile equipment and instructions of its use in risk areas; planning of maintenance, control and checking; cleaning; signposting.

02.2.1.3 Deterministic accident analysis

Deterministic accident analysis analyses the radiological consequences of foreseeable accidents. Accidents are classified into three levels according to the probability of their occurrence and their severity measured in terms of the exposure they may cause to members of the public outside to the restricted area under the operator's control.

The three levels are:

- Level I: Those most likely to occur during the lifetime of the Plant and that could give rise to releases to the environment in the vicinity of the Plant that would produce doses of less than 0.015 mSv, much smaller than the annual dose limits due to effluent discharges under normal conditions.

- Level II: Those unlikely to occur during the lifetime of the Plant and that could give rise to the release of radioactive materials into the environment that would produce doses of less than 0.15 mSv. This category also includes those accidents that could have serious consequences, not necessarily radiological, for the Facility and those in which, without causing damage to the Facility or to the personnel, there is a potential risk that they could lead to such damage.

- Level III: Those not expected to occur during the lifetime of the Plant and that could give rise to significant releases of radioactive materials outside the restricted area, leading to doses at the boundary of the restricted area of less than 5 mSv.

The only Level III accident that is postulated is the criticality accident.

The following accidents have been studied in relation to fires. These accidents cover all the possible scenarios that can occur in the installation based on the processes that take place and the fire protection systems in place.

- Level I:
    - Leakage in the flammable gas piping system without fire inside the Manufacturing Hall
    - Incipient fires inside the manufacturing hall
    - Incipient fires outside the Manufacturing Hall that do not affect the Gas storage area
- Level II:
    - Sintering furnace explosion
    - Fires and Explosions inside the Manufacturing Hall
    - Fires and Explosions in the gas storage area

The probability of occurrence of each of these accidents is assigned according to the protections in place at the facility due to the application of the defence in depth principle, including the sectorisarion of the area in which fuel rods are manufactured, the fire detection and alarm system covering the entire facility, the flammable gas detection system that covers all areas where there is a possibility of hydrogen gas leaks, the interlocking of the gas supply system with the fire detection or the flammable gas detection systems, which allows the gas supply to be cut off at the gas storage area on detection of one of these systems, and the suppression systems and resources available in each of the areas of the facility, all of them adapted to the characteristics and risks of each area.

The consequences, in terms of dose outside the restricted area, are determined on the basis of the amount of material estimated to be released to the environment and in all cases result in negligible doses.

The assessment of the radiological consequences in case of accidents involving gaseous effluent emissions, which is the situation that arises in the event of fire, is analysed by taking inhalation as the critical path. The dose conversion factors used are taken from the *ICRP Database of Dose Coefficients: Workers and Members of the Public An Extension of ICRP 68 and 72*, 1999. Members of the public have been considered to be adults and a HEPA filter bank efficiency of 99.95% has been given credit. Dilution coefficients are calculated using the PAVAN software.

The fire protection system of the facility covers the entire manufacturing hall, as this is where the nuclear material is handled, in addition to the auxiliary installations in which the safety systems, that are included and detailed in the Technical Specifications, are located.

02.2.1.4 Integrated safety analysis

According to NUREG-1513 Rev. 0 *Integrated Safety Analysis Guidance Document* [82], the integrated safety analysis is a systematic examination of the processes carried out at the facility, its equipment, structures and staff activities that guarantees that all relevant risks that could cause unacceptable consequences have been adequately analysed. The analysis also identifies appropriate protective measures.

All risks leading to radiological consequences are assessed, either directly (criticality, contamination, irradiation, etc.) or indirectly (fire or explosion, chemicals, external events, credible relevant natural phenomena, etc.). These analyses consider not only normal operating conditions, but also any credible deviations from these conditions, including start-up, shutdown, maintenance, etc.

The analysed sequences identify the credible causes that may lead to the event and its consequences. The assessment of the consequences solely and exclusively takes into consideration the generic safeguards of the installation applicable to the accident sequence under analysis, but not the specific safeguards that prevent the occurrence of the initiating event.

The severity of the consequences (S) is assigned a value (1, 2 or 3) according to the criteria indicated in the following table, which conservatively reflect the criteria of the reference NUREG-1520 Rev. 1 *Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility* [83]. The assigned value for S corresponds to the worst consequences of the event, regardless of the controls in place to prevent the sequence from developing (non-mitigated value).

Severity of Consequences (S)

Range	Criticality		Radiological	
	Multiple independent Control Parameters for Criticality Control	Single Criticality Control Parameter with multiple independent controls	Workers	Public
3	Loss of all Independent Control Parameters.	Loss of all controls	$D_{Effective} > 1Sv$	$D_{Effective} > 250mSv$ Ingestion of more than 30mg of U Effluent release above the limits of the Technical Specifications
2	Loss of one or more Independent Control Parameter(s) so that only one Independent Control Parameter remains intact	Loss of one or more control(s) so that only one control remains intact	$50mSv \leq D_{Effective} \leq 1Sv$	$5mSv \leq D_{Effective} \leq 250mSv$ Effluent release that does not exceed the limits of the Technical Specifications and is reportable.
1	Loss of some Independent Control Parameters so that the Double Contingency Principle remains intact	Loss of some control so that the Double Contingency Principle remains intact	$D_{Effective} < 50mSv$	$D_{Effective} < 5mSv$ Effluent release Non-Notifiable according to the Technical Specifications

In addition, for each of the identified sequences, its probability (Non-mitigated Probability) is determined.

Non-Mitigated Probability (NMP)

Range	Frequency	Probability
3	More than once every 2 years	Likely to occur in the near future
2	Once during a period between 2 and 50 years	Likely to occur during the life of the facility
1	Less than once in 50 years	Unlikely to occur during the life of the facility
0	Incredible	Indistinguishable from zero

The data in this table are based on the values established by the reference facility for this type of analysis.

For fire sequences, the Non-mitigated Probability is established as a function of the combustibility hazard coefficient (Ci) and the dimensionless activation risk coefficient (Ra). The first weighs the degree of danger of a possible fire due to the combustibility of the materials present in the fire area and the second corrects the degree of danger according to the risk of activation due to the industrial activity being carried out.

Values of the combustibility hazard coefficient Ci

High	Average	Low
Liquids classified as Class A in the ITC-MIE-APQ1	Liquids classified as subclass B_2, in ITI-MIE-APQ1	Liquids classified as Class D, in accordance with ITC-MIE-APQ1
Liquids classified as subclass B_1, in accordance with ISIC-MIE-APQ1	Liquids classified as Class C, in accordance with ITC-MIE-APQ1	
Solids capable of initiating combustion at temperatures below 100 ° C	Solids igniting at a temperature between 100 °C and 200 °C	Solids igniting at a temperature above 200 °C
Products that may form explosive mixtures with air	Solids emitting flammable gases	
Products that can initiate spontaneous combustion in air		
C_i= 1.60	C_i= 1.30	C_i= 1.00

Activation Risk Values Ra

Activation risk	High	Medium	Low
Coefficient Ra	2	1.5	1

As stated in the Fire Hazard Analysis, the different areas where the process takes place are low risk 1 or 2, i.e. a large fire is not expected. Accordingly, since the fire analysis is performed by area and not by equipment and since the fire analysis assumes normal process conditions and not deviations from them, a starting value of NMP equal to 1 is set for all fire sequences. Therefore, the probability of the process deviation and the probability of the sequence developing with consequences from a Radiation Protection and/or Criticality point of view, respectively, must be added to the probability of a fire. For those areas with high Ci and high Ra NMP is conservatively set to 2.

From the values obtained for the severity of the consequences (S) and for the non-mitigated probability (NMP), the non-mitigated risk (NMR) is determined as S×NMP, which conservatively reflects the criteria of the reference NUREG-1520 Rev. 1 *Standard Review*

Plan for the Review of a License Application for a Fuel Cycle Facility. The NMR level associated with each sequence indicates the risk of occurrence.

Non-Mitigated Risk Level Matrix (NMR)

	PNM			
S	0	1	2	3
3	Null	Moderate	Unacceptable	Unacceptable
2	Null	Acceptable	Moderate	Unacceptable
1	Null	Acceptable	Acceptable	Acceptable

For sequences identified with unacceptable or moderate unmitigated risk, additional controls in the process need to be defined and implemented to minimise the probability of occurrence or to reduce the severity of the sequence. These controls are referred to as the IROFS (Items Relied on for Safety).

The current Integrated Safety Analysis analyses 258 accident sequences related to fires and/or explosions, all of which have been assessed as having an acceptable unmitigated risk and therefore it has not been necessary to implement IROFS associated with these sequences.

02.2.1.5 Combination of accidents

In the Juzbado Safety Analyses, accidents are studied in a deterministic or probabilistic manner individually, not including combinations of them.

Following the accident at the Fukushima nuclear power plant in Japan, stress tests were defined for European nuclear power plants to analyse a set of extreme situations in order to demonstrate the robustness of the protection measures currently in place and to identify appropriate safety improvement plans. The CSN agreed to apply these stress tests to Juzbado, issuing for this purpose the *Complementary Technical Instruction in relation to the Stress Tests to be required of the Juzbado Fuel Manufacturing Facility*, reference FCJUZ/JUZ/SG/11/12 [23] and dated 30th June 2011.

The assessment consisted of an evaluation of the facility's response to a set of considered extreme scenarios and a verification of the preventive and mitigating measures chosen following the "defence in depth" philosophy: initiating events, consequential loss of safety functions beyond their design basis and consequence management.

The analyses assume, under a deterministic approach, the sequential loss of existing defence measures, independently of the probability of occurrence of such loss. In particular, it should be taken into account that the loss of safety functions and extreme accidental situations can only occur when numerous design provisions have failed. Moreover, it must be assumed that the means available to adequately manage these situations are successively lost.

The technical scope of the latter was defined taking into account the problems highlighted by the events at Fukushima, which have included the combination of initiating events and multiple failures. The following extreme situations, corresponding to increasingly degraded conditions, have therefore been addressed:

a) Credible initiating events at the site: Earthquakes, floods and other extreme natural events.

b) Consequent loss of safety functions: Loss of power, including station blackout (SBO).

The following analyses were carried out in these fire-related stress tests and associated actions were identified to eliminate weaknesses:

- Earthquake outside the design basis concurrent with other events.

  As a result of the possibility of a water supply and a fire suppression system loss, countermeasure number 3 in the following section was established.

- Fire caused by an earthquake (or other initiating event):

  1. Relocation of the components warehouse located in the Mechanical Area, outside of the Fabrication Hall. This is due to the fact that the location is considered to be a weak point given that there are wooden containers of various materials in this warehouse, including components made of zirconium, which represent an additional risk in the event of a fire in this area due to the nature and behaviour of this material.

  2. Change of the routing of the special fluid piping that ran inside the Fabrication Hall to prevent a leakage that could cause an explosion, resulting in structural damage to the facility.

  3. Implementation of a fire water supply capable of operating after an earthquake.

- Loss of offsite power (LOOP). The need to increase the autonomy and robustness of the generator sets and the fire pump was identified as follows:

  1. To separate the filling lines of the Generator Sets tanks, for this purpose the tank of set 2 has been connected to the underground tank, maintaining the connection between the tanks of sets 1 and 2.

  2. Automation of the fuel transfer between the underground tank and the Diesel generator and fire pump tanks.

  3. Acquisition of a portable pump for transferring diesel fuel between tanks and installation of the corresponding connections on the current pipelines to connect flexible conduits in order to be able to transfer fuel in the event of the failure of any of the components of the system.

- Station Black Out. The total loss of power in the installation does not represent an accident situation, therefore no external actions are expected in the event of a SBO, but additional measures were taken to increase the robustness of the system, through action 3 in the previous section.

- In the evaluation of the margins to validate the assumptions of the Design Basis, studies were carried out to verify the seismic behaviour of the firefighting tanks.

As a conclusion of the analysis, a seismic water tank for fire protection was implemented.

02.2.2 Key assumptions and methodologies

Due to the special characteristics of the safety analyses of Juzbado, the hypotheses and methodologies have been detailed in each of the analysis described above.

02.2.3 Fire phenomena analyses: overview of models, data and consequences

Due to the special characteristics of the safety analyses of Juzbado, the calculations performed have been detailed in each of the analysis described above.

02.2.4 Main results / dominant events (licensee's experience)

Due to the special characteristics of the safety analyses of Juzbado, the results have been detailed in each of the analysis described above.

02.2.5 Periodic review and management of changes

Juzbado received its last operating authorisation in June 2016 following the periodic safety review carried out during the previous year, and will restart the PSR process in 2025.

02.2.5.1 Overview of actions

The second periodic safety review carried out by the factory covered the period from 01/01/2005 to 31/12/2014, obtaining the renewal of the Operating and Manufacturing Authorisations on 05/07/2016.

The conclusions of this PSR were that the fire safety analyses did not require updating, and therefore no action was required.

02.2.5.2 Implementation status of modification/changes

The design modifications that have had or will have an impact on the safety analyses of the facility are as follows:

- Replacement of propane in sintering and densification furnaces by ignition resistors.
- Refurbishment of the gas storage area and control panel.
- Elimination of the foam suppression system used for steam boilers.
- Automatic double-swinging doors in the ceramic area for trolley passage.

02.2.6 Licensee's experience of fire safety analyses

02.2.6.1 Overview of strengths and weaknesses identified

The conclusions of the Integrated Safety Analysis and the Accident Analysis included in the Safety Study show that the risk analysis carried out in the installation has allowed the correct implementation of fire protection in the installation.

No weaknesses have been identified in the analyses and they are considered to provide conservative coverage of the expected events at the facility.

02.2.6.2 Lessons learned from events, reviews, fire safety missions, etc.

No lessons learned have been derived from the review of the safety analyses.

02.2.7 Regulator's assessment and conclusions on FSA

Regarding the performance of the safety analyses at Juzbado, the performance of the integrated safety analysis (ISA) has been one of the main efforts carried out recently as indicated below.

02.2.7.1 Overview of strengths and weaknesses identified

The integrated safety analysis (ISA) has enabled an integrated and comparative analysis of the different risks in the installation and the identification of the most important basic safety elements. From this point of view, fire does not appear to be a factor requiring additional IROFS.

On the other hand, fire regulations for this type of installation are strongly based on industrial regulations and the prevention of occupational hazards, although it is necessary to take into account the differentiating aspects of radiological risks.

Finally, event combination analyses have led to design improvements such as the re-routing of the hydrogen lines and the construction of the seismic water tank for FP, both of which are considered a strength in firefighting.

02.2.7.2 Lessons learned from inspection and assessment

The different assessments and inspections carried out at Juzbado have shown adequate monitoring of the installation by the regulator, and the actions taken by the licensee of the facility have been considered adequate.

02.2.7.3 Conclusions drawn on the adequacy of the licensee's FSA

The analyses carried out by Juzbado's licensee are considered adequate to identify and limit the main fire and explosion risks at the facility. Nevertheless, a Periodic Safety Review is scheduled to be carried out in connection with the next renewal of the operating permit, and within this framework it is foreseen that the licensee will be required to analyse the standards available for installations of the same type, leading to the adoption of a FP programme involving the integrated management of fire risks and the factors involved in fire protection.

03 Fire Protection Concept and Its Implementation

03.1 Fire prevention

03.1.1 Fire prevention in NPP

The Spanish nuclear power plants apply the principle of defence in depth, the first level of which is to apply preventive measures to prevent fires from occurring.

As measures typically applicable to fire prevention, the specification [2] mentions three measures relating to the control of the following elements:

- Fire loads (minimisation and segregation of both fixed and transient fuels as far as possible; location, spatial distribution and properties of fuels, etc.).

- Ignition sources (in particular, minimisation of potential ignition sources as far as possible, strict control of any ignition sources and separation of ignition sources from fire loads and management of hot works or jobs where there is risk of fire).

- Oxygen (reduction of oxygen concentration, inert atmospheres, etc.).

All three measures are applied in Spanish nuclear power plants. The first two are set out below, in this block 03.1.1 together with the oxygen reduction measures by limiting the storage and use of oxygen; and, additionally, CO_2 or other inert gas flooding systems are used as a suppression measure in some areas, which is set out in section 03.2.1.

The WENRA reference levels are applicable to nuclear power plants. In particular, SV 6.11 is applicable to fire prevention.

The same RL and S-26 and S-27 apply in waste disposal and spent fuel storage facilities included in nuclear power plants, as well as in decommissioning facilities.

In Spain, the WENRA reference levels for fire protection are reflected in the national standard for nuclear power plants in IS-30 [4].

The articles of IS-30 [4] concerning the establishment of fire prevention measures are as follows: 3.1 Fire safety objectives (3.1.1 adoption of the defence in depth principle); 3.2 Design basis (3.2.1 design should meet the criteria of defence in depth and fire postulation, 3.2.2 safety important SSCs must be designed and located to minimise the likelihood of fire and its consequences by using non-combustible and heat resistant materials, 3.2.3 the plant should be fitted with fire resistant materials, 3.2.14 requires cables qualified to withstand the flame propagation test); 3.4 Fire protection systems (3.4.11 RCPs oil leakage collection system, 3.4.12 specific protection requirements for areas with particular fire hazards or special safety impact); 3.6 Maintenance and administrative controls (3.6.1 procedures to control and minimise the amount of combustible material and ignition sources).

The general guidelines for complying with the above requirements are set out in the following sections of SG 1.19 [29], as a reference guide: 3 Basic criteria and general design assumptions (3.1, 3.2, 3.3); 5 Administrative controls; 8 General guidelines (8.1, 8.11, 8.12) and 10 Guidelines for specific areas of the plant.

Additionally, plants that have transitioned to the NFPA-805 standard as the licensing basis for fire protection [5] have been adapted to comply with section 3.3 on prevention.

03.1.1.1 Design considerations and prevention means

In Spanish nuclear power plant design, the probability of fires occurring is reduced through the control of combustible materials in the safety buildings, in accordance with sections 8.1 and 8.11 of SG 1.19 [29], which develop articles 3.2.1, 3.2.2, 3.4.11 and 3.4.12 of IS-30, establishing the following measures:

In general, safety important SSCs are designed and located to reduce the risk of fire on them to a minimum by using non-combustible and heat-resistant construction materials and by protecting important SSCs through separation by distance or by interposing fire-resistant barriers between the fire hazard and the SSCs. (8.1 and 8.11 of SG-1.19 [29]).

03.1.1.1.1 Separation of safety SSCs from combustible materials

Paragraph 8.11.1 of SG 1.19 indicates measures related to the separation of safety SSCs from combustible materials.

1. Almaraz NPP

Almaraz NPP has transitioned to NFPA 805, based on a risk-informed and performance-based methodology, while maintaining defence in depth criteria and adequate safety margins.

With regard to prevention in design, the articles of NFPA 805 have been analysed and will be mentioned in each sub-section. Specifically in relation to combustible materials, Articles 3.3.8 and 3.3.12 have been analysed.

<u>In relation to NFPA 805 Article 3.3.8:</u>

The diesel storage tanks for the diesel generators, the auxiliary boiler and the FP diesel pump (five tanks in total) are located outdoors, separated from each other and from buildings containing safety important SSCs at distances greater than those required by NFPA 30 [84].

Each tank is designed according to recognised standards, has adequate vents and a corresponding containment basin for any possible fuel spillage, and an automatic water spray system on the outside of the tank.

The tanks for the diesel generators also have an automatic water-foam injection system, although in this case the manual opening of a valve is required for effective discharge.

The turbine oil tanks are separated from other adjoining fire areas with R180 barriers and have thermovelocimetric detection and fixed water spray systems and fire hose cabinets (FHC), one of them with foam concentrate.

With regard to diesel generators and their associated tanks, each diesel generator is located in a separate and independent fire area with R180 barriers. Except in the case of the 4DG (where the oil and diesel day tanks are located in fire areas separate from each other and from the DG room itself), the day tanks are located in the same fire area as their corresponding DG. In all five DGs, there are automatic pre-action systems at the DG bench and gas flooding systems for the area (with CO_2 in diesel 1, 2 and 3, with FE-13 in the 4DG electrical room, and with FM-200 in the 5DG electrical room). Additionally, in the case of the 4DG, there are automatic water spray systems with foam in the oil and diesel tanks (day tank). In all cases, FHC and fire extinguishers are available as back-up facilities. The DG cubicles act as retention cubicles.

In relation to NFPA 805 Article 3.3.12:

The RCPs oil collection system has a leakage collection tank for each of the 3 main pumps, with sufficient capacity and located outside the pump enclosure. Each tank is fitted with a flame suppressor in the vent. The applicable requirement of NFPA 805 is equivalent to 3.4.11 of IS-30.

2. Vandellós NPP

The daily oil and fuel tanks of the emergency diesel generators are located in separate fire areas with R180 barriers and protected with automatic water systems (pre-action sprinklers).

The clean and the dirty oil and turbogenerator lubrication tanks are located in separate fire areas with R180 barriers and protected with automatic water systems (water-foam sprays).

An oil leakage collection system is provided for the reactor coolant pumps (RCPs). This oil is piped to tanks outside the pump enclosures. The tanks are emptied manually when required. The collection system fulfils a number of additional criteria according to Article 3.4.11 of IS-30 [4] which are described below.

3. Cofrentes NPP

The daily fuel tanks of the emergency diesel generators are adequately protected according to the results of the risk studies of the area. They are located in separate fire areas with R180 barriers and protected with AFFF foam systems.

03.1.1.1.2 Control of combustible or flammable gases

In relation to the control of flammable or combustible gases, the guidance in paragraph 8.11.2 of SG 1.19 is followed.

1. Almaraz NPP

Almaraz NPP in this respect has carried out the analysis of Article 3.3.7 of NFPA 805.

There is no fixed storage of flammable or oxidising compressed gases in the power block and temporary storage is subject to a regime of authorisation and regular monitoring.

The outdoor hydrogen storage for the alternators is located next to the south wall of the turbine building, with its axis parallel to the south wall and shielded by protective walls.

2. Vandellós NPP

The storages of hydrogen, nitrogen and carbon dioxide are located outdoors and do not affect safety important SSCs. A review of the outdoor areas has recently been carried out as a follow-up action to the last PSR (see more information in section 02.1.5.2).

The collection of compressed gases (flammable or oxidising) inside buildings is not permitted in accordance with procedure PCI-63, which will be explained in detail in section 03.1.1.2.1. Cylinders containing these gases must be stored in the mechanical or electrical workshop (outside the power block) or in the hot workshop in case of the controlled area. As far as PR-10 (flammable) gas is concerned, its presence is limited to those locations where an equipment for monitoring is available for contamination control in the controlled area (2 PR-10 cylinders per equipment, one of them as a reserve). The presence of this gas is included as a fixed fire load in the FHA in the applicable fire areas.

With regard to the storage of high-pressure gases in outdoor areas, the arrangement of the hydrogen cylinder bank KH-T04A/B/C/D (located next to the west façade of the Control building) is worth mentioning. These are arranged with their longitudinal axis perpendicular to the west wall of the Control Building. Therefore, within the scope of the 3rd PSR an area for improvement was identified to modify its layout with the longitudinal axis of the bottles parallel to the wall or to have a physical barrier to protect the surrounding buildings from possible impacts.

3. Cofrentes NPP

Hydrogen is stored outdoors and in the turbine building.

Compressed gas cylinders in buildings containing safety-related SSCs are seismically supported. The anchoring method used allows the longitudinal axis of the cylinders to be parallel to the walls of the building.

03.1.1.1.3 Plastics control

In relation to the control of plastics, the guidance given in section 8.11.3 of SG 1.19 is followed.

1. Almaraz NPP

It is recommended to minimise the use of halogenated plastics such as PVC and neoprene. They should only be used when no alternative non-combustible material is available.

2. Vandellós NPP

The use of plastic materials is limited to the minimum necessary, especially halogenated plastics. For cable insulation, ethylene-propylene (EPR) is used for power cables and cross-linked polyethylene (XLPE) for instrumentation and control cables. Hypalon (chlorosulphonated polyethylene) and in some cases neoprene are used for the cable sheaths because of their good flame propagation behaviour (the cables have passed the flame test according to IEEE 383 [72]). Finally, PVC has been used as a filler material in the technological safeguards towers. However, it is rigid PVC with a flame spread index of less than 25, meeting the requirements of ASTM E84 [85], and falls within the definition of a non-combustible material according to this standard.

3. Cofrentes NPP

It is recommended to minimise the use of halogenated plastics such as PVC and neoprene. They should only be used when no alternative non-combustible material is available.

03.1.1.1.4 Storage of flammable liquids

Section 8.11.4 of SG 1.19 [29], on the storage of flammable liquids is followed, both in the design, following the guidelines of the NFPA 30 standard, and in the storage by means of the storage control procedures for combustible and transitory materials (PCI-63 at Vandellós NPP, PPCI 2.1.2.1 and PC 050 at Cofrentes and DAL-94 at Almaraz NPP).

03.1.1.1.5 Hydrogen lines

Section 8.11.5 of SG 1.19 is followed.

In accordance with RD 681/2003 [80], an explosion protection document is drawn up and kept up to date, in which the plant locations susceptible to generating explosive atmospheres are reviewed and the adequacy of the protection measures to prevent the ATEX risk is verified. In particular, the following aspects, among others, are verified:

- The substances used are those required for the development of the activity and their storage and management is in accordance with regulatory requirements. The storage of flammable substances or bottles in quantities greater than those established in the CTI-01 of the Regulation on the Storage of Chemical Products RD 656/2017 [86] (APQ No. 5848 warehouse 9, No. 5846 warehouse 5) have the installation legalisation and have the measures required by this decree.

- In relation to installations, it is verified that according to the terms of the ATEX Directive 2014/34/EU [87] (formerly 94/9/EC), all electrical and non-electrical equipment installed in a potentially explosive area after 30/06/2003 must have the CE ATEX marking appropriate to the area in which they are installed, in order to ensure that they do not constitute an effective ignition source. In the case of installations prior to their application, they must have the appropriate protection measure.

- If equipment is used in classified areas, it must be verified that it complies with RD 1215/97 establishing the minimum safety and health requirements for the use of work equipment by workers [88].

- In accordance with Directive 1999/92/EC [89] and Royal Decree 485/1997 [90] on minimum requirements for health and safety at work, access to areas where there is a risk of explosive atmospheres in quantities hazardous to the health and safety of workers is signposted.

1. Almaraz NPP

Almaraz NPP in this respect has carried out the analysis of Article 3.3.7 of NFPA 805.

The hydrogen supply lines to the VCT have been rerouted outside the buildings, keeping essential small interior lines for which piping with guard pipe (vented along most of their length) has been installed. These lines are the only ones of H_2 that run through safety-related areas. This upgrade was implemented as a result of the NFPA 805 transition project. These lines are seismically supported to guarantee structural integrity criterion IIA and have a seismic margin of 0.3 g, in accordance with the design modification 1/2-MDP-03512-06.

2. Vandellós NPP

In accordance with SAR Chapter 9.3.8, the only hydrogen line that runs through safety-related areas is the supply line to the Volume Control Tank (VCT). Although this line is class 2D (seismic category 2) in part of its route, it is designed according to the requirements of ANSI/ASME B31.1 [91], is small in diameter and carries a fluid of moderate energy, so no rupture or through cracking is postulated in it. A flow limiting valve is also provided. In addition, this pipeline was seismically evaluated within the scope of the Stress Tests derived from the Fukushima event for the 0.30 g earthquake (RLE). This calculation is included in document 16626/SSA/IIT 019 Ed. 0B *Seismic capacity of potential fire sources - Vandellós NPP*.

Vandellós has an Explosion Protection Document in accordance with RD 681/2003[80], revised on 3 February 2018 and a computer application, RD 1215/97 Inspection, for monitoring revisions and managing observations and corrective measures. Equipment within the scope of the classified areas is recorded in this application.

3. Cofrentes NPP

At Cofrentes NPP there are two systems that transfer hydrogen, the H_2 and CO_2 Generator Supply System (N44) and the Hydrogen and Oxygen Injection System (P73).

The function of the N44 is the cooling of the electro-generator by means of hydrogen, which is normally obtained from a battery of sixteen (16) cylinders of standard shape and dimensions, installed in the Turbine Building (a not safety-related building).

P73 is involved in the chemical control of the reactor feedwater to protect the vessel, its internal structural components, and the piping and equipment of the Recirculation System, against the effects of intergranular stress corrosion. Hydrogen injection takes place at the suction of the condensate booster pumps and is therefore not in any safety-related area.

03.1.1.1.6 Guidelines for specific areas

Section 10 of SG 1.19 [29] sets out guidelines for specific areas as detailed below:

Primary and secondary containment

Specific guidelines are included in section 10.1 of SG 1.19.

1. Almaraz NPP

   The containment area in each of the two units consists of 9 different fire zones.

   The containment (in each unit) has automatic fire detection by means of thermal and thermovelocimetric detectors, strategically distributed within the containment, that provide alarm capability in the safeguards panel, the control room and in the COSS.

   Containment suppression is manual and is carried out by means of portable fire extinguishers (demineralised water) and the network of fixed fire hydrants connected to the main ring. There is the possibility of supply to the FHC from the FP seismic subsystem. Water spray systems are provided in the reactor coolant pump areas and in the electrical penetrations area.

   Additionally, section 03.1.1.1.1 describes the oil leakage collection system of the main pumps.

2. Vandellós NPP

The design of the leakage collection system complies with the provisions described above, with one leakage collection tank for each of the 3 RCPs, which has a flame suppressor in the vent.

The containment building consists of a single fire area, divided into 15 zones for the analysis, as it has concrete walls that partially enclose, limiting the spread of a fire.

Thermal and photoelectric detection is provided in the cable tray passage areas and in the reactor coolant pump area. Detection in areas where safety-related trays pass has been reinforced with detectors located between the trays. Water hoses are available as primary suppression system. The water supply to the hose network is normally shut off by means of a motorised containment isolation valve, located in the auxiliary building. This valve can be opened from the control room or locally.

3. Cofrentes NPP

The containment area consists of 19 fire zones belonging to the same fire area, due to the fact that all floors are connected by grids, for pressurisation in case of LOCA (Loss-of-Coolant Accident).

The primary containment has optical detectors strategically distributed within the containment. The corresponding Fire Alarm Control Panel (FACP) of these detectors produces an alarm locally and at the remote Control Room panel.

Fire detectors installed in primary containment are classified as N1E and therefore do not require environmental qualification.

The suppression in the primary containment is manual and is carried out by means of portable extinguishers and the network of fixed FHC connected to the main ring.

The dry well is a totally inaccessible area with the power plant in operation.

In this area, environmental conditions prevent the use of any type of gaseous suppression agent in the area. Fixed water systems are ruled out because of the impossibility of controlling possible sporadic discharges, which could damage the equipment contained in the area, and because of the maintenance of isolation valves.

In general, it does not contain combustible materials (since all the cables are in metallic conduit), except for the Reactor recirculation pumps and the system valves, the main fuel load is lubricating oil. The lubrication oil is confined within the metal casing of the pumps and is not pressurised, which minimises the possibility of leakage. This design is similar to that of the BWR-6 pumps, which is considered acceptable by the NRC. NRC explicitly states that no leakage collection system or any additional fire protection is required for the trays in the area. This equipment is not safety equipment, so any possible leak does not affect the possibility of bringing the power plant to a safe shutdown.

The FHCs are installed outside the Dry Well.

Control room and adjoining rooms

The specific guidelines are set out in paragraph 10.2 of SG 1.19.

1. Almaraz NPP

The fire area in which the control room is located is made up of three different fire zones, located immediately above the cable room in the Electrical/Auxiliary Building and is common to both units. The zone in each unit that contains the control panels has three fireproof panels for compartmentalisation. Due to the cable routing in the control panel, the safe shutdown functions are fulfilled through the alternative shutdown panels, in accordance with the transition to NFPA 805.

The control room is separated from other fire areas by three-hour rated barriers.

There is detection both in the control room and inside the control panels; the corresponding gas flooding suppression systems are provided in raised floors, armoured cable trays and inside the panels. A sufficient number of self-contained breathing apparatus is available in the control room.

The detection system acts by isolating the control room ventilation, whose inlet and outlet ducts are fitted with smoke detectors.

FHC are also available in the immediate vicinity of the control room as well as back-up CO_2 extinguishers.

Cables in the false ceiling are routed in accordance with requirement 3.3.5 of NFPA 805.

2. Vandellós NPP

The design of the control room complies with the provisions described. The control room has large dimensions (931 m^2) and volume (5586 m^3). It is located in the control building. Train A cables come from the cable distribution room at the elevation bellow and enter directly into the control room cabinets through the bottom of the cabinets, while train B cables from the cable distribution room at elevation above and enter through the top via cable trays, but do not enter through false ceilings. The area with a false ceiling is the area corresponding to the horseshoe and annexed offices. It has been verified that the cables that are routed above the false ceiling are routed in metal conduits of 4" (10 cm) or less.

Smoke detection is available in the area. There is also smoke detection inside the desks and control panels where train A and B coexist, inside the air intake ducts to the control room, and inside the panels related to the technological safeguards water system. FHC and CO_2 extinguishers are available as suppression systems.

3. Cofrentes NPP

The control room fire area consists of six (6) fire zones, which include the Control Room, computer area and the control room ventilation and filtration equipment rooms. The fire resistance of this area is 3 hours.

The Control Room is not used as a passageway between areas, cables entering the Control Room terminate at a panel in the Control Room. The cable laying at Cofrentes NPP has been carried out in accordance with the indications of IEEE standard No. 384 [92] and the R.G. 1.75 [93], as indicated in the Designation Study, Identification and separation of piping and equipment.

Electrical equipment rooms

The specific guidelines are set out in paragraph 10.5 of SG 1.19.

1. Almaraz NPP

Redundant electrical safety equipment is located in separate fire areas.

All rooms have automatic detection with local and control room alarm.

In addition, all rooms are adequately covered by a FHC. Portable fire extinguishers are available both inside and outside each fire area.

Fire dampers are also provided to prevent the spread of fire. Also, the operation of the extraction unit of the area of not controlled access may facilitate smoke removal in the event of a fire.

2. Vandellós NPP

At Vandellós II, the above-mentioned premises relating to the separation by means of R180 barriers separating the electrical safety equipment of redundant trains, minimisation of cables passing through rooms that do not terminate or do not perform a function in them and optimisation of the routes in order to reduce the fire load are complied with.

Fire detection with local and control room alarm is provided. As suppression systems, FHC are generally available with the jet position overridden (in fog spray position) or CO_2 with the support of CO_2 extinguishers and in some areas there are automatic fixed systems using gaseous agents FE-13 (electrical rooms of the technological safeguards water system) and Novec 1230 (electrical rooms of the auxiliary building).

3. Cofrentes NPP

Redundant electrical safety equipment is located in separate fire areas by means of R180 barriers.

Fire detection with local and control room alarm is provided. FHC with fog spray position and CO_2 extinguishers are available as suppression systems. In some areas, fixed automatic systems using Novec 1230 and CO_2 gaseous agents are available.

Remote shutdown panel

The specific guidelines are set out in paragraph 10.6 of SG 1.19.

1. Almaraz NPP

An Alternative Shutdown Panel (ASDP) and a Remote Shutdown Panel (RSDP) are provided in each unit to cope with a control room fire scenario that only results in the control room being abandoned due to loss of habitability.

In a scenario of control room abandonment due to a fire in the control room or cable room causing undetermined damage to equipment and components, only the

Alternative Shutdown Panel is used, which ensures safe shutdown by means of electrically independent control and indication from the control room and cable room.

The alternative shutdown panel and the remote shutdown panel are located in separate fire areas, separated by 3-hour fire resistance barriers of the control room and the cable room.

The panels have automatic detection inside them that provides local and control room alarms, as well as the automatic actuation of an FM-200 gas suppression system inside the panels.

The rooms in which they are located also have automatic detection with alarm in the control room, portable fire extinguishers and adequate coverage by means of FHC (in the rooms themselves or in adjacent rooms).

2. Vandellós NPP

At Vandellós II, the above premises are being fulfilled. RSDP fire areas have a calculated fire severity of less than 3 min.

The remote shutdown panels, one for each train, are located in two fire areas separated by R180 barriers from the rest of the plant and from each other. Additionally, one of the trains is electrically independent from the control room, complying with the general design criterion 19 of IS-27. The areas have fire detection with local and control room alarms. FHC and portable CO_2 extinguishers are available as suppression systems.

3. Cofrentes NPP

The fire area in which the RSDP is located has an automatic detection system with local alarm and remote panel signal and Control Room signal.

The RSDP fire zone is equipped with a Novec gas suppression system. It also has FHC suppression support systems and portable CO_2 extinguishers. The fire area of the remote shutdown panel is protected with 3-hour fire-resistant barriers.

Safety-related battery rooms

The specific guidelines are set out in paragraph 10.7 of SG 1.19.

Redundant battery rooms are located in separate rooms for each train, which constitute distinct fire areas and are separated from each other and from other areas of the plant by barriers with 3-hour fire resistance.

Rectifiers and other DC equipment are located in rooms adjacent to the battery rooms of the respective train, which constitute separate fire areas.

Both battery rooms and charger rooms have automatic detection with local and control room alarm.

The main suppression system consists of FHC outside the room and CO_2 extinguishers as a back-up.

The ventilation system continuously renews the air in the room and is designed to keep the hydrogen concentration below 2%.

The need for an explosion-proof electrical installation is analysed in accordance with ATEX regulations.

Turbine building

The specific guidelines are set out in paragraph 10.8 of SG 1.19.

1. Almaraz NPP

   The turbine building is separated from adjacent structures containing safety important equipment by barriers with a fire resistance of 3 hours and additionally, section 03.1.1.1.1 covers the treatment of oil storage in the turbine building.

2. Vandellós NPP

   The Turbine building is separated from the other buildings containing safety relevant SSCs (Switchgear, Auxiliary and Turbine Penetrations) by R180 barriers. This fire resistance according to the NBE-CPI/82 [94] standard applicable to the design of construction barriers, and to the ASTM-E119 [95] standard applicable to the fire test for the approval of fire barriers that meet both thermal insulation and structural integrity criteria.

   The clean and dirty lubrication oil tanks are located in a specific fire area, while the turbo-alternator lubrication tank is located in different fire area. Both areas are separated from the rest of the Turbine building by R180 barriers, have optical detection (sensors) with local and Control Room alarms and thermal detection to activate the automatic water and foam spraying systems that cover the areas.

3. Cofrentes NPP

   The structural design of the buildings containing safety related SSCs of Cofrentes NPP are capable of maintaining their structural integrity against the collapse of an adjacent building and therefore, in the event of a possible collapse of the Turbine building on top of the Auxiliary building, the latter would not be damaged.

   Oil tanks are installed in areas where 3-hour barriers are available and have no direct connection to buildings containing safety-related SSCs.

   The suppression systems are defined according to the risks assessed within the fire hazard analysis.

Diesel generator areas

The specific guidelines are set out in paragraph 10.9 of SG 1.19.

1. Almaraz NPP

   The description of the treatment of the diesel generator areas in the case of Almaraz has already been detailed in section 03.1.1.1.1.

2. Vandellós NPP

   The diesel generator areas are separated from each other and from the other areas by R180 barriers and are equipped with smoke and heat detection and automatic suppression systems using pre-action sprinklers. Water and CO_2 hoses, CO_2 and multi-purpose powder extinguishers and portable foam generation equipment are available as back-up suppression systems.

   The daily fuel tanks of the EDGs are located in separate fire areas with R180 barriers, which are protected by an automatic fixed water system based on pre-action sprinklers and have a containment dike to contain the entire tank volume in case of a leak (4000 litres per tank).

3. Cofrentes NPP

   The diesel generator areas are separated from each other and from the other areas by R180 barriers.

   The diesel generator rooms are equipped with sprinklers on the generator benches and CO_2 suppression systems in the control panels.

   Novec suppression systems are available in the electrical rooms. FHCs and fire extinguishers are distributed in all rooms.

   The day tank compartments of diesel generators are different fire areas. The floor of this area is considered as a retaining basin for the possible discharge of diesel oil in case of a spill. The fire resistance of the cubicle is 3 hours. They are protected by fixed, automatically activated water spray systems with synthetic foam (AFFF).

Fuel storage areas for diesel generators

The specific guidelines are set out in paragraph 10.10 of SG 1.19.

1. Almaraz NPP

   The description of the treatment of the fuel storage areas for diesel generators in the case of Almaraz has already been detailed in section 03.1.1.1.1.

2. Vandellós NPP

   The fuel storage tanks of the EDGs are vertical, have a unit capacity of 313 m^3 and are located in outdoor areas. This location is more than 15 metres from buildings containing safety important SSCs. The tanks are not fully buried and are located in cubicles separated by R180 barriers, capable of retaining possible spills.

   They have automatic detection and suppression systems using an external water spray system, as well as an internal manually operated AFFF foam system.

   At Trillo NPP there is a regulatory approval by the CSN with a distance of less than 15 m without R180 (there are building walls, but they are not considered R180) between the diesel generator diesel tanks and the building corresponding to the transfer pumps and the diesel generators themselves.

3. Cofrentes NPP

The fuel tanks for the diesel generators at Cofrentes NPP are six in number and are of the non-buried type. This list should include the auxiliary boiler oil tank which can also transfer oil to the other tanks.

The fuel tanks of the diesel generators and the auxiliary boiler fuel storage tank form separate fire areas and are protected by fixed automatic synthetic foam flooding (AFFF) systems installed in the tanks, and are also provided with external cooling by fixed water spray systems.

The tank is contained in a retaining cubicle with a useful capacity greater than 100% of the useful capacity of the tank, so that in the event of a breakage of the diesel tank, it is stored in the cubicle.

Transformer areas

The specific guidelines are set out in paragraph 10.12 of SG 1.19.

1. Almaraz NPP

Almaraz NPP in this respect has carried out the analysis of Article 3.3.9 of NFPA 805.

Oil-cooled transformers are located outdoors. They have oil collection and containment bins which are regularly inspected, except in the case of two stand-by transformers.

2. Vandellós NPP

Transformers are equipped with an oil collection system and are located in outdoor areas more than 15 metres from buildings or safety components or have R180 barriers when this distance is lower.

3. Cofrentes NPP

There are no oil-cooled transformers installed inside the buildings of Cofrentes NPP. Oil-cooled transformers are installed outdoors. All of them are equipped with a retaining bins for the collection of spillages. The transformers are separated from each other by fire-resistant walls.

Fresh fuel areas and spent fuel pool areas

The specific guidelines are set out in paragraphs 10.13 and 10.14 of SG 1.19.

1. Almaraz NPP

Both fire areas (fresh and spent fuel) have ionization detection at ceiling level with alarm in the auxiliary building FP panel and in the control room.

For the fresh fuel area, there is a portable CO_2 fire extinguisher inside the room and another one outside, next to the access door, as well as a FHC with a range over the whole room. The thermal load in this area is negligible

In the spent fuel pool area, the main suppression system consists of FHC (fed from conventional and seismic FP), with portable CO_2 extinguishers as a back-up system. The filtration units incorporate a flooding system required by RG 1.52 [96]. In this area the thermal load is low.

2. Vandellós NPP

The fresh fuel area and the spent fuel pool are located in the Fuel Building at different elevations, in the same fire area. Combustible materials in this area are mainly due to cable insulation and Radiation Protection (RP) passage areas and give rise to a severity of less than 1h, being in particular negligible in the swimming pool enclosure.

The area has smoke and flame detection (ultraviolet) with alarm on the local panel and in the control room, as well as FHC and CO_2 extinguishers.

In the case of Trillo NPP, the pool is located inside the containment area and is equipped with FHC and portable CO_2 extinguishers. The CSN has a regulatory approval of the absence of detection in the area on the basis of the low specific thermal load, no significant fire sources and no safety-related cables.

3. Cofrentes NPP

The fresh fuel is stored in the same area where the spent fuel pools are located, inside the fuel building. This area has automatic detection with optical detectors, FHC and portable CO_2 extinguishers. The alarms in this zone are connected to a FACP, which has a local alarm and indication on the remote control room panel.

A gas treatment system is provided, whose function is to filter and process the air coming from, among others, the fuel building in the case of high activity. There are two filter trains consisting of a filtration unit (with carbon filters), a main fan, a disintegration heat removal fan as well as the associated dampers and instrumentation.

Safety-related water tanks

The specific guidelines are set out in paragraph 10.16 of SG 1.19.

1. Almaraz NPP

Safety-related water tanks (refuelling and auxiliary feed water) are located outdoors and without storage of combustible materials in their immediate vicinity. The water that constitutes the final heat sink is located in the Arrocampo and the Essential water reservoirs.

2. Vandellós NPP

The water tanks required for safe shutdown: feed water system support tank, condensate storage tank and RWST are located in outdoor areas. According to the procedure PCI-63 transient combustibles are not allowed within 8 metres distance from safety-related tanks.

3. Cofrentes NPP

The water required for the safe shutdown is stored in the UHS tank, which is located outdoors and is enclosed to prevent unauthorised access. The pond itself is not considered combustible.

Cooling towers

The specific guidelines are set out in paragraph 10.18 of SG 1.19.

1. Almaraz NPP

Almaraz NPP has no safety-related cooling towers. The existing cooling towers do not perform any safety function and are sufficiently far away from safety-related SSCs.

2. Vandellós NPP

The safety-related cooling towers are those related to the EJ system, which are located next to the basin and are made of concrete. Rigid PVC with a flame spread index of less than 25 has been used for the infill material of the towers and is therefore considered to be non-combustible according to the definitions of paragraph 1 of the FHA.

In accordance with procedure PCI-63, no transient combustibles are allowed within 8 metres of the tower area.

According to the FHA, hydrants connected to the fire protection water loop (located in the vicinity of the towers) are available as a primary suppression system and powder extinguishers as a back-up measures. The water supply to the hydrants covering the tower area in case of fire is independent of the water in the reservoir and the wells of the towers themselves.

At Vandellós II NPP there are no non safety-related cooling towers.

At Trillo NPP, the forced draft cooling towers of the essential services water system are made of concrete and contain no combustible material. A regulatory approval is available for the absence of R180 separation between the fans of redundancies 1 and 2, as well as between those of redundancies 3 and 4.

The two natural draft towers of the circulating water system (condenser heat sink) are located in the same fire area, away from any safety-related system and with low fire risk, so any possible interference with them or the spread of a possible fire is ruled out.

3. Cofrentes NPP

There are no safety-related cooling towers at Cofrentes NPP. The final heat sink function is performed by the UHS pond.

Non-safety-related natural draft and forced draft cooling towers form individual fire areas and a fire in them would not affect safety-related SSCs. Even in the event of a collapse of these towers, according to point 3.7.2.8 of the SAR, no safety-related buildings would be affected.

ISFSI

The independent Spent Fuel Storage Installation must comply with the applicable regulatory requirements of 10CFR72 [97] and IS-29 [19], in particular section 3.5.3 contains design requirements to minimise risk and limit fire damage.

1. Almaraz NPP

An ISFSI separate from the nuclear island is provided with a suppression system (four monitor water cannons fed from a dedicated loop independently fed and covering the entire storage area) designed on the basis of the postulated aircraft fallout fire calculations. The ISFSI is a concrete slab with a concrete perimeter wall. The storage slab is remote from other facilities (ISFSI plant and auxiliary buildings). Due to the virtual absence of thermal load, the slab has no other FP measures except for the system indicated, in accordance with the postulated fires and the design of the containers. Portable fire extinguishers are available in the buildings in the vicinity.

2. Vandellós NPP

Vandellós NPP does not have an ISFSI.

Trillo NPP, unlike the other Spanish NPPs, has an ISFSI inside a building. The storage area, due to the virtual absence of thermal load, has no FP measures inside. However, if necessary, existing portable equipment in adjacent areas inside the ISFSI or nearby hydrants outside the building are expected to be used.

3. Cofrentes NPP

Point 3.5.3 of IS-29 states that the design of the installation shall provide the necessary measures to reduce the risk and limit the damage from fire, through levels of protection based on fire prevention, detection and alarm, suppression, and confinement of the fire through the design of fire resistant barriers, in such a way that the safety functions are fulfilled in any case.

At Cofrentes NPP, the appropriate protection system has been designed for this fire area as indicated in articles 3.4.2 and 3.4.12 of IS-30.

The building is composed of a single fire area. The area consists of 3 fire zones.

The first area corresponds to the ISFSI Auxiliary Building where incipient fire detection is provided and is protected by manual water equipment (hydrant) and back-up suppression means (powder and CO_2extinguishers).

The second zone corresponds to the ISFSI Control Building where optical-thermal detection has been provided and is protected by means of manual water equipment and back-up suppression means (powder extinguishers).

The third area corresponds to the Spent Fuel Storage slab, where the storage containers are housed. It is protected by portable powder and CO_2 extinguishers.

The PFP foresee the use, if necessary, of the portable means available in the surrounding areas (outdoor hydrants).

03.1.1.1.7 Other requirements applicable to power plants that have transitioned to NFPA

Plants that have transitioned to NFPA 805 have adapted their design to meet the requirements of Chapter 3. Some of these requirements have already been covered in previous sections of this report, so the requirements not covered elsewhere in the document are detailed here. Specifically, the following NFPA 805 articles have been reviewed:

1. Article 3.3.2:

   The construction materials of the foundations, structure, enclosure and roof of the power plant buildings have been assessed from the fire point of view. The materials used can be considered non-combustible according to RD 842/2013 [98] without the need for testing.

2. Article 3.3.3:

   The characteristics of the interior finishes of buildings have been analysed, finding painted, unpainted or untreated concrete finishes.

   A more detailed definition of the interior finishes of walls and ceilings can be found in NFPA 5000 [99]. This standard explains that if the material applied directly to the wall or ceiling is less than 0.9 mm thick, it is not considered an interior finish and is exempt from testing to the Class A requirements of the NFPA 101 *Life Safety Code* [100].

   In the paint specifications, at Almaraz NPP, the specified thicknesses for walls and ceilings are less than 0.9 mm. Therefore, paints are not considered as interior finishes.

   The interior finishes to be considered for walls and ceilings are the materials they are made of (concrete, non-combustible sandwich panel, precast concrete block) which are non-combustible. Therefore, they comply with NFPA 101.

   As for the floors, the paint used has a reaction to fire classification Class BFL s1, according to the UNE-EN 135011:2004 standard [101]. This means that its critical radiant flux is greater than 0.8 W/cm^2, thus meeting the NFPA 101 requirement (greater than 0.45 W/cm^2).

3. Article 3.3.4:

   The materials used in insulation have been assessed.

   With regard to those used in ventilation ducts, insulating materials have been accepted in HVAC ducts if they comply with reaction to fire class B-s1-d0 according to UNE-EN 14303 [102], thus complying with NFPA 255, which requires for this use materials with limited combustibility that have a flame spread index of less than 50.

   Regarding thermal insulation and reflective material, the materials considered in the insulation specifications of Almaraz NPP are non-combustible (mineral wool, silicates, insulating and finishing cements and austenitic stainless steel).

4. Article 3.3.5:

- In relation to cables in false ceilings, in the process of transition to NFPA 805 and also due to the analysis of the IS-30 requirement, cables were identified as being laid without being routed as required (conduit or armoured tray) in the control room and other areas of the electrical building. Appropriate modifications (installation of conduits for cables, as well as the installation of automatic detection and suppression systems) have been implemented to meet these requirements. Radioactive emissions are ruled out in the COSS buildings and in the building of access to the controlled area and, additionally in the latter, the possible effluents derived from a fire would be filtered, hence implementing improvements in these areas is not considered necessary.

- The cable trays (which are made of galvanised steel sheet metal) and conduits (made of galvanised steel) installed at Almaraz NPP, according to the specifications used, comply with the requirements of this section of NFPA 805.

- No safety-related flame-spread cables have been identified at Almaraz NPP.

- The power, control and instrumentation cables were purchased with an appropriate specification requiring the cables to be qualified in accordance with IEEE 383/1974 [72] to demonstrate their ability to perform during normal, accident and post-accident environmental operating conditions. This specification includes a requirement for flame resistance testing, in accordance with paragraph 2.5 of IEEE-383/1974, on representative samples of each manufacturing unit of the cables offered.

  An analysis has been carried out taking as a starting point the Fire Analysis Cable Database, which includes all cables considered in the PSA and Fire Safe Shutdown Analysis, and includes all 1E cables, plus train-associated cables and plus control cables (and some non-train cables). This analysis has been documented without having identified any cables with qualification deficiencies.

5. Article 3.3.6:

   The characteristics of the roofs of the Almaraz NPP buildings have been assessed in relation to this section of NFPA 805. Although these decks were not constructed to meet the requirements of NFPA 256 (endorsed in this section of NFPA 805), the plant situation is considered to meet the intent of this article and approval has been obtained in the transition process.

6. Article 3.3.10:

   All hot pipes and surfaces (above 60°C) are thermally insulated so that ignition of fuel that may come into contact with them is not foreseeable.

   A temperature higher than 43°C (design temperature) is not foreseeable in diesel lines.

   Possible oil spills on insulation are cleaned up immediately after detection in periodic rounds.

7. Article 3.3.11:

At Almaraz NPP, electrical equipment is not located in areas close to combustible materials. If in some cases this is not possible (transformer oil collection tanks), appropriate physical barriers are put in place.

03.1.1.2 Management and control of fire load and ignitions sources

At the Spanish nuclear power plants, in accordance with article 3.6 of IS-30 [4], administrative controls are established as preventive measures aimed at reducing the probability of the occurrence a fire.

To this end, procedures are in place to designate management personnel within the plant responsible for reviewing proposed fire protection programme activities, for identifying potential temporary hazards, and for specifying procedures for additional fire protection activities (SG 1.19 [29] section 5 point 4). Each plant's fire protection manual (FPM), together with the installation's Operating Regulations, include all these responsibilities. The FPM lists the different procedures applicable to all fire protection activities, including prevention. (At Cofrentes the FPM is called DB-04).

In order to develop the different administrative controls aimed at minimising the possibility of a fire, the procedures described in the following subsections are available.

03.1.1.2.1 Control of transitional fuels

The specific guidelines are set out in paragraphs 5 and 10.9 of SG 1.19.

1. Almaraz NPP

At Almaraz NPP, there is a procedure for the management and control of transient combustible storage zones (DAL-94, *Integral management of controlled transient combustible storage zones*) according to which requests for temporary storage are evaluated from the point of view of fire risks (fire load, accessibility to FP systems, basis for compliance with the transition to NFPA 805), as well as seismic and other risk criteria. This procedure establishes time and distance limitations to safety SSCs and graduates the level of clearance required based on established criteria. Storages for which there is a justified permanent need are analysed in the framework of the FHA and are included in the FHA. In addition, periodic inspections are carried out, in accordance with procedure GE-CI-02.06, to detect unauthorised storages, deficiencies in authorised storages, and other potential degradations in the configuration (leaks, hot spots, electrical degradations, etc.).

2. Vandellós NPP

For the control of transient combustibles, procedure PCI-63 is available, which establishes the method for limiting or prohibiting the accumulation of transient flammable and combustible materials in and around buildings containing safety important SSCs.

The procedure establishes a number of non-permitted storage locations inside buildings containing safety important SSCs, as well as around buildings and safety-related tanks in outdoor areas up to a distance of 8 m, defined in accordance with NFPA-30 [84], perimeter that is identified and marked on the ground. Limitations are placed on the storage of combustible materials in other areas. The procedure also defines the compensatory measures to be applied in the event that temporary storage in an area defined as "No storage location" or exceeding the permitted fire load in a "limited storage" area is necessary on a case-by-case basis.

Finally, according to the GMMM-007 maintenance document, at each refuelling outage (18 months) the torque tightening of those EDG elements that could potentially leak oil is checked.

3. Cofrentes NPP

Procedures PPCI 2.1.2.1- *Control of storage of combustible and flammable materials* and PC 050 *Procedure for the management and control of Auxiliary Plant Items* are available, which establish the method for limiting, prohibiting or permitting the storage of transient combustible and flammable materials. At CNC, the entry of wood and cardboard into the controlled area is prohibited except with the express authorisation of the Radiation Protection service in accordance with P-PR/2.5.20 *Rules for access, stay and exit of exposed workers from radiation areas*.

The waste removal control is carried out according to PPCI 2.1.2.1 "Control of storage of combustible and flammable materials" and the preventive monitoring follows PPCI 2.1.2.17 *Preventive fire monitoring*.

03.1.1.2.2 Control of use of ignition sources

The specific guidelines are set out in paragraphs 5 of SG 1.19, points 5 and 7.

1. Almaraz NPP

Almaraz NPP has a procedure for the control of fire risk works (GE-CI-02.07, *Management of fire risk work permits*). This procedure includes the limitation to 24h of the fire risk work permit.

Limitations on fire risk work also include restrictions on HRE during shutdown modes in the fire areas of the power plant.

2. Vandellós NPP

For the control of ignition sources, procedure PCI-15 establishes the controls to be carried out for work that generates sparks, fire, smoke, high temperature, flash photography, work with sprayed diesel fuel and any other work that could be a source of fire ignition or the undesired activation of fire detection and/or suppression systems. In general, permits shall be valid for a maximum of 24 hours. These permits are issued separately by fire zone or fire area.

The procedure is based on the reference standard NFPA-51B [103], for work that generates a fire risk, the 35 ft (11 m) rule is established as a general rule, verifying the absence of combustible materials in the vicinity or the establishment of necessary measures such as fire blankets. While the work is being carried out, at least two persons shall be available so that one person is on fire watch duty, and will remain until 30 minutes after completion of the work.

In 2014, in accordance with procedure PA-126, a prohibition on granting fire risk work permits during refuelling periods when the plant is in reduced inventory conditions (Plant Operating States 11 and 12) was introduced in a number of fire areas of the containment, auxiliary and control buildings in accordance with the guidelines of document CEN-30 [42] on key safety functions during shutdown.

3. Cofrentes NPP

Procedure PPCI 2.1.2.2 *Open flame work, welding and cutting* controls the use of ignition sources. In paragraph 5 of this procedure, it is stated that permits shall not be valid for more than 24 hours for areas where SSCs related to the safe shutdown are located.

03.1.1.2.3 Periodic inspections to ensure compliance with controls

In accordance with paragraph 5, point 8 of SG 1.19, regular inspections are carried out to ensure ongoing compliance with the above administrative controls.

1. Almaraz NPP

A procedure is in place for the assessment of the exposure to fire risk (GE-CI-02.06, *Integrated management of exposure to fire risk*). This procedure is intended to and contains instructions for:

- Evaluating changes in the plant's FP configuration and identify compensatory measures.
- Carrying out the required monitoring according to the existing FP configurations in the plant.
- Conducting periodic plant inspections to identify uncontrolled situations of exposure to fire risk.
- Managing special situations of exposure to fire risk (oil changes in main pumps during outage, situations of inoperability of the charging pumps, the essential services water and the component cooling systems, etc.).
- Continuously monitoring the aggregate fire risk indicator.

Surveillance can be continuous, hourly or every 2, 4 or 8 hours, and responds to the requirements set out in the TRM as well as other FP specific regulation, taking into account the aggregate impact on fire risk and FP configuration.

In relation to inspections, the following are carried out:

- Specific to inventoried storage areas. Temporary/permanent storage areas are monitored weekly/quarterly or monthly/semi-annually, depending on their status (secure or non-secure areas) or whether they have fuel or not.
- FP configuration thorough inspections. They are carried out on a weekly basis and aim at detecting unauthorised storage areas, electrical anomalies, hot spots, fuel liquid leaks, etc.

2. Vandellós NPP

In addition to the inspections in the previous procedures, weekly inspections are carried out using procedure PCI-42 in areas with a higher risk of fire or explosion to verify that there is no accumulation of flammable or combustible materials, that there are no leaks of combustible liquids and that the area is clean and tidy. These watches make it possible to control the disposal of waste, oil spills, etc. as well as compliance with administrative controls. Likewise, the procedure for the control of transient combustibles (PCI-63) provides for periodic monitoring of authorised transient storage location, the frequency of which ranges from hourly to weekly, depending on the area in which the storage is located.

3. Cofrentes

Preventive watches to verify compliance with FP procedures are carried out according to PPCI 2.1.2.17 *Preventive fire watches*.

Preventive fire watches can be classified as scheduled and unscheduled:

- Scheduled watches:

  Taking into account the fire risk of each of the areas and fire zones of the Plant, as well as the safety-related SSCs, and taking into account Radiation Protection accessibility criteria, the following types of watches are established:

  1. Daily watches: In high fire risk areas.
  2. Weekly watches: In medium fire risk areas.
  3. Monthly watches: In low fire risk areas, unclassified areas and regulated radiological access areas.

- Unscheduled watches:

  Periodic monitoring of the activity shall be conditional on whether the work to be monitored is in safety-related or non-safety-related areas. Taking this into account, the frequencies may be: hourly in TRM areas, two watches per shift, every 3, 4 or 8 hours, or continuous.

03.1.1.2.4 Measures in special protection areas

According to section 11 of SG 1.19 additional measures must be taken in special protection areas as detailed below.

Acetylene and oxygen storage areas

No storage of gas cylinders, such as acetylene or oxygen, in areas containing or affecting safety important SSCs or their fire protection system.

A special permit system is established for the use of this equipment in safety-related areas of the plant (SG-1.19 [29] paragraph 11.1).

1. Almaraz NPP

   In accordance with the procedures for preventive measures in the execution of work and for management of fire risk work permits (GE-SS-07.01, GE-CI-02.06), the storage of flammable gas cylinders is not permitted except for the execution of work where it is necessary and for which the corresponding permit (which is limited to the working day) will be obtained. The transfer of cylinders must always be carried out in an upright position with the valve closed and the cap on, and with the appropriate transfer tool.

2. Vandellós NPP

According to PCI-63 procedure, storage of flammable gas cylinders (propane, methane, hydrogen) and oxidising gas (oxygen) inside power block or waste buildings is not permitted. After completion of the work, these cylinders must be stored in the workshop building or in the hot workshop (in the case of work in a controlled area). The workshop building is separated by more than 15 metres from the power block and the waste block. The hot workshop is attached to the waste block, separated from it by R180 barriers in accordance with the FHA.

3. Cofrentes NPP

Procedure PPCI 2.1.2.1- *Control of combustible and flammable materials storage* sets out the limit for the use of gases.

The type of gas must be identified, the cylinders must be secured, the valve protection cap must be in place, movement must be by trolleys or cages designed for this purpose. Cylinders comply with the hydraulic tests required by Royal Decree 2060/2008, of 12 December, approving the Pressure Equipment Regulation [104].

Areas where combustible or flammable materials are stored shall be monitored by surveillance watches (their frequency is set out in Maintenance Sheet No. 026/PCI), which shall be carried out by the FP unit.

The storage of empty gas cylinders is not permitted, as they pose a serious risk of explosion in the event of fire. When empty, those responsible for the work must remove them within a reasonable time, with a maximum time limit of the end of the working day.

The storage of filled gas cylinders is prohibited in the containment building and other areas with safety important SSCs. Gas cylinders shall only be allowed for the duration of the work and within the same working day; they shall be removed at the end of the working day to other areas where the storage of full gas cylinders is permitted.

Ion-exchange resin storage areas

Unused resins are not stored in areas containing or affecting safety important SSCs (SG-1.19 paragraph 11.2).

1. Almaraz NPP

Ion exchange resins for refilling demineralisers are not permanently stored at Almaraz NPP. They arrive on site when the demineralisers need to be filled and are stored temporarily.

The procedure DAL-94 *Integral management of storage areas* is applied for their transfer, and they are considered as thermally loaded.

2. Vandellós NPP

The ion exchange resins used to refill the demineralisers are not permanently stored at Vandellós II NPP. They arrive on site when the demineralisers need to be filled and are temporarily stored in a level at the waste building, the fire areas of which do not contain safety important SSCs. For the demineralisers located on a specific level of the auxiliary building (fire area containing safety important SSCs) the new resins are not stored therein, but are brought to the auxiliary building from outside areas to carry out the corresponding filling.

However, they are always hydrated resins and therefore are not considered a fire load.

3. Cofrentes NPP

Procedure PPCI 2.1.2.1- *Control of storage of combustible and flammable materials* establishes the limit of use of ordinary combustible materials, gases and liquids, combustible and flammable, carbon and high efficiency particle air (HEPA) filters, dry ion-exchange resins, or other fuels in areas containing safety important SSCs during all phases of operation, and especially during maintenance, modification or refuelling operations.

Hazardous chemicals

Hazardous chemicals are not stored in areas containing or likely to affect safety important SSCs (SG 1.19 paragraph 11.3).

1. Almaraz NPP

Storage of hazardous chemicals in fixed tanks are outside the power block (DAL-16.20B *Regulatory Inspection Manual*. *Storage facilities for corrosive liquids in fixed containers, in plant*).

Chemicals are stored outside the power block, except for laboratory products. These, as well as other possible transients, are subject to procedure DAL-94, *Integral management of storage locations*, as well as procedure GE-79.19, *Control, management, precautions and use of chemical products*. In order to obtain the relevant permit, applications for temporary storage are assessed from the point of view of fire risks (fire load, accessibility to FP systems, basis for compliance with the transition to NFPA 805), as well as seismic criteria and other risks. This procedure establishes time and distance limitations to safety SSCs and graduates the level of authorisation required based on established criteria. Storages for which there is a justified permanent need are analysed in the framework of the FHA and are included in the FHA.

2. Vandellós NPP

According to procedure PCI-63 chemical containers must be stored in cabinets of at least R60 when not in use. In this respect, according to the chemistry and radiochemistry department, the cabinets located in different areas of the plant are R90. PA-180 procedure specifies the maximum quantities permitted to be stored in such cabinets for flammable, corrosive and toxic products.

In general, cabinets are not located in areas containing or potentially affecting safety important SSCs. Of the total number of FR cabinets available at the Vandellós II NPP, only 1 of them is located in an area containing safety important SSCs. However, it cannot affect these SSCs as it is far away from them and the fire resistance of the cabinet (R90) is higher than the fire severity of the area (35 minutes according to the calculation of fire loads and severities), so in no case the stored products will pose an added fire risk in the area or a risk of toxicity, as they will be kept confined in the cabinet and protected from an external fire.

3. Cofrentes NPP

In the procedure PPCI 2.1.2.1 *Control of storage of flammable and combustible materials*, the control of chemical products is established according to the Complementary Technical Instruction ITC MIE-APQ 1 *Storage of flammable and combustible liquids* (Royal Decree 656/2017, of 23 June, approving the Regulation on the storage of chemical products [86]).

Liquid storages should be identified and liquids kept in safety containers certified or approved for this use. For liquids with special handling requirements, such as alcohols, paints or chemicals, their original containers may be used. When not in use, they must be stored in a cabinet certified or approved for the storage of this type of products (at least R60 according to standard UNE-EN-1634-1 [106] or similar).

Materials containing radioactivity

Materials that absorb and contain radioactivity, such as spent resins, ion exchangers, carbon filters and HEPA filters, are stored in closed metal devices and placed in areas with low fire risk and no ignition sources.

These areas are protected from fires in adjacent areas (SG 1.19 [29] paragraph 11.4).

1. Almaraz NPP

Solid radioactive waste is confined in airtight metal containers and stored in the radioactive waste temporary storage buildings. These storages are separate from the power block and they have no significant ignition sources. These are non-traffic areas and have detection and alarm systems (incorporated or upgraded as a result of NFPA 805 transition analysis) and suppression systems (powder and CO_2 extinguishers) in each of the two fire areas, as well as hydrants outside.

2. Vandellós NPP

As established in the Radioactive Waste Management Plan, most of the low and intermediate level radioactive waste generated is conditioned in closed metallic containers.

Spent filters and ion exchange resins from the plant's radioactive systems are stored in closed metal containers in the Radioactive Waste Storage, which is separated from the fire loads and ignition sources in adjacent areas (such as the low activity storage polymer area) by concrete walls. Additionally the adjacent area with fire loads and ignition sources has detection and a sprinkler suppression system.

Only the resins from the steam generators purge, which have a very low content of radioactive activity, are stored in closed metal containers or plastic bins in other areas of the plant.

Regarding the carbon filters located in the controlled area (filter units in the fuel building), they are temporarily stored in airtight, non-combustible metal containers in the fuel building for the time necessary to fill and empty the units. The corresponding fire area has low fire severity and low fire risk. The containers with the spent filters are temporarily stored for a period of 2-3 days to check that the contamination is below the threshold for off-site processing as non-radioactive waste, and a specific fire watch is set up in the area during that time.

3. Cofrentes NPP

The Radioactive Waste Management Plan (DOE 07) is established in order to include the criteria and methods for the safe management of the radioactive wastes generated at the facility.

As stated in the Supporting Study, the waste materials produced as a result of the operation, with the exception of spent fuel and special wastes, can be classified into different categories. For the different materials, different management modalities are used.

Resins, filters are stored in drums as stated in procedures PQ/2.1.31 *Determination of the activity of a waste package* and PQ/2.1.32 *Solid waste*, which describes the control of the filling process.

The containers comply with the criteria set out in Royal Decree 656/2017 of 23 June, approving the Regulation on the storage of chemical products [86], thus ensuring that no radioactivity is released to the outside in the event of fire or other accidents.

ISFSI

The ISFSI must comply with the applicable regulatory requirements of 10CFR72 [97] and IS-29 [19], in particular section 3.5.3 contains design requirements to minimise risk and limit fire damage in spent fuel temporary storage facilities by preventing the generation of fire and section 4.9 requires operational fire watch procedures.

1. Almaraz NPP

The Almaraz NPP ISFSI constitutes a fire area that is subdivided into different fire zones. The storage slab is surrounded by a perimeter wall and is separated from the other fire zones in the area.

There is no thermal load on the storage slab, and four monitor water cannons cover the entire area and are fed from a dedicated supply loop independent of the main plant ring.

The Almaraz NPP ISFSI is in the scope of the FPM and the plant's FP procedures apply to it, as well as the FP extensive damage mitigation guidance (GMDE-PCI).

2. Vandellós NPP

There is not an ISFSI at the Vandellós site.

The TRILLO NPP ISFSI is subject to the same procedures applicable to the rest of the plant: CE-A-CE-2503 *Application and control of storage areas*, CE-A-CE-2501 *Permit* *for fire risk works or for the activation of fire detection/suppression* and DTR-09 *Trillo fire protection manual*.

3. Cofrentes NPP

   The fire prevention procedures applicable to the ISFSI are the same as for the rest of the plant. The procedures can be found in the first three sections of this block 03.1.1.2, as well as in section 03.2.1.3.

03.1.1.2.5 Other requirements applicable to power plants that have transitioned to NFPA

With regard to fire prevention activities and control of combustible materials and ignition sources, compliance with article 3.6.1 of the corresponding IS-30 has been justified, with the result detailed above. The following indicates compliance with NFPA 805 articles related to fire prevention activities and control of combustible materials and ignition sources:

1. Article 3.3.1:

   Within the specific FP organisation of the plant, there is a risk prevention group focused on: fire risk surveillance, control of ignition sources and control of transient combustibles.

   These activities are performed in accordance with procedures GE-CI-02.06, GE-CI-02.07 and DAL-94, indicated above.

2. Article 3.3.1.1:

   Procedure GE-62.11 *Training requirements in common subjects at the Almaraz-Trillo nuclear power plants* defines, among other things, the type of fire protection training, its duration and periodicity, for both staff and contractor personnel. Fire drills are conducted on a regular basis.

   Procedure GE-CI-02.06 (mentioned above) aims at detecting potential fire situations and risks that could lead to a fire, and at channeling actions to eliminate fire risk situations.

   The technical operation office collects annually the revision of the applicable fire protection procedures, either by expiry or by application of deviations or alterations.

3. Article 3.3.1.2:

   This point of NFPA 805 is also required by the IS-30 Rev. 2, Section 3.6.1.

   Almaraz NPP has established procedures DAL-94, GE-CI-02.06 and GE-CI-02.07 (mentioned above) for the control of transient combustibles, inspections of fire risk in the plant and control of works with fire risk, respectively.

   In relation to the use of flame-retardant plastics, it should be noted that, for the protection of equipment during hot work, flame-retardant protective curtains with characteristics that reduce the propagation of flames are used and are certified in accordance with the UNE-EN-1598 standard [107].

4. Article 3.3.1.3:

Almaraz NPP has procedure GE-CI-02.07, which sets out the process to be followed in fire risk works, considering as such those that produce ignition sources such as welding, oxy-fuel cutting, work with open flames, with radial grinders, etc. This procedure complies with NFPA 51B [103].

Smoking is prohibited inside the protected area of the plant, and appropriate signalling is provided.

Works that generate open flame and smoke are controlled by procedures (GE-CI-02.07). These works do not include flow or leakage tests. Therefore, there are no flow or leakage tests to be performed with open flame or fumes.

Procedure GE-CI-02.06, among the different criteria for the inspection of the FP configuration, includes the verification of the condition and correct functioning of temporary/portable electrical equipment,

In addition, the Electrical Maintenance service carries out inspections to check for hot spots and deficiencies in electrical components: cables with damaged insulation, presence of moisture in switchboards, junction boxes, etc., switchboards and electrical boxes with defective or missing covers, existence of a burning smell, existence of electrical arcs or hot spots, deficiencies in heaters, cookers, etc. and deficiencies in temporary connections and sockets.

03.1.1.3 Licensee's experience of the implementation of fire prevention

03.1.1.3.1 Overview of strengths and weaknesses

Fire prevention is an issue that has been greatly reinforced in recent years in all Spanish plants.

All the Spanish plants have a computerised system for the management of temporary storage areas.

According to the recommendation of the insurance company NEIL, all Spanish power plants have installed specific protections in the turbine building's oil system in locations which are susceptible to oil spray leakage.

The Spanish nuclear power plants set up a working group made up of plant engineering staff, with the aim of carrying out a study of the impact of the change from US to European standards. An analysis of the regulations on FP Passive Protections was carried out. This document was technically certified by an independent laboratory. Although a generic solution has not yet been adopted, certain scenarios for its use have been adopted.

Once the improvement actions due to the IS-30 adaptation processes have been implemented (considering the guidelines of Chapter 3 of NFPA-805 in the applicable plants), as well as those derived from the latest periodic safety reviews, it is not considered that there are any areas for improvement in fire prevention at the Spanish plants.

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

As a result of the processes of adaptation to new regulations, as well as improvements derived from external inspections, the following actions have been carried out in recent years:

1. Almaraz NPP

No AFIs have been identified in either the Peer Review WANO (2020) or the OSART mission (2018).

In CSN inspections, in the area of prevention, the findings focus on aspects of safety culture that are reinforced at management level: illegal storages, open doors without administrative control.

In addition, the following prevention-related procedures have been revised in recent years (outside the process of adaptation to NFPA 805):

- *Integrated fire risk management*:
  - Generation of the aggregate fire risk impact indicator to monitor the status of the plant's FP configuration.
  - Reinforcement of FP monitoring criteria by fire zones taking into account the aggregate fire risk impact. Considered a strength by the licensee.
  - Implementation of the criteria and requirements of the Complementary Technical Instruction (CSN/ITC/SG/AL0/20/15) on roving continuous fire watches
  - Reinforcement of fire risk inspection criteria (implementation of weekly inspections throughout the plant, increased frequency of inspection of storage areas).
  - Implementation of restrictions on barrier breaching, on placing systems out-of-service and other changes to FP configuration in situations of special fire risk due to inoperability of charging pumps, component cooling and essential service water systems.
- *Management of system functionality losses and FP barriers*. The procedure unifies and replaces 3 previous procedures. A format for recording short-term blockages of the CO_2 suppression system in the diesel 1, 2 and 3 rooms has been included.
- *Fire risk work permits*. The establishment of FP continuous monitoring has been included as a requirement in non-static FRWPs, i.e. involving work along a route, moving work equipment and means of protection (fire extinguishers, blankets, etc.).
- *Management of storage areas*. The prohibition of combustible material storage in the outage material storage area and the temporary solid waste store has been included (improvement derived from the transition to NFPA 805).
- *Large fires suppression*. The suppression strategy outside the walled perimeter of the ISFSI has been included.
- Transition from Surveillance Procedures to TRM surveillance requirements Procedures for FP systems and barriers, by transferring them the TRM and transitioning to improved TS/TRM.
- Other changes in system and barrier maintenance procedures:
  - Inclusion of the maximum response time of smoke aspiration fire detectors according to NFPA 72 [108].

- Inclusion of criteria for maintaining flow at hydrants and FHC for approximately one minute (NEIL/NFPA requirement).

- Increased frequency of functional testing of curtain fire dampers, per ASME requirement.

- Separated surveillance test for detection and valves that are not accessible during normal operation (inside containment).

2. Vandellós NPP

Improvements have been made to the transient combustibles control procedure due to the process of IS-30 adaptation. The different revisions of PCI-63 (4 to 8) have introduced improvements required by the CSN as a condition for several regulatory approvals of equivalent compliance with IS-30, such as the establishment of control of use in addition to the control of transient storage in certain areas and the reinforcement of compensatory measures in the event of the need to store combustible materials in a number of areas. It also includes improvements derived from the computerised management of combustible storages and prohibitions on combustible storages in certain areas for some operational states, in accordance with *Key safety functions during shutdown* procedure.

Likewise, following the recommendation of a WANO Peer Review, specific guidelines have been included for the control of leaks of combustible and flammable products, establishing, in the event that an oil or diesel leak is detected in the plant systems, periodic inspections and specific administrative controls on the leak.

In the procedure for the management of fire risk works (PCI-15 Rev.13), the actions to be carried out have been updated once compensatory measures are no longer required due to fires affecting associated circuits, as POF-327 *Operator's Manual Actions in Fires located outside the Control Room* has been implemented. In addition, the POSs which, according to the *Shutdown Key Safety Functions* procedure, require the prohibition of fire risk works in the indicated fire areas have been modified and editorial improvements have been included.

In the third periodic safety review in relation to design aspects, in terms of improving fire prevention by analysing the degree of compliance with regulations SG 1.19 and RG-1.189 Rev.3, the following areas for improvement and improvement actions were identified:

- Prevention of transfer of combustible liquids through the drainage network between 2 fire areas of the Turbine building.

  In accordance with paragraph 8.1.14 of SG 1.19 it is recommended that the design of the drainage network should prevent the passage of liquid combustibles into safety-related areas. It is identified that in the fire area where the turbine oil tank is located, the design of the drainage network does not have valves to isolate the drainage line that collects water from the suppression system that protects the tank itself, so that in case of leakage, the oil would go directly to the drainage well located in another fire area that contains fire safety important SSCs (some of them related to safety). Therefore, the improvement action of installing a leakage isolation valve in the floor drain line was proposed and implemented in January 2022.

- Hydrogen batteries with wall-piercing capability in case of cylinder failure.

According to SG 1.19 paragraph 8.11.2 it is considered appropriate that the arrangement of the high pressure gas tanks should be with the longitudinal axis parallel to the walls of the buildings. The hydrogen cylinder bank is arranged with the longitudinal axes of the cylinders facing the west wall of the Control building, so it was proposed to install an impact protection barrier, which was implemented in July 2021.

A NEIL inspection identified a recommendation to install a system to contain or collect and drain oil from the auxiliary turbine lubrication systems (CJ) and alternator oil (CD) and water from the fire sprays associated with the equipment of both systems. A design modification was therefore implemented in August 2009 to install:

- In the CD system an oil collection sump with a drain to convey additionally the water from the associated fire sprays;
- In the CJ system a series of perimeter channels allow the collection and conveyance of as much oil or water as possible to the drainage system of the Turbine building.

3. Cofrentes NPP

As a result of the processes of adaptation to new regulations, as well as improvements derived from external inspections, the following improvements have been carried out in recent years or will be carried out in the future:

- Improvements derived from the WANO Peer Review:

  The procedure PG 50 *Management and control of auxiliary elements* has been revised along with P-PCI/2.1.2.1. *Control of storage of combustible and flammable materials*, establish the control of storage and use of combustible and flammable materials.

At Cofrentes NPP, the procedures relating to prevention have been reviewed in recent years.

- *Control of storage of combustible and flammable materials*. The areas in which storage is allowed and is not permitted were indicated and a general plan of permitted and non-permitted areas was included. The ISFSI was included in the scope of the procedure. The obligation to detail outside each cabinet a list of the material stored inside was included also in the procedure. (FP.1.1.2.1 Peer Review 2018)
- *Open flame work, cutting and welding*. It was clarified how the FP Service should act in order to activate the permit and it was indicated that the worker cannot leave the work area until the FP Service arrives to activate the required systems. The ISFSI was included.
- *Integrity of fire barriers breached*. It was indicated that the compensatory measures to be established in the event of TRM barriers non functionality will be those indicated in the TRM, and for Non TRM barriers they will be those considered by the Control Room.
- Control of inoperability of fixed suppression systems and/or fire detection systems. The inoperability control form was improved.

- *Preventive fire protection monitoring*. Unscheduled surveillance, the periodic surveillance control, the criteria of the Complementary Technical Instruction (CSN/ITC/SG/COF/20/06) on itinerant roving fires watches and the scheduled watches of the EMAC and SSSA buildings were included.

- *Control and monitoring of permits for the storage of combustible materials.* This includes limitations on storage within 15 m of Hydrogen and Oxygen supply zones.

- *Monitoring operability of fire doors.* Turbine doors were included.

03.1.1.3.3 Overview of actions and implementation status

Improvements derived from Peer Review

1. Almaraz NPP

   No areas for improvement were identified in the last CNAT Peer Review (2020), nor were there any facts in the area of Prevention and Passive Protections.

2. Vandellós NPP

   As a result of the peer review, establishment of specific guidelines for the control of leaks of combustible and flammable products were introduced by establishing, in case of detection of an oil or diesel leak in the plant systems, periodic inspections and specific administrative controls on the leak.

   In the last two Peer Reviews (the last one in June 2023) no areas for improvement have been identified.

3. Cofrentes NPP

   No improvements were identified by the WANO Peer Review at Cofrentes NPP in the area of Prevention.

PSR-derived improvements

1. Almaraz NPP

   Given the coincidence of the NFPA 805 transition project and the PSR, no PSR-derived improvements were identified at Almaraz NPP, as they were managed in the transition process.

2. Vandellós NPP

   - Leak isolation valve installed on floor drain line between turbine building fire areas of.

   - An impact protection barrier was installed between the hydrogen cylinder battery and the Control Building.

3. Cofrentes NPP

   No improvements were identified in the PSR at Cofrentes NPP in the Prevention area.

Improvements resulting from the process of IS-30 adaptation

1. Almaraz NPP

   In the area of prevention, procedures have been modified, as detailed in previous sections.

2. Vandellós NPP

   - Establishment of prohibited combustible storage fire areas: Status: implemented.
   - Establishment of use control for some fire areas with particular characteristics in relation to their fire barriers: Status: implemented.
   - Establishment of a more frequent monitoring as a compensatory measure for some areas where combustible storage is not allowed, through the establishment of hourly monitoring. Status: implemented.

3. Cofrentes NPP

   Fire risk analyses have been reviewed

Improvements resulting from NEIL insurance evaluations

As a result of NEIL's assessments according to the *Loss Control Manual*, the following improvements have been implemented.

- Implementation of splash guards on the flanged connections of oil systems in the Turbine building in all plants: Status: implemented.
- In addition, at Vandellós NPP, implementation of systems for collecting and draining oil and fire suppression water leaks in the lubrication systems of the auxiliary turbines and the alternator oil in the turbine building: Status: implemented.

03.1.1.4 Regulator's assessment of the fire prevention

The entry into force of IS-30 and of the construction and administrative control requirements for fire loads and combustible materials that it requires, as well as the Technical Instructions issued for the improvement of the Technical Specifications of the FP systems, have led to the unification of a regulatory framework that facilitates, in addition to the inspection work, the exchange of experience between the owners of the installations in order to improve the safety of the installations and their working procedures.

The integrated analysis of the fire risks from the point of view of working and operational methods, as well as the administrative procedures, allows an optimisation of resources and an improvement on the awareness of the organisation's safety culture in relation to fire risks and their prevention.

03.1.1.4.1 Overview of strengths and weaknesses in the fire prevention

The main good practices identified in this section by the nuclear power plants are as follows:

- cutting and welding work procedures

- procedures for the control of combustible materials storages
- procedures for periodic surveillance of fire resistant structures
- optimisation of surveillance watches used as compensatory measures through the use of electronic devices.

On the other hand, the following area for improvement can be suggested, aimed at further strengthening the safety culture in relation to fire prevention at the plants:

- Participation in the development of the operational experience databases (FIRE) and incorporation of the lessons learned that may be derived from this database as an additional source to those already analysed.

03.1.1.4.2 Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

Overall, a significant improvement has been observed in all factors contributing to fire prevention. Again, this allows to focus inspection tasks carried out under procedures PT.IV.204 and PT.IV.205 on those aspects previously identified by having a thorough and complete review that has allowed the surfacing of inadequately documented fire resistant elements and the establishment of review programmes to prevent obsolescence or deterioration of functionality due to ageing.

In terms of fire watch procedures, a substantial improvement has been made through the use of electronic devices for better monitoring and planning. This improves the monitoring carried out by the regulator of the effective implementation of surveillance and its planning.

03.1.1.4.3 Conclusions drawn on the adequacy of the licensee’s fire prevention

A strengthening of administrative controls over the storage and use of combustible materials and fire watches has been observed. In general, it can be concluded that the licensees have implemented an adequate fire prevention programme at their facilities.

03.1.2 Fire prevention in FCF

03.1.2.1 Design considerations and prevention means

The design criteria are set out in the Order of the Ministry of Industry and Energy of 12 December 1980 authorising Empresa Nacional del Uranio, S. A. (ENUSA), the construction of a uranium oxide fuel plant at Juzbado (Salamanca) [109] and in the Order of the Ministry of Industry and Energy of 14 January 1985 granting ENUSA the provisional operating permit for the Uranium Oxide Fuel Plant at Juzbado (Salamanca) [110]. All of them were published in the corresponding Official State Gazettes of 23 December 1980 and 21 January 1985.

Currently, when design modifications are made, the criteria established in Royal Decree 2267/2004, of 3 December, approving the Regulation on Fire Safety in Industrial Establishments [74], Royal Decree 513/2017, of 22 May, approving the Regulation on Fire Protection Installations [78] and Royal Decree 450/2022, of 14 June, amending the Technical Building Code in the sections associated with fire prevention [111], are mainly used.

03.1.2.2 Management and control of fire load and ignitions sources

Once the fire risk of the different areas into which the installation is subdivided has been quantified and/or qualified by means of the fire risk analysis (detailed in section 02.2.1.1 of this NAR), the control of the fire risks that may occur in these areas is achieved through the application and/or provision of the administrative measures and technical means of protection that have been arranged.

- Administrative measures:

    - Application in all fire areas that make up the Facility of the general preventive measures reflected in the Fire Protection Programme (Fire prevention, active protection, passive protection). Included in the internal procedure of prevention rules for fire protection.

    - Smoking is prohibited in all internal areas of the facility.

    - Limitation and proper storage of flammable, combustible and hazardous materials (storage of flammable liquids in safety containers; fire resistant cabinets, safety bins...). Indications contained in the procedure for prevention in the handling and storage of flammable and combustible liquids.

    - Control of the use of ignition sources through Work Permits for all cutting and welding operations with spark or flame generation. Detailed in the cutting and welding work procedure.

    - Analysis and evaluation by the managers and engineers responsible for the Safety Systems, as well as by the different groups that make up the Safety Organisation, of all new implementations and/or modifications that are carried out in the installation in order to have prevention measures and means of protection in place. The requirements to be fulfilled are detailed in the procedure for the development and modification of systems, installations and equipment.

    - Correct handling of combustible gases, permanent control of leaks and procedural interventions for grounding, ventilation, inertisation, etc. Information contained in the procedure on Prevention rules in the handling and storage of compressed, liquefied and dissolved pressurised gas cylinders, in addition to the correct performance of work according to their risk assessments.

    - Continuous surveillance and control of the operability of the Fire Protection means and systems, with an adequate inspection and maintenance programme of the equipment through Surveillance Requirements established in the Technical Specifications. Detailed in section 03.2.2.3.

    - Permanent availability of human resources at the Installation, which make up one of the Emergency Groups, the Fire Brigade, with a large number of members belonging to the First Intervention Team (FIT) or Second Intervention Team (SIT). The SIT acts under the command of the FP brigade chief or the Emergency response organisation chief, and are properly trained in live-fire interventions. Detailed in section 03.2.2.3.

    - The use of the active and passive means of protection available in the different fire areas and sectors.

- Technical means of protection:

  The technical means of protection are those detailed in later sections 03.2.2 and 03.3.2 of this NAR dedicated to active and passive fire protection, respectively.

03.1.2.3 Licensee's experience of the implementation of fire prevention

The operating experience of Juzbado is made up of the set of relevant events and resulting actions relating to Nuclear Safety and Radiation Protection that have occurred at Juzbado or at similar facilities. These events are divided into:

- Own Operational Experience: Events occurring in the installation. These events could furthermore be classified as Notifiable Events according to the provisions of the Technical Specifications or situations that have triggered the activation of the On-Site Emergency Plan (OSEP).

- External Operational Experience: In accordance with the Complementary Technical Instructions associated with the Operating and Manufacturing Permits (CSN/C/SG/JUZ/16/01) [112], the events that comprise it are:

  - Events at other Spanish nuclear facilities that have been considered applicable.

  - Notifications of supplier defects and non-compliances, in application of 10 CFR 21 [113], submitted to the US Nuclear Regulatory Commission (NRC) on components, equipment and services supplied to the operator.

  - Written recommendations from suppliers regarding safety components, equipment and services.

  - Event Notification Reports applicable to facilities under 10CFR70 [114] (Event Notification Reports).

  - Generic communications that apply to facilities under 10CFR70 (Information Notice).

  - Events reported to the IAEA (IAEA News and FINAS)

  - Experiences whose evaluation has been formally requested by the CSN

The entire Operational Experience evaluation process is regulated in an internal procedure and serves to improve the factory's operating process.

Another process that contributes to the improvement of the operation in Fire Protection features is through Design Modifications. Design modifications may be the result of both in-house and external operating experience, as well as improvements arising from the operation of the installation itself and from the updating and modernisation of the installations

This process is regulated in the CSN Safety Guide SG 03.*01 Modifications at Nuclear Fuel Manufacturing Facilities* [115] developed and implemented in an internal procedure.

03.1.2.3.1 Overview of strengths and weaknesses

The second periodic safety review carried out by the factory covered the period from 01/01/2005 to 31/12/2014, obtaining the renewal of the Operating and Manufacturing Authorisations on 05/07/2016.

The findings of this PSR in relation to Fire Prevention showed that the Licensing Basis and the Basis of Design were complied with and that surveillance and maintenance were carried out according to the established requirements ensuring its correct operation.

No need for improvements was identified.

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

Throughout these years, different types of actions have been implemented as a result of incidents occurring at the facility.

The most relevant incidents leading to improvements have been the following:

- Non-fulfilment of two surveillance requirements relating to checking to be carried out on the absence of leakage at furnace start-up due to human error.
- Fire in an extraction unit due to faulty bearing assembly or bearing failure because of a manufacturing defect.
- Activation of detectors of the flammable gas detection subsystem due to the fact that during the shutdown of an extractor fan, the furnace was tampered with and H_2 concentration values in the area increased.
- Activation of detectors of the flammable gas detection subsystem of the FP system due to the fact that during the shutdown of an extractor fan to change the pre-filter there was an increase in the H_2 concentration inside the gas box due to non-renewal.
- Incipient fire during the extraction of zircaloy dust.
- Hydrogen supply cut-off interlock due to false alarm in a detector of the flammable gas detection subsystem located in the exhaust duct of a furnace.
- Slippage of a BWR fuel element from the mounting beam due to a failure of the clamping piece resulting in sparks due to the lower head rubbing against the metal sheet underneath the mounting beam.

Improvements have also been implemented following incidents at other facilities. The incidents were as follows:

- Fire in the nickel plating room at the Columbia Fuel Element Factory.
- Fire in a decontamination room where metal parts were being cut.

03.1.2.3.3 Overview of actions and implementation status

The corrective actions or improvements implemented as a result of the lessons learnt from the Operational Experience, including those extensions carried out because of the event analyses, were:

- Administrative measures:
    - Reviews of internal procedures regulating activities such as surveillance requirements, assembly operations, furnace operations, maintenance and cleaning of areas where zircalloy dust is present.
- Design modifications:
    - Installation of an information screen at the entrance of the areas informing about the different activities that are being carried out.
    - Interlock the H_2 line pressure switch and the gas shut-off valve.
    - Installation of an industrial type hoover with specified requirements in the area of the active scanner and replacement of the vacuum cleaners for the collection of zircalloy dust in the production line by others with the requirements established for the operations.
    - Modification of the positioning of duct detectors according to the manufacturer's recommendations and replacement of problematic ones with new ones.
    - Modification of the location of the control that operates the verticalisation of the fuel element.
    - Change of the location of the control buttons of some equipment.
    - Improvements to lifting equipment.
    - Purchase of plasma cutting equipment in the ceramic zone.

Other design modifications have also been made that have led to significant improvements in the installation in terms of FP prevention, among which the following are worth highlighting:

- New flammable gas detection subsystem with a new gas control unit and detectors to comply with ATEX regulations.
- Refurbishment of the gas storage area and control panel for the modernisation of all instrumentation.
- Change of position of the purge valves to eliminate a hazardous area and to cancel the end of line of the old densification furnace and place them in the ATEX classified area.
- Modification of the PWR and Gd area gas line ends, placing a check valve in N_2 piping as an improvement identified in the ISA, improving safety.
- Modification of the route of the gas pipes outside the building so that they do not run through the interior of the building.
- Replacement of propane in the sintering and densification furnaces by ignition resistors in order to reduce the level of fire and explosion risk in the installation.

03.1.2.4 Regulator's assessment of the fire prevention

From the point of view of the regulator, fire prevention at Juzbado is adequately established in the training received and in the working methods, and is supervised by the CSN through the performance of biennial inspections in accordance with procedure PT.IV.87.

03.1.2.4.1 Overview of strengths and weaknesses in the fire prevention

Taking into account the organisation of the work at the installation, the training provided in relation to fire prevention in work practices is considered adequate.

However, in the framework of the implementation of an integrated FP programme, it is suggested to include the contents of training and prevention actions in such a programme.

03.1.2.4.2 Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

The biennial assessment and inspection processes under procedure PT.IV.87 are considered to ensure adequate oversight by the regulator of fire prevention settings and working practices.

03.1.2.4.3 Conclusions drawn on the adequacy of the licensee's fire prevention

Fire prevention at the Juzbado fuel factory is considered to be adequately implemented at the operational, training and resources levels.

03.2 Active fire protection

03.2.1 Active fire protection in NPP

The fire detection and suppression system is the second level of defence in depth with respect to fire safety in nuclear power plants and is covered by the term "Active Fire Protection".

Defence in depth is the basic principle to be applied to ensure fire safety in nuclear installations as described in Section 01.2.1.

The Spanish nuclear power plants adopt the principle of defence in depth in fire protection, implementing measures to prevent a fire before it starts; to detect, control and extinguish it as soon as possible in the event of its occurrence; and to prevent its spread to other areas that might affect safety.

The design of the fire protection system addresses the criteria of separation of safety important systems to satisfy defence in depth requirements and takes into account the postulation of a fire in which the total combustion of all combustible material in the area affected by the fire and the loss of existing equipment or components in the fire area, are considered.

The criteria of single risk, as regards the non-existence of two fires simultaneously in two different areas of the plant, and of the simultaneous nature of the causes, as regards non-concurrence of the fire with other accidents, are considered (Article 3.2.1 of IS 30 [4] and 3.4 of SG 1.19 [29]).

At the plants, adequate detection and suppression systems are designed and installed to prevent fires and explosions at the point of origin or, otherwise, to minimise their consequences in fire areas containing safety important SSCs (article 3.2.2 of IS 30 [4]).

03.2.1.1 Fire detection and alarm provisions

03.2.1.1.1 Design approach

The applicable WENRA reference levels for detection and alarm are SV 6.8 and SV 6.11.

Fire detection and alarm systems are designed and installed in the required areas according to the risk analysis and are tested during commissioning for correct operation and, also periodically during the service life of the equipment.

The detection and alarm system meets the requirements of Articles 3.4.1, 3.4.13 and Annex A. Article A.1 of IS-30 [4] and 9.1 of SG 1.19 [29].

The following articles must additionally be complied with by plants that follow a risk-informed and performance-based methodology as an alternative to some of the requirements of the IS-30 [4] in accordance with Article 3.2.8: 3.8 (Fire Alarm and Detection Systems), 3.8.1 (Fire Alarm) and 3.8.2 (Detection) of NFPA-805[5].

The Spanish nuclear power plants comply with the WENRA reference levels applicable to detection and alarm, as indicated in the following sections.

03.2.1.1.2 Types, main characteristics and performance expectations

The fire detection and alarm system consists of the following elements: fire detection centre or local Fire Alarm Control Panels (FACP), fire detectors, manual alarm buttons, fire sirens and control and signal exchange modules.

Each area with safety important SSCs is equipped with fire detection and alarm.

The alarm signals of the fire detection system are unique and distinct so as not to be confused with any other alarm system in the plant.

The detection and alarm systems installed are designed taking into account the normal plant conditions where they are located, using equipment with the characteristics and working ranges appropriate to the areas where they are installed.

The following types of fire detectors are available:

- Smoke and combustion product detection: ionisation, photoelectric, optical smoke detectors and aspirating smoke detector.

- Thermal detection: fixed temperature and thermovelocimetric.

Detection systems are chosen in such a way that their characteristics are optimally adapted to the specific risk to be covered, taking into account the following factors: expected combustion products, foreseeable development of the fire, risk layout, ventilation characteristics, area congestion, area geometry, foreseeable operational activities in the area and environmental characteristics of the area (temperature, humidity, radiation).

In cable areas or areas dominated by type A fuels, where the first foreseeable manifestation of fire is the formation of aerosols and smoke, ionisation or optical detectors are recommended, except in cases where adverse environmental circumstances could lead to false alarms. In large enclosures, or enclosures of high height, optical and/or linear detection shall be used, according to the manufacturer's standards and recommendations.

In areas with type B liquid fuels, where the first and most noticeable manifestation of fire is the rapid release of large amounts of heat, thermal and/or thermovelocimetric detectors are recommended and may be installed in combination with optical detectors.

In areas with different types of fuel (solids and liquids), combined detection of several technologies (optical and thermovelocimetric) is recommended, matching their location to the location of the combustible material.

In outdoor installations (fuel tanks, transformers, oil stores, etc.), the installation of thermal and/or thermovelocimetric detectors located on the fuel material is recommended.

In the interior of some panels, false ceilings, raised floors and in particular cases requiring enhanced detection, aspirating smoke detection systems are installed.

Regarding the layout of fire detectors and alarms, they are reflected in the detection system plans, where the detectors, sirens, push buttons and FACP of each of the fire areas are detailed, and in the Pre fire plans (PFP), which are a compilation of data on detection and suppression systems, safety important equipment located in the area, plans, strategies and procedures for each fire zone or area, which serve as an aid to firefighting.

The aim of these PFP is to facilitate the action of those involved in firefighting in the event of a fire. To this end, they are distributed throughout the plant at significant points, including the Control Room.

Detection systems are tested during commissioning for correct operation. Once in service, they are periodically tested as detailed in section 03.2.1.3 Administrative and Organisational Aspects of Fire Protection.

Procedures and maintenance documents are available to meet monitoring and maintenance requirements.

As the FP system is not a safety-related system, the equipment is not required for accident conditions, and therefore the equipment is qualified for the normal environmental operating conditions of the cubicles or areas in which it is located.

The required environmental conditions are specified in the purchase specifications and/or manufacturer's documentation.

1. Almaraz NPP

Almaraz NPP has two centralisation systems for the different local panels that the plant has: 1) The central alarm station with analogue addressable technology, which has been integrating with modules, the conventional detection lines and local panels of the detection systems, and 2) the centraliser panel, which centralises the signals from different panels with conventional detection through local alarm transmitters of the zones not integrated in the central alarm system. Conventional local panels are being replaced and integrated into the central alarm station network.

The central alarm station consists of a server located in the COSS room and three control stations, two in the U1 and U2 Control Room, respectively, and one in the COSS. The centraliser panel is also located in the Control Room.

Each panel groups together different detection and alarm systems covering the entire plant. Alarms identify the affected area in both subsystems. There is no panel in the FP brigade building.

As an additional criterion to that indicated in the general part on types of detectors, in the emergency filtration units of the Auxiliary Building fitted with active carbon filter, CO detectors are used, located inside the filtration units.

In relation to Articles 3.8.1 and 3.8.2 of NFPA 805, their compliance was checked within the framework of the transition project to a methodology informed by the risk and based on performance (3.2.8 of IS-30), having implemented the best improvements identified. With regard to Article 3.8.2 on detection, the minor deviations identified were justified, were analysed by the regulatory body and approved in the transition authorisation.

The provision of detectors and panels is reflected in the Detection Plans and in the fire area plans of Almaraz NPP's fire risk analysis.

The detection systems have the following test and maintenance procedures:

- Verification of fire alarms operation
- Inspection, verification and functional testing of fire detection systems
- Reviews and maintenance contained in the non-nuclear FP regulation

2. Vandellós NPP

The Vandellós NPP has a detection and alarm system whose function is to constantly monitor the different areas of the plant causing local and remote alarms in the Control Room and in the Fire Brigade monitoring panel. It will also, in some cases, operate automatic suppression systems or prepare them for operation.

In the control room there is a chronological recorder for all alarms in the main cabinet. A general alarm is provided in the central switchboard which is triggered by any alarm condition in the main fire control cabinet.

The system basically consists of a series of local fire panels (FACP) distributed throughout the plant that send a fire or fault signal to the central panel located in the Control Room. In the event of an alarm, the turbine operator gives the alert and a firefighter goes to the relevant FACP, usually located at the entrance to the building in question. In the FACP the fire fighter will see the fire zone that has been activated and will go to the area to confirm whether it is a real fire or an activation due to some other cause or spurious alarm. According to the PCI-90 procedure, the firefighter confirms the fire by reporting the exact location of the fire to the control room within 10 minutes. From that moment on, the control room summons the 1st intervention brigade to come and carry out the suppression activities.

The power supply to each detection panel is 220V, single-phase from the 400V system, Class No-1E, with support from the Essential Diesel No-1E. Each detection panel is equipped with batteries with an operating autonomy of 4 hours, in the event of failure of the main power supply.

All the floors of each of the plant's buildings are divided into what are called "Fire Zones", and in each of them there are a series of detectors, whose characteristics and mode of operation will depend on the type of risk or fuel they have to cover. Each area with safety important SSCs is equipped with local fire detection and alarm in accordance with the Fire Risk Analysis.

The layout of fire detectors and alarms is included in the figures in Appendix 9.5B Fire Hazard Analysis to the SAR and in the PFP Control Procedure.

The revision and testing of the detection systems of Vandellós NPP is carried out with the procedures *Functional Test of Fire Detectors*, *Quarterly revision of detectors*, *Batteries of the local fire panels and main panel A-70 verification*, *Annual test of the aspirating detection systems* and *Visual verification of the state of the AC power supply of the FACPs*.

3. Cofrentes NPP

Fire detection and fire alarm systems are analogue addressable systems.

Each area with safety important SSCs is equipped with local fire detection and alarm. All these signals are sent to a Fire Protection Management computer system, for the integrated management of all information related to the Organisational Fire Protection Unit. There are two control panels, one in the Control Room and one in the firefighting service building.

All systems and equipment involved in automatic fire detection are provided with a main power supply and an alternative independent power supply, with an autonomy of at least 24 hours. The layout of the fire detectors and alarms is detailed in the detection system drawings and in the Pre Fire Plans (PFP).

At Cofrentes NPP, the independence of the fire areas is maintained, as each fire area is covered by an independent detection system, governed by a FACP. The alarms are sent to two computers located in the Control Room and the fire building. The displays identify the fire zone to which the alarm belongs. The fire areas are sectored by R180 passive barriers.

The procedure for the revision of Cofrentes NPP detection systems is *Review of detection equipment of the Fire Protection System*.

03.2.1.1.3 Alternative/temporary provisions

Compensatory measures are applied according to the importance of the equipment to be protected. There are systems or equipment that are included in the TRM and others that are not. Systems and equipment included in the TRM are required to undergo periodic surveillance tests to ensure their functionality and, in case of non-functionality, have compensatory actions and deadlines to be followed to re-establish functionality.

CSN Technical Instruction CSN-IT-DSN-10/08/11 and 12 [25] on improvements to the FP TS/TRM improves the Technical Requirements Manual (TRM) with regard to fire protection.

1. Almaraz NPP

At Almaraz NPP there are different procedures in place that establish compensatory measures for inoperabilities.

Details of these procedures are given in section 03.2.1.3 Administrative and Organisational Aspects of Fire Protection. However, those applicable to the detection system are listed below:

- *Management of fire risk work permits*.
- *Management of loss of functionality of FP systems and barriers*
- TRM Technical Requirements Manual 3.3.9 *Fire Detection Instrumentation*

In case of loss of functionality of a detection system, compensatory measures consisting in the implementation of periodic or continuous watches are established, taking into account the fire risk impact of the affected area.

2. Vandellós NPP

At Vandellós NPP there are different procedures in place that establish compensatory measures for inoperabilities of the various FP systems.

Details of these procedures are given in section 03.2.1.3 Administrative and Organisational Aspects of Fire Protection. However, those applicable to the detection system are listed below

- Performance Standards of the FP unit in the FP System for inoperabilities affected by TS, also applicable to the scope affected by the FP Technical Requirements Manual (FP TRM).
- FP unit performance standards in the FP system for non-functionalities of systems that are neither in the scope of TS nor FP TRM.
- *Permit for Work Involving Fire, Smoke, Sparks or High Temperatures*.

3. Cofrentes NPP

The Cofrentes NPP has various procedures that apply in the event that a fire protection system needs to be taken out of service due to work on the system itself or on other non-fire protection systems.

Details of these procedures are given in section 03.2.1.3 Administrative and Organisational Aspects of Fire Protection. However, those relating to the detection system are listed below.

- *Open flame work, welding and cutting*.

  This procedure applies to all cutting and welding work with oxyacetylene torch, electric welding, work with open flame or other work that could activate the fire detection system (due to the generation of dust, vapours, etc.).

- *Control of inoperability of fixed suppression systems and/or fire detection systems*.

  The purpose of this procedure is to establish the actions to be taken in the event that, due to corrective or preventive work, tests or other causes, it is necessary to render a fixed suppression system and/or a fire detection system inoperable, as well as to define the measures and compensatory actions to be taken in such cases.

- TRM Technical Requirement 6.3.3.10 *Fire detection and control instrumentation*.

  It establishes the actions and deadlines to be followed to re-establish the operability of the fire detection and control instrumentation, indicated in the Fire Protection Manual (DB 04).

03.2.1.2 Fire suppression provisions

03.2.1.2.1 Design approach

Once a fire has been detected, it must be extinguished and the installation must be brought to a safe condition. For this purpose, the fire protection water system and other suppression means are available.

The function of the Fire Protection water system is to supply water for fire suppression, at the point of demand and in suitable conditions of flow and pressure, so that the following objectives are satisfied:

- Bring plants to a safe shutdown condition in case of fire.
- Prevent a fire from resulting in an increase in the release of radioactivity to the environment beyond the maximum permitted under normal conditions.
- To prevent unacceptable personal injury or economic damage in the event of fire.

Suitable suppression systems are designed and installed in the plants to prevent fires and explosions or, to minimise the consequences in fire areas containing safety important SSCs. The FP measures taken for each of the fire areas of the power plant, main suppression and support systems are defined according to the fire risk. These systems are designed and located in such a way that their failure, breakdown, spurious or inadvertent operation does not prevent safety important SSCs from performing their function.

The plants comply with the requirements developed in article 3.2.5, which indicates that means must be provided to limit the damage that a fire may cause, by means of passive barriers of 3 hours fire resistance or automatic detection and suppression systems to guarantee the capacity for safe shutdown in the event of fire and in annex A.7 of IS 30 [4] concerning suppression systems in safety important cable trays.

Additionally, an automatic suppression system is required in case cable trays necessary for safe shutdown are exposed to an external fire risk or in case safety-related cables cannot be separated from their redundant ones by 3 h fire-resistant barriers.

Finally, fixed suppression systems are required on safety important cable trays that may be more difficult to extinguish manually using hoses, such as those that lack detection, have a higher fire load or are difficult to access. Point 3.9 of SG 1.19 sets out the criterion of accessibility to the affected area.

In order to assess the potential fire risks in the power plant, classify them, locate them and provide the appropriate means of fire protection in each case, the different areas are defined, in order to separate with fire barriers, redundant equipment, necessary for the safe shutdown of the plant. Within each fire area, fire zones are considered as a study unit value to define the necessary detection and suppression systems according to the thermal loads and densities and the type of risk to be protected.

In the Fire Hazard analysis, for each of the fire zones defined in the plant, the different particularities regarding the fire risk in each building, area/fire zone, elevation, contained equipment, list of main elements both mechanical and electrical or instrumentation, type of combustible material contained and evaluation of thermal loads are indicated.

Additionally, the FP measures adopted for each of the fire zones in the plant are specified, classifying the fire risk, type of main suppression and support systems, and type of detection system, as well as FACP and other complementary data.

Suppression systems are preferably water based, provided that the characteristics of the protected materials and equipment allow it. This is because the plants have an FP water supply network to each zone, designed according to the single failure criterion, so that these systems can be considered very reliable. Where water cannot be used, suppression systems using gas as the extinguishing agent are employed.

The applicable requirements in relation to the fire suppression systems are given in Articles 3.4.2, 3.4.3, 3.4.4, 3.4.4, 3.4.12, 3.4.13 and Annex A of IS-30 [4] and points 9.2, 9.3, 9.4 and 10 of SG 1.19.

Plants following a risk-informed and performance-based methodology as an alternative to the requirements of IS-30 [4] must comply with the following articles of NFPA-805 [5]: 3.5.1 to 3.5.16, 3.6.1 to 3.6.5, 3.7, 3.9 to 3.9.6 and 3.10 to 3.10.10.

03.2.1.2.2 Types, main characteristics and performance expectations

The Spanish nuclear power plants comply with the WENRA reference levels applicable to fire suppression, through the use of the suppression systems described throughout this section.

In order to comply with the requirement set out in WENRA SV 6.9, the plants analysed have the following systems:

1. Almaraz NPP

At Almaraz NPP, 151 fire areas are defined, subdivided into 428 fire zones.

In order to be able to assess the potential fire hazards, classify them, and provide the appropriate means of protection in each case, the following criteria have been followed:

- Each Plant Building has been considered as a separate fire area, except the Purge Treatment Building, which has been considered attached to the Auxiliary Building.
- Within each building, different fire areas have been considered in order to separate the redundant equipment required for the safe shutdown of the plant from each other and from the rest of the plant's high-risk equipment with fire barriers. Spaces containing elements of very high combustibility and high thermal load of combustion also constitute fire areas.
- The fire barriers in the different areas have been defined in such a way as to make maximum use of the internal architectural walls of the power plant.
- All equipment required for safe shutdown in the event of an SSE shall be provided with FHC from the seismic FP system.

- For each defined fire zone, the total combustion heat load has been established, assuming complete combustion of all combustible material contained in the zone, due to the postulated design fire.

- The total heat of combustion of each fire zone has been determined taking into account the combustible materials associated with the zone. Transitory or temporary fuel loads shall be subject to Administrative Control.

- The specific combustion heat loads of each fire zone have been classified into the following categories:

  - Low (B): less than or equal to 220 Mcal/m^2

  - Medium (M): between 220 and 542 Mcal/m^2

  - High (A): greater than or equal to 542 Mcal/m^2

- Finally, in each case, the detection and suppression measures and systems to be implemented are established.

The FP water system has the capability to be sectorised and has quick connections for use in the mitigation of large fires, in accordance with the specific requirements set out in the regulations.

Below is a summary table of the number of fire zones with suppression systems, taking into account that some of the zones do not have extinguishing systems, as they are cubicles in which the fire hydrants are located at the entrance door to the cubicle, outside the cubicle:

EXTINGUISHING SYSTEMS	NUMBER OF FIRE ZONES
Fixed automatic water spray systems	3 TRM +31 not TRM
Stationary manually operated water spray systems	9 TRM +2 not TRM
Fixed automatic sprinkler systems (with automatic preaction)	16 TRM
Fixed automatic sprinkler systems (without automatic preaction)	7 not TRM
Fixed manually operated sprinkler systems	1 TRM
Water-foam systems	6 TRM +1 not TRM
Fixed manually operated water mist systems	1 TRM
NOVEC 1230 Automatic System	1 TRM + 2 not TRM
Automatic CO_2 System	3 TRM
FE13 Automatic System	1 TRM +2 not TRM
Automatic Argon System	2 TRM
FM-200 Automatic System	7 TRM +3 not TRM
FHC (Number of units)	167 TRM + 101 not TRM
Fire hydrants and FP equipment huts (no. of hydrants/huts)	19/9 in protected area + 27/7 outside protected area
Fire extinguishers (no. of extinguishers per type)	44 of water; 830 of CO_2 and 663 of powder

In relation to the sections of NFPA 805, 3.5 on FP water supply, 3.6 on risers, 3.7 on extinguishers, 3.8 on detection, 3.9 on automatic water suppression systems and 3.10 on gas suppression systems, their compliance has been analysed within the framework of the transition project. The improvements identified have been installed or the minor deviations found justified. These deviations have been analysed subsequently by the regulatory body and approved in the transition authorisation.

2. Vandellós NPP

At Vandellós NPP there is a similar layout to that of Cofrentes NPP and Almaraz NPP in terms of the definition of fire areas in each building and their subdivision into fire zones (185 fire areas subdivided into 276 fire zones), as well as the arrangement of main suppression and support systems.

The main and back-up suppression systems used in the different areas of the plant are included in Appendix 9.5B to the SAR, Fire Hazard Analysis.

Below is a summary table of the number of fire areas in the power block buildings that have each of the suppression systems, taking into account that some of the areas do not have a water suppression system, as they are cubicles in which the fire hydrants are located just outside the entrance door:

EXTINGUISHING SYSTEMS	NUMBER OF FIRE AREAS
Fixed automatic water spray systems	19
Fixed manually operated water spray systems	12 (1)
Fixed automatic pre-action sprinkler systems	22
Fixed automatic sprinkler systems (without automatic preaction)	12
Water-foam systems	4
NOVEC 1230 automatic system	4
FE13 automatic system	11
FHC (Number of units)	246
Hose connections	65
Fire hydrants and FP equipment huts (no. of hydrants/huts)	27 / 27
Extinguishers	820

(1) Two of the systems have foam concentrate tanks that serve the sprays in the oil tank room and the turbine turbo-alternator lubrication oil tank with a minimum autonomy of 10 minutes and then switch to water spray operation.

At Trillo NPP the fixed suppression systems that do not use water use FM200.

3. Cofrentes NPP

Cofrentes NPP has 160 fire zones, including the ISFSI zones.

In order to be able to assess the potential fire hazards, classify them, and provide the appropriate means of protection in each case, the following criteria have been followed.

- Each building, with the exception of the turbine and heater buildings, has been considered as a separate fire area from the others. In order to choose the enclosures that have to comply with the fire barrier requirements, the criterion of risk isolation has been followed.

- Within each building, in turn, different fire areas have been considered, in order to separate redundant equipment required for the safe shutdown of the plant from each other and from the rest of the equipment with barriers. These are the study units to establish the necessary detection and suppression systems that are most appropriate for each area. The amount of combustible material and the predominant fuel type are assessed, and the thermal load and expected fire duration time in each area are calculated. Defining the most suitable main and back-up suppression systems for each area considered, as well as the specific requirements in each case, which enables the subsequent detailed design of the different systems.

- The Fire Protection Water system, in order to meet the requirements for Potential Loss of Large Areas due to large fire scenarios (Large Fire Mitigation) has the capability to sectorise the internal water distribution rings of each of the main plant buildings by means of isolation valves. There are also quick connections for the connection of portable pumping equipment installed in the Turbine, Waste, Electrical and Heaters Buildings. The objective is to be able to restore the functionality of the undamaged portions of the FP network in the event of a potential loss of a large area of the plant.

The main and back-up suppression systems used in the different areas of the Plant are listed in the Fire Protection System Design Study.

Below is a summary table of the number of fire zones that have each of the suppression systems, taking into account that in some of the zones the suppression systems are located just outside the entrance door to the cubicle:

EXTINGUISHING SYSTEMS	NUMBER OF FIRE ZONES
Atomised water-foam preaction system (AFFF)	3
Water connection	5
Automatic sprinkler system	24
Manual N_2 system	2
Automatic dry powder system	1
Automatic aqueous film-forming foam (AFFF)	10
Automatic spraying system	14
Manual high expansion foam system	11
FHC	121
NOVEC 1230 Automatic System	10
Automatic CO_2 System	3
Extinguishers	145

Water supply - tanks

The tanks comply with the requirements of Annex A2 of IS-30 and Articles 9.2 of SG 1.19. These requirements stipulate, inter alia, that the firefighting water supply capacity shall not be less than two water tanks of 1136 m^3 each.

1. Almaraz NPP

The source of water for the Almaraz NPP FP system is the Arrocampo reservoir for the electric motor driven pumps and the essential reservoir for the diesel pump, being at different intake structures (circulation water and essential services water, respectively). Compliance with sections 3.5.1 and 3.5.2 of NFPA 805 has been analysed and no deviations have been found. The water inventory is therefore theoretically unlimited.

2. Vandellós NPP

At Vandellós NPP, the fire protection water is stored in two sets of tanks, each set consisting of two tanks connected by communicating vessels so that each set has a volume of at least 1359 m^3. This volume, as required in IS-30 Rev. 2 [4], is based on the water consumption for a 2-hour period considering the highest demand in an in-plant sprinkler or spray system (2490 gpm), with the addition of 1900 l/min (500 gpm) for the use of hand hoses.

3. Cofrentes NPP

There are two atmospheric water storage tanks, each with a capacity of 300,000 gallons (1,150 m^3). The two water storage tanks are connected by a pump suction manifold in which there is a normally closed isolation valve.

Water supply - pumps

The pumps comply with the requirements of Annex A2 of IS-30 and Articles 9.2 of SG 1.19.

1. Almaraz NPP

Almaraz NPP has two main pumps driven by an electric motor (with independent power supplies) and a third one driven by a diesel engine. Each pump has a 100% capacity. The pumps are stopped manually and have automatic recirculation. It has two pressure groups with pressurisation tanks. The electric FP pumps are located in one intake structure (circulating water) and the diesel pump in a different one (service water) and separated from other pumps in the vicinity by FP barriers. The diesel pump is equipped with an automatic water spray suppression system. Compliance with sections 3.5.3 to 3.5.9 of NFPA 805 (NFPA-20) has been analysed and no deviations have been found.

2. Vandellós NPP

The fire protection system at Vandellós NPP has three 50% capacity fire pumps, two driven by diesel motors and one driven by an electric motor. The pumps are located in a separate building exclusively for them, separated by 3-hour fire walls. The fire protection system has a pressure pump (jockey pump) to keep the fire protection network full and pressurised and to minimise the operation of the main pumps.

At Trillo NPP there are 4 electric FP pumps, each with 50 % capacity, fed from the safeguards power supply system.

3. Cofrentes NPP

The pumping equipment consists of 2 main fire pumps with 100 % capacity each. One of these two main pumps is driven by an electric motor and the other by a diesel engine.

An electric motor-driven circuit pressurisation and leakage pump (Jockey pump) is available.

A pressurisation tank is provided to maintain pressure in the associated water systems using a compressed air manifold.

The diesel-driven main firefighting pump and its associated control and battery charging panel as well as the diesel oil day tank are located inside the purpose-built pump house. The rest of the equipment (electrically driven main pump, jockey pump and pressurisation tank, together with the control panel of this equipment) are located nearby, outdoors. The day fuel tank is separated from the rest of the equipment by a three-hour fire-resistant wall.

Water Supply - Loop and Distribution System

The distribution system complies with the requirements of Annex A2 of IS-30 and Articles 9.2 of SG 1.19.

1. Almaraz NPP

Almaraz NPP has an external distribution loop (12" bore) with double feed to each building. It also supplies FP water to the outdoor areas of the plant. Along the outer loop, there are isolation valves between every two water intake points, allowing sections of the circuit to be isolated in the event of breakage, maintenance, etc., without losing the water supply.

Compliance with sections 3.5.10 to 3.5.14 of NFPA 805 (NFPA-24 [116] and ANSI B31.1 [91]) has been analysed and minor deviations that have not been resolved with the implemented improvements have been justified. These deviations have been analysed by the regulatory body and approved in the transition process to NFPA 805.

2. Vandellós NPP

At Vandellós NPP, the distribution of water stored in the firefighting tanks to the different fire protection systems is carried out via a 12" main distribution loop, from which branches supply the different areas and buildings of the plant, as well as the external hydrants.

With regard to the loop's isolation valves, the underground sections of the loop have manhole with isolation valves, and in the sections of the loop that run through a gallery, the isolation valve is located in the gallery itself, in an accessible place. The connection of the fire water supply loop to the hydrants is provided with a locked open isolation valve.

There are dual connections to buildings containing safety-related SSCs: the hose system is fed from one connection and the fixed suppression systems from the other. Isolation valves, locked in the open position, separate the two connections in order to isolate part of the loop without losing the water supply to the primary and back-up system simultaneously.

At Trillo NPP there is a single connection from the FP loop to the essential services water pump house and to the transformer area of the unit.

3. Cofrentes NPP

The Cofrentes NPP loop is 12" in diameter and surrounds the plant's buildings. From this loop, the water distribution pipes run to the interior of each building. The loop can be sectorised and complete sections can be isolated without losing the supply to the buildings.

Within each building, a closed loop is also provided, collecting all the building's water supply outlets. The distribution pipes to the fire areas of the buildings run from this loop to supply the various suppression equipment installed.

The system supplies firefighting water to buildings and outdoor areas of the plant.

Seismic system FP

The FP seismic system complies with the requirements of Article 3.4.8 and Annex A2 of IS-30.

1. Almaraz NPP

As part of the modifications and improvements derived from the transition to NFPA-805, which requires in section 3.6.4 that a water supply be available to the FHC located in areas of the plant with equipment necessary for safe shutdown in the event of an earthquake (SSE) and as a result of the implementation of IS-30, which requires in article 3.4.8 the availability of a seismic subsystem, the installation of a seismic FP system has been carried out.

The system consists of a new safe source of water and associated pumping equipment, independent of the conventional FP, which provides water in the event of a fire after an earthquake to the existing FHC related to the safe shutdown equipment in the power plant. The main system criteria are: storage and pumping capacity consistent with a two-hour supply to two FHC, seismic support and a redundant and diverse pumping station (1E electric and diesel).

Its water source is the reactor make-up water tank, which has a reserved capacity (114.6m^3, exceeding the criterion of two FHC, 17m^3/h x 2 for two hours) for this purpose. It has two pumps (electric and diesel) with 100% capacity, including an R180 barrier.

After aligning and isolating the Seismic FP system from the Conventional FP system, water is supplied to the FHC in fire areas with safe shutdown SSCs in the event of an earthquake. Compliance with sections 3.6.4 and 3.6.5 of NFPA 805 has been analysed and no deviations have been found.

2. Vandellós NPP

The hose network in the safety-related buildings is seismically supported and sized to be able to supply water to two FHC with a flow rate of 75 gpm (150 gpm total) for 2 hours and protect safety-related equipment in the event of a fire following a SSE. The water supply is provided by the essential services support system, which is a seismic category 1 and class C source consisting of two electric pumps fed by redundant class 1E trains, each with 100 % capacity. The buildings protected by this network are: Auxiliary, Containment, Fuel, Components, Turbine Penetrations, Control, Diesel and Pump House, Technological Safeguards exchangers, Electrical buildings, Pump Room and Technological safeguards cooling water system Galleries.

3. Cofrentes NPP

The distribution network of the seismic FP subsystem is fed by a seismic tank with a capacity of 1,786 m^3, has an independent pumping group and although it does not perform safety functions, it is designed so that, in the event of a SSE, the isolation valves are closed, thus being able to supply water to the equipped FHC of those fire areas that contain equipment required to reach and maintain the safe shutdown of the plant.

EDMG Systems

A number of equipment and connections (pumps, generators, portable compressors...) are available to be used following the guidelines of the Extensive Damage Mitigation Guidelines (EDMG) and the Emergency Support Centre (ESC), including the strategy for extinguishing large fires, for which an alternative loop can be deployed using pumps and hoses, with the possibility of interconnection with the main fixed loop.

The ESC equipment can be used for these actions, and also serve as a backup for portable equipment from other mitigation guides if degradation or wear of the plant's own portable equipment in use is observed.

Final suppression systems

Final suppression systems comply with the requirements of Articles 3.4.2 and 3.4.12 of IS-30 and Section 10 of SG 1.19.

The type of the main suppression system is determined by the type and quantity of combustible material and the accessibility of the area.

In areas where the special characteristics of the equipment located inside do not allow the use of water as an extinguishing agent, the most appropriate systems are used.

When the main suppression system is a fixed system, FHC and portable extinguishers are used as back-up. If the main suppression system are FHC, portable extinguishers are used as back-up.

In areas where electrical equipment is present, the hoses are fitted with a two-position nozzle: fog and shut-off.

The type of portable extinguisher is chosen according to the characteristics of the materials and equipment present in the area. If there is electrical equipment, gas extinguishers are used; if the fire involves solids or combustible liquids, water extinguishers or multi-purpose powder extinguishers are used.

Final suppression systems - Hydrants

The hydrants comply with the requirements developed in Annex A.2 of IS 30 [4].

Hydrants are provided in outdoor areas and sheds equipped with hoses, adapters and other auxiliary equipment, installed as required next to the hydrants.

The hydrants are fitted with threaded connections compatible with those used by the external organisation supporting the plant in the event of a fire.

1. Almaraz NPP

Almaraz NPP has hydrants with coverage outside the plant buildings with SSCs important for fire safety (there are 17 in the protected area and 26 in the exclusion area and the ISFSI). An analysis of compliance with section 3.5.15 of NFPA 805 (NFPA-24) in terms of separation is available, with justification for the minor deviations found, which have been analysed by the regulatory body and approved in the process of transition to NFPA 805.

2. Vandellós NPP

The protected area of the Vandellós plant has a total of 27 hydrants distributed throughout the plant. Double outlet hydrants are installed at approximately 250 ft (76 m) intervals along the main loop.

A study of the coverage of the hydrant network has been carried out taking into account its location on the plant, the length of hose available in the cabinets (30 m) and the theoretical range of the water jet (27 m). The theoretical range has been validated by field testing on one of the most unfavourable hydrants due to its distance from the pumping station, obtaining a jet range of 37 metres.

The study concludes that the available hydrants guarantee coverage of the buildings located within the protected area and the fire risks present, with the exception of the area of the HVAC shed located on the corner formed by the façades of the Switchgear and Turbine buildings, which would not be covered by the hydrant network taking into account the parameters of the field test (1 hose of 30 metres with a water jet range of 37 metres). This shed contains no combustible load (only fire dampers are located in the shed). Likewise, the façades of the buildings are made of non-combustible material (concrete) and the fire areas located inside the buildings are equipped with their own fire protection means (water hoses), so there is no need for such coverage. In this respect, if necessary, two hoses connected in series could be used, as 2 hoses of 30 metres in length are available in the cabinets next to the hydrants. It has been verified by field test that, with two hoses connected in series, the required flow rate and pressure are obtained.

3. Cofrentes NPP

The Cofrentes plant has a total of 58 hydrants distributed throughout the plant.

The hydrants are installed in outdoor areas, with a maximum distance of 75 metres between them. They are connected to the main loop through isolation valves. Sheds equipped with hoses, adapters and other equipment as required are available.

Final suppression systems - FHC

The requirements for FHC are set out in Annex A.3 of IS-30 [4].

The installation of FHC inside buildings provides effective water flow to any indoor location where fixed fuels may compromise safety important SSCs.

FHC are positioned so that any point likely to present a fire exposure to safety important SSCs is covered by the jet of at least one hose. The location of the FHC is established in accordance with the fire hazard analysis to facilitate firefighting.

The water supply in the event of a SSE is ensured, as a minimum, to the hose network protecting the safe shutdown equipment, by a seismic subsystem complying with the requirements of section 3.4.8 of IS-30 [4].

1. Almaraz NPP

Almaraz NPP has FHCs (approximately 250) with adequate coverage inside the plant buildings. The length of the hoses is between 15 and 30m so that adequate coverage is guaranteed; they have a diameter of 45 mm and Barcelona couplings. The minimum working pressure is 4.5 bar and the maximum is 12.1 bar, in accordance with NFPA-14 [117].

An analysis of compliance with sections 3.6.1 to 3.6.3 of NFPA 805 (NFPA-14) is available, and the minor deviations found have been justified by the licensee and they have been analysed and approved by the regulatory body in the process of transition to NFPA 805.

2. Vandellós NPP

There are 246 FHCs located throughout the buildings and in areas near stairwells and separated from each other by no more than 100 feet (30 metres). The FHCs are equipped with 15 or 20 m long hoses with a diameter of 45 mm and are fitted with nozzles appropriate for the area to be protected. In addition, there are 65 connections for 2 ½" hoses with Barcelona couplings for the use of portable hoses. These 2 ½" connections are installed near stairwells in all buildings except containment.

Water hoses are the primary suppression system in 100 fire areas.

At Trillo NPP, in some particular cases in the containment, annulus, auxiliary, galleries, ventilation chimney, diesel, emergency and electrical buildings, there are no FHC and/or fixed systems on cable trays. In those cases there are specific systems on the fire sources.

3. Cofrentes NPP

In the specific case of the Cofrentes plant, a total of 121 FHCs are available. They are located so that any area with safety important SSCs is covered by at least one FHC. The FHCs are 45 mm in diameter, with a maximum length of 30 m and are spaced no more than 50 m apart and have Barcelona-type couplings.

In fire zones where an automatic suppression system is in place, FHCs are considered the secondary system. In areas where FHCs and extinguishers are present, FHCs are the primary extinguishing system.

Final suppression systems - Sprinkler, water spray and foam systems

The sprinkler, water spray and foam systems comply with the requirements developed in Annex A.3 of IS-30 [4] as referred to in point 3.4.13.

Fixed suppression systems of sprinklers, water spray, foam and FHC equipped as determined by the fire hazard analysis are used. Generally, fixed systems are used as the main system and FHC as back-up. FHC may be used as the main system in areas in which the equipment located inside may be damaged by water.

Each sprinkler, water spray, and foam system and the FHC have an isolation valve.

1. Almaraz NPP

Almaraz NPP has sprinkler, water spray and foam systems in accordance with the analysis contained in the FHA. There are 106 fixed water-based suppression systems in the plant.

The areas protected by these systems are cable distribution rooms and certain cable ducts, turbine areas, diesel generators, fuel storage for diesel generators, the reactor cooling pump areas and other safety-related areas (diesel oil, essential cooling…), transformers, and other areas such as storage tanks for different fuels, the auxiliary boiler and filtration units.

An analysis of compliance with section 3.9 of NFPA 805 (NFPA-13 [118], 15 [119], 16 [120] and 750 [121]) is available, improvements have been implemented and the minor deviation found regarding the listing of FP equipment has been justified by the licensee and analysed and approved by the regulatory body in the process of transition to NFPA 805.

2. Vandellós NPP

Vandellós NPP has 65 fixed water-based suppression systems, of which 53 are automatic systems and 12 are fixed manual systems. These include automatic sprinkler systems, pre-action sprinklers, automatic water spray and manual water spray and foam systems.

According to paragraph 10 of SG 1.19, the areas protected by these systems are the cable distribution rooms, turbine areas, diesel generator areas, diesel generator fuel storage areas, safety-related pump areas, transformers, radioactive waste and decontamination areas, and other areas such as storage tanks for different fuels, the auxiliary boiler, vertical cable tray areas and filtering units.

3. Cofrentes NPP

Cofrentes NPP has sprinkler, water spray and foam systems in accordance with the analysis contained in the FHA. This type of installation covers 62 fire zones in the power station.

The areas protected by these systems are the cable distribution rooms, turbine areas, diesel generator areas, fuel storage areas for diesel generators, transformers, storage tanks for different fuels and the auxiliary boiler.

Final suppression systems - CO_2 suppression systems

The requirements to the CO_2 suppression system are set out in Annex A.4 of IS-30 [4] as indicated in paragraph 3.4.13 of IS-30.

1. Almaraz NPP

Almaraz NPP has CO_2 suppression systems in the diesel generator rooms 1, 2 and 3, according to the analysis included in the FHA. Each system is powered by a battery of CO_2 cylinders. An analysis of compliance with section 3.10 of NFPA 805 is available and the minor deviations found have been justified by the licensee and analysed and approved by the regulatory body in the process of transition to NFPA 805.

Ascó NPP has high and low pressure CO_2 suppression systems. The low pressure system includes a common CO_2 storage tank from which the 27 automatic suppression stations protecting the electrical equipment areas and battery rooms and the 9 x CO_2 hose reel stations are fed. The high-pressure systems each have a separate cylinder bank to cover 13 zones of electrical equipment.

2. Vandellós NPP

Carbon dioxide hose stations powered by cylinder batteries are available. Each 1" diameter, 20 m long hose is powered by a battery of 4 CO_2 cylinders of 66 lb (30 kg) each (2 of which are in reserve).

Each hose station is equipped with a self-contained breathing apparatus (SCBA) with a 45 minutes autonomy. These hose stations are located to protect the following areas: in the control building (MCC, power centres, distribution centres and battery rooms); areas of electrical penetrations in containment; electrical switchgear building; turbo-alternator and exciter bearings; and diesel building electrical equipment rooms.

3. Cofrentes NPP

Cofrentes NPP currently has an automatic carbon dioxide suppression system in three electrical panels. CO_2 cylinders are available and will be actuated when the incipient detection system detects the need.

Final suppression systems - Clean agent gas flooding suppression systems

The requirements to the clean agent flooding suppression system are set out in Annex A.5 of IS-30 [4] as indicated in section 3.4.13. They have a local blocking system subject to administrative controls and additional administrative controls are in place to regulate the deactivation or inhibition of these automatic systems if necessary.

1. Almaraz NPP

Almaraz NPP has Novec-1230 suppression systems in areas adjacent to the control room (computer room and on cable trays in this area; also in auxiliary buildings, security room and simulator), in accordance with the analysis included in the FHA. The extinguishing gas is contained in cylinders specific to each system.

In addition, Almaraz NPP uses argon-based suppression systems (certain cable rooms in the electrical building), FE-13 (COSS room, electrical panel area, 4 DG electrical room building and the communications room) and FM-200 (5D electrical panels, control room panels and alternative shutdown and hot shutdown panels, pre-treatment plant and turbine cooling tower system) to which the above applies.

An analysis of compliance with section 3.10 of NFPA 805 is available and the minor deviations found have been justified by the licensee and analysed and approved by the regulatory body in the process of transition to NFPA 805.

2. Vandellós NPP

Vandellós NPP has Novec 1230 gas suppression systems that protect four rooms with electrical equipment and components located in the Auxiliary Building. The systems are total flooding systems and are designed according to NFPA 2001 [122]. The system consists of two batteries of bottles, each feeding the fire areas of a train, charged with the extinguishing agent and connected to a network of distribution pipes ending in diffusers through which the extinguishing agent is discharged inside the enclosure to be protected.

In addition, Vandellós NPP uses FE-13 total flooding suppression systems (Main Computer Room, Electrical Cabinets and Archive Bunker in the CAT-Diesel building and in the electrical rooms and vertical cable trays area of the electrical building of the technological safeguards water system).This system is designed in accordance with NFPA-2001.

3. Cofrentes NPP

Cofrentes NPP has a Novec flooding suppression system, which is installed in 10 fire zones. Bottles and a distribution network to the discharge nozzles are available.

Final suppression systems - Portable fire extinguishers

The requirements to the portable extinguishers are set out in Annex A.6 of IS-30 [4] as indicated in section 3.4.13 of IS-30.

The extinguishing agent is appropriate to the fire hazard in each area and its effectiveness and possible damage to the safety equipment located in the area, especially if it is dry powder, should be assessed. The type of portable extinguisher is chosen according to the characteristics of the materials and equipment present in the area. If there is electrical equipment, gas extinguishers are used; if the fire involves solids or combustible liquids, water extinguishers or multi-purpose powder extinguishers are used.

1. Almaraz NPP

Almaraz NPP has water, carbon dioxide and multi-purpose powder extinguishers as the main or back-up means, according to the analysis contained in the FHA. These extinguishers are distributed throughout the plant according to the required coverage, and additional extinguishers are available to be placed in any area when main extinguishing systems are not functional.

An analysis of compliance with section 3.7 of NFPA 805 (NFPA-10 [123]) is available, and the necessary adaptations have been made (redefinition of the position of some extinguishers).

2. Vandellós NPP

Vandellós NPP has 820 portable extinguishers that cover the buildings and outdoor areas within the power block. They are selected and installed in accordance with the requirements of NFPA-10.

Portable CO_2, pressurised water and dry powder fire extinguishers are available, distributed throughout the different fire areas according to the fire risks and taking into account possible damage to safety SSC:

- CO_2 extinguishers in electrically hazardous areas (10 kg trolleys or 5 kg portables)
- Pressurised water extinguishers (10 litre portable) available in some areas of the TSC (technical support centre) building where there is paper fire load.
- Powder extinguishers in all other areas except containment and fuel building, where CO_2 extinguishers are used. These extinguishers have a larger capacity in the turbine area (100 kg of ammonium phosphate mounted on a trolley).

3. Cofrentes NPP

Cofrentes NPP has portable water, carbon dioxide and multi-purpose powder extinguishers as the main or back-up systems, in accordance with the FHA. The extinguishing agent is appropriate to the fire risk in each area. These extinguishers cover 145 fire zones.

The type of portable extinguisher is chosen according to the characteristics of the materials and equipment present in the area.

- Gaseous extinguishers are used for electrical equipment,
- For solids or combustible liquids, water extinguishers or multi-purpose powder extinguishers are used.

03.2.1.2.3 Management of harmful effects and consequential hazards

As stated in Article 3.4.2 and Annex A.3 of IS-30 [4] safety important SSCs which do not require protection by fixed water suppression systems, but which may be affected by water when these are actuated, should be protected by shielding or screens and additionally adequate drains are provided in areas with such equipment to prevent possible damage due to discharge from such water systems.

1. Almaraz NPP

The pipes of the FP water system are classified as moderate energy for the purpose of postulating defects in the flooding analysis.

In many rooms of the plant, the failure of the FP piping is considered to be a source of flooding and in several of them it is the piping failure that causes the highest flooding level. The main detection method in all these scenarios is the FP pumps start-up alarm and the method of isolation is the closure of the valves of the system.

Flooding protection of critical equipment is achieved by one of the following methods:

- Placing redundant equipment in separate rooms that are not simultaneously affected by the same flooding.
- Placing the equipment above the flood level.
- Providing protective barriers.
- Installing automatic fault detection and isolation systems.
- Demonstrating that equipment performs its function, even when submerged.

Regarding the effects of spraying on equipment due to pipe failures, the specific analysis of this effect also considers FP water pipes. In these analysis protection of essential equipment is achieved by one of the following methods:

- Placing redundant equipment in separate rooms that are not simultaneously affected by the same pipe failure.
- Providing protective barriers.
- Demonstrating that the equipment does its job, even if it suffers from spraying.

With regard to the spurious performance of FP suppression systems, there is a specific analysis of the effects on essential equipment due to the flooding caused, which concludes that the flooding levels reached are lower than those caused by the failure of pipelines and, when this is not the case, no essential equipment is affected.

The analysis of the effects of spraying on critical equipment due to spurious actuation of FP suppression systems is covered by the general spraying analysis as all rooms where suppression systems are present are already analysed for pipe failures, taking into account that as a general assumption when one line fails all SSCs in the area are considered to be affected by spraying unless they have a specific environmental qualification in this respect.

2. Vandellós NPP

The components of the Vandellós NPP FP system have been designed in such a way that their breakage or inadvertent operation does not cause loss of function of safety important SSCs. To this end, the following provisions have been considered in the design:

The suppression systems located in the containment are dry line, and isolated from the main system by a normally closed containment isolation valve. Other suppression systems protecting safety important components or areas are installed in such a way that there is a suppression system for each A or B train. Inadvertent operation of a suppression system shall not affect both trains of a safety-related system.

However, to avoid damage to a single train due to spurious or intentional actuation of the suppression systems (whether manual or automatic), the following measures are available:

- Automatic water spray systems are activated by cross detection and automatic sprinklers in areas with safety-related equipment are pre-action sprinklers (with dry pipe pressurised with compressed air to monitor for possible breakage of the sprinklers or the pipe itself), thus avoiding wetting of equipment by spurious actuations or breakage. The only exception is the area where the pumps related to the technological safeguard (EJ) system, are located as they are water resistant and have a wet pipe sprinkler system.

- Even considering the failure of the fire control panel, the only fire areas with safety-related SSCs that have fixed open-nozzle automatic spray systems are the control cable distribution rooms, where there is no equipment that could be directly affected by the spray, as the cables are qualified to be wetted and there is no electrical equipment in these areas that could be affected by the fire.

- In those areas where fixed water suppression systems are in place, adequate drainage has been provided so that the water level reached, taking into account the seals resistance for that flood level, ensures that equipment required for safe shutdown in adjacent areas will not be affected by the discharge of water, thus ensuring that the ability to perform the safety functions required to achieve safe shutdown of the plant is maintained.

- In areas with safety important electrical equipment, fixed water systems are not used, but water hoses with blocked fog position and CO_2 hoses. The only exception are the areas of the air-conditioning units of electrical penetrations in the auxiliary building, where pre-action sprinklers are provided and the electrical cabinets have seals at the cable entry to protect against water discharge. In the particular case of the electrical building related to the technological safeguards (EJ) system, automatic FE-13 systems are available and in the electrical areas of the auxiliary building, Novec 1230 systems are available.

3. Cofrentes NPP

There are risks arising from the operation or rupture of the fire suppression systems. In areas where a water flooding suppression system is provided, and where there is safety equipment either within the area or in adjacent areas, which may be damaged by the possible flooding caused by the action of the suppression system, retaining walls have been installed to prevent water from reaching this equipment.

Several cases can be identified:

- Areas containing no safety equipment and in which the primary combustible material contained therein is liquid. In these cases, the area has been considered as a cubicle in which, in order to control possible fuel spills, the drain has been plugged with a removable plug and the levels of the access doors and any other openings have been raised in order to contain the maximum expected discharge of the water suppression system.

- Areas that do not contain safety equipment and that may be damaged by water flooding and where flooding can be expected due to the discharge of the water suppression system, either because of insufficient drainage or a possible functional failure in the drainage system. In this case, in order to protect the safety equipment contained in the adjacent areas that may be affected by the water from the suppression system, walls have been installed in the areas of communication, capable of containing the maximum amount of water to be poured.

- Areas containing safety equipment other than fire risk equipment which may be damaged by flooding of the intended suppression system. These are usually electrical panels with connection terminals close to the ground which can cause short circuits. In these areas, one of the following solutions has been adopted: equipment rise by means of pedestals or isolation by means of placing retaining walls around.

03.2.1.2.4 Alternative/temporary provisions

There are various procedures in the plants that apply in the event that a fire protection system needs to be taken out of service due to work on the system itself, or on other non-fire protection systems.

CSN Technical Instruction CSN-IT-DSN-10/08, 11 and 12 [25] on improvements to the TS/TRM improved the Technical Requirements Manual (TRM) with regard to fire protection.

Details of these procedures are given in section 03.2.1.3 Administrative and Organisational Aspects of Fire Protection. However, those relating to the suppression system are listed below.

1. Almaraz NPP

At Almaraz NPP there are different procedures in place that establish compensatory measures for inoperabilities.

Details of these procedures are given in section 03.2.1.3 Administrative and Organisational Aspects of Fire Protection. However, those applicable to suppression systems are listed below:

- Management of loss of functionality of FP systems and barriers.

- Technical Requirements Manual (sections for each system)

2. Vandellós NPP

At Vandellós NPP, there are different procedures that establish compensatory measures for inoperabilities.

Details of these procedures are given in section 03.2.1.3 Administrative and Organisational Aspects of Fire Protection. However, those applicable to suppression systems are listed below:

- Performance Standards of the FP unit in the FP System for inoperabilities affected by TS, also applicable to the scope affected by the FP Technical Requirements Manual (FP TRM).

- FP unit performance standards in the FP system for non-functionalities of systems that are neither in the scope of TS nor FP TRM.

3. Cofrentes NPP

The procedures applicable in the event of inoperability at Cofrentes NPP are as follows:

- Control of inoperability of fixed suppression systems and/or fire detection systems. It establishes the actions to be taken in the event that, due to corrective or preventive work, testing or other causes, it is necessary to render a fixed fire suppression and/or fire detection system inoperable. It defines the compensatory measures and actions to be taken in such cases.

- FP TRM Technical Requirement 6.3.7.6-Sprayer and/or water sprayer systems. It establishes the actions and deadlines to be followed to re-establish the operability of the systems indicated in the Fire Protection Manual.

- FP TRM Technical Requirement 6.3.7.7 -Portable Fire Extinguishers. Establishes the actions and deadlines to be followed to re-establish the operability of the portable fire extinguishers indicated in the Fire Protection Manual.

- FP TRM Technical Requirement 6.3.7.8 - Fixed gaseous agent suppression systems. Establishes the actions and deadlines to be followed to re-establish the operability of the fixed gaseous agent suppression systems indicated in the FPM.

- FP TRM Technical Requirement 6.3.7.9 -Manual Hose Reel Stations. It establishes the actions and deadlines to be followed to re-establish the operability of the manual hose reel stations indicated in the FPM.

- FP TRM Technical Requirement 6.3.7.10 - Outside loop fire hydrants and firefighting gear sheds. Establishes the actions and deadlines to be followed to re-establish the operability of the outside loop hydrants and material sheds indicated in the FPM.

03.2.1.3 Administrative and organizational fire protection issues

03.2.1.3.1 Overview of firefighting strategies, administrative arrangements and assurance

In addition to the design provisions, the administrative and organisational aspects of fire safety are very important in the fire protection of a facility.

Administrative controls are governed by Article 3.6.1 of IS.30 [4] which requires the development of procedures to establish the necessary inspections, maintenance and testing of active and passive components of fire detection and suppression systems.

The requirements to the firefighting organisation and fire brigade are set out in Article 3.7 of IS-30 and paragraph 6 of SG 1.19 [29].

In order to comply with this article, the Fire Protection Manual details the roles and responsibilities of the fire protection organisation, the regulations applicable to fire protection design bases, programme requirements, fire hazard analysis, administrative controls to control and minimise the amount of combustible material, inspections, maintenance and testing of active and passive fire protection components (detection and suppression systems, and fire resistant barriers).

The fire brigade is properly equipped, educated and trained. It has at least 5 people permanently on site. The physical fitness of all members of the brigade must be periodically certified in accordance with the requirements of the corresponding Complementary Technical Instructions issued by the CSN (CSN/ITC/SG/AL0/20/05, CSN/ITC/SG/VA2/20/01 and CSN/ITC/SG/COF/20/01 [20]). The CTI allow an alternative to the physical tests indicated in SG 1.19 paragraph 6 point 5, by means of other alternative tests based on NFPA 1582 [124].

Fire drills will be conducted so that the brigade can practice as a team. These drills are conducted on a regular basis so that each member of the brigade participates in at least two drills per year. At least one drill per year should be unannounced, and so that each year it is conducted on a different brigade shift. In addition, one drill per year must be carried out by the second intervention or support fire brigade. And at least one of the annual drills must involve the external firefighting support organisation.

For each safety important fire area, applicable firefighting strategies must be defined that, as a minimum, include: the fire hazard covered, the suppression systems to be used, the components necessary for safe shutdown and safety functions that may be affected by the fire, other potential associated hazards (toxic, radiological, or any others that may affect the work of the fire brigade), access and escape routes, and the basic instructions necessary to undertake the fire suppression. This information is available through the Pre Fire Plans which are a compilation of data, plans, strategies and procedures, which serve as an aid to firefighting in the event of a fire emergency in the plant. The aim of these PFP is to facilitate the action of those involved in firefighting in the event of a fire.

The Spanish nuclear power plants have a permanent fire protection brigade on site, so that specific firefighting situations with loss of access routes to the installation do not represent a major incident as the brigade is on site.

There is also an external organisation for firefighting support to the plant, with which, as indicated above, practices are carried out to achieve adequate coordination between plant personnel and external personnel and to ensure the latter's familiarisation with the plant's resources and risks.

Procedures

In order to maintain the safety level of the Fire Protection Programme and to ensure that, in the event of a potential fire in any fire area of the plant, safe shutdown can be achieved and maintained, minimising the possibility of radioactive releases to the environment, the Fire Protection Manual is available during operation at power and during all plant operating modes.

The main objectives of the FPM are:

- To compile in a single document, easy to locate and consult, by reference or direct inclusion, those means, methods and information that are useful in fire protection in order to minimise the effects that a fire could have on plant personnel and on the general public, as well as to protect against fire those elements whose deterioration could pose a risk to the safety and safe shutdown of the plant and/or serious economic losses.

- Define the roles and responsibilities, the organisation's means of action, the controls in place to minimise the fire risks and the training necessary to keep the plant's staff able to deal with fires that may occur with the appropriate degree of effectiveness.

- Define the processes to meet the Test Requirements corresponding to fire protection of the Technical Requirements Manual (TRM), as well as to comply with Royal Decree 513/2017 (Regulation of fire protection installations) [78].

1. Almaraz NPP

The purpose of the FPM is to define the development bases, the scope and processes, and the implementation elements of the Almaraz NPP Fire Protection Programme (FPP).

This handbook presents the following elements:

- Bases for the development of the programme.

- Scope and processes covered by the programme.

- Elements of programme implementation: Organisation, Procedures and Means.

- Maintenance processes of the programme's implementation elements.

- Records management process derived from the implementation of the programme and its maintenance.

Additionally, there is also a document defining behavioural expectations, including those related to FP.

The procedures referenced in the FPM are divided into the following categories:

- Procedures for monitoring and maintenance of suppression and detection systems and FP barriers (according to requirements of the TRM and other applicable FP regulations).

- Procedures for verification and maintenance of other FP means.

- Fire brigade operating procedures.

- Administrative procedures for fire risk control (control of storage areas, loss of functionality and fire risk works, comprehensive management and inspections).

- Administrative procedures for the maintenance of other programme elements (training, drills).

2. Vandellós NPP

Vandellós NPP also has a Fire Protection Manual (FPM) with a content equivalent to that described for Cofrentes NPP and Almaraz NPP. The FPM aims to define the development basis, scope and processes, and implementation elements of the Fire Protection Programme.

The manual includes the means, methods and information that are useful in fire protection in order to: (1) to minimise the effects of a fire; (2) to define the roles and responsibilities, the organisation's means of action, the controls in place to minimise the risks of a fire and the training necessary to keep the plant staff fit to deal with fires; and (3) to define the different requirements for operation and surveillance for fire protection, clearly differentiating those deriving from Nuclear Safety and Radiation Protection requirements from those deriving from the application of the Industrial Safety Regulations.

The procedures referenced in the FPM are divided into the following categories:

- Organisational procedures and other FP activities.

- Procedures corresponding to activities required by FP facility regulations or other standards.

- Monitoring procedures corresponding to the Technical Specifications of plant operation.

- FP systems surveillance procedures subject to the FP TRM.

3. Cofrentes NPP

In Cofrentes NPP the FPM covers the organisation of Cofrentes NPP, the regulations applicable to the fire protection design bases, the programme requirements and defines the administrative controls.

In addition, in order to maintain the safety level of the Fire Protection Programme, the following are available:

- Cofrentes NPP Expectations and Behaviour Manual. They contain the behaviours and work practices expected of all persons working in the facility.

- Computerised fire protection management system. The aim of the management system is to have an overall view of the FP system and to maximise efficiency in work management. There are two control panels, one in the Control Room and one in the fire building.

- Procedures related to the monitoring and maintenance of systems. Procedures and maintenance documents of the Fire Protection, Operation and Maintenance organisational units are in place to meet the surveillance requirements and required maintenance. The procedures for the surveillance of the detection and suppression systems are as follows:

  - Checks of portable fire extinguishers of the Fire Protection system.

  - Review of detection equipment of the Fire Protection System.

  - Other FP systems.

  Through these procedures, the maintenance programme is established, indicating the established periodicity, procedure, maintenance document or reference instruction of the FP equipment.

  - FP maintenance sheets. Various FP maintenance sheets have been developed through which equipment is checked, tested and monitored for operability.

03.2.1.3.2 Firefighting capabilities, responsibilities, organisation and documentation onsite and offsite

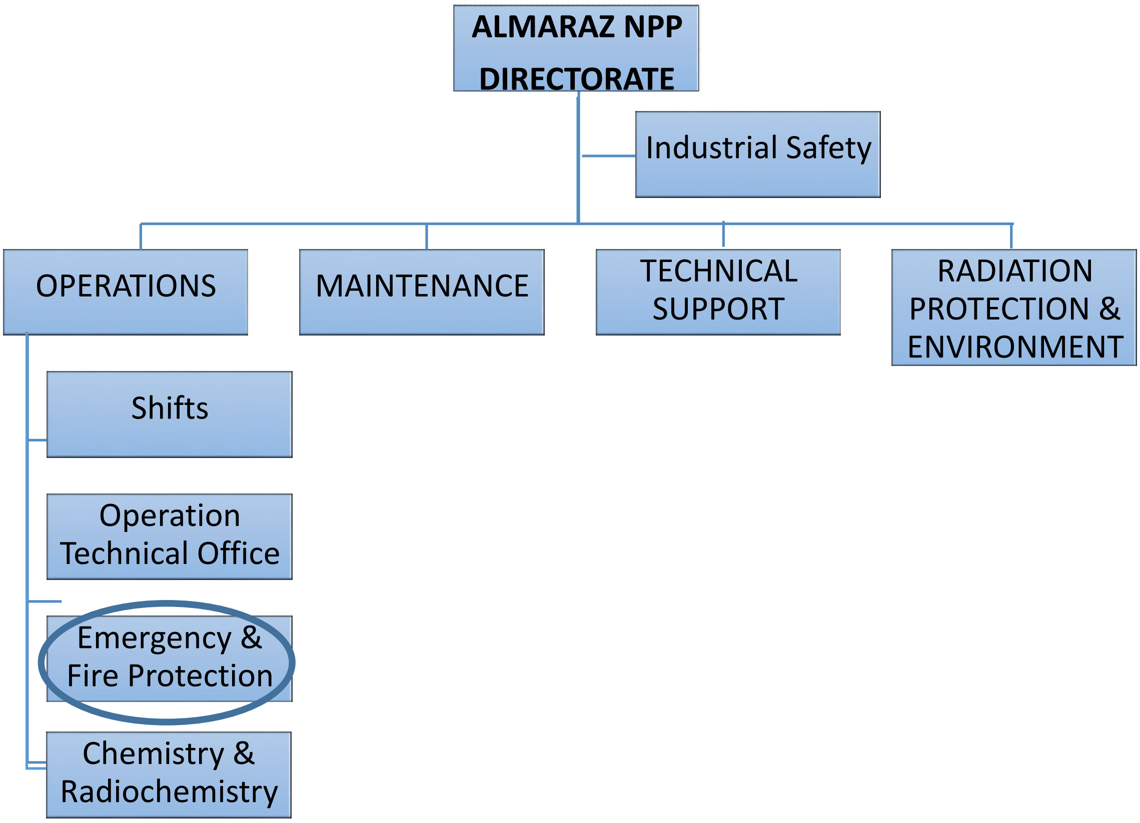
This section contains the description of the organisation of each plant in compliance with the WENRA reference levels SV 5.10, SV 6.11, SV 6.12 and SV 6.13 relating to the administrative and organisational aspects of fire protection.

The requirements to the Firefighting Organisation and fire brigade are set out in Article 3.7 of IS-30 [4] and paragraph 6 of SG 1.19 [29].

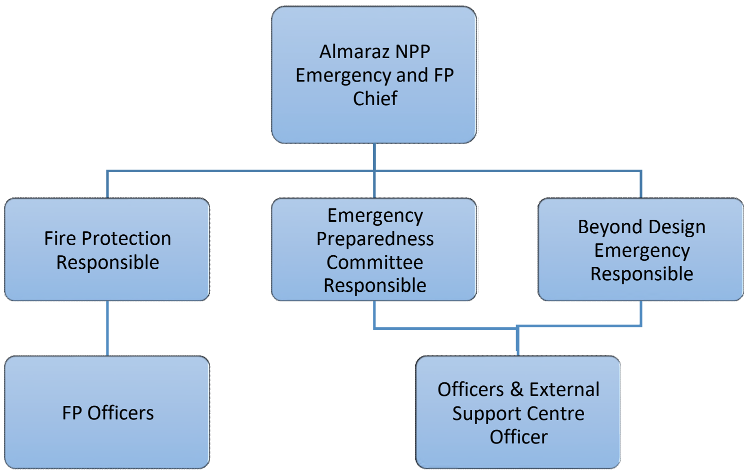
Organisation

1. Almaraz NPP

The FP organisation of Almaraz NPP is part of the Plant Operations Directorate, in accordance with the organisation chart of the Plant's Operating Regulations:



The composition of the Emergency Management and FP unit is presented in the Almaraz-Trillo Organisation Manual:



This unit is responsible for the maintenance of the FP Programme means and fire risk control activities, for which it has an external service that reports to the FP Manager.

In addition, firefighting activities are the responsibility of the Fire Brigade, as part of the Emergency Response Organisation.

The composition of the Fire Brigade is as follows:

- First intervention team. It is composed of the 5 professional firefighters on duty, one of whom is the Brigade Leader. This brigade is directly responsible for firefighting actions in the field. At least two members of each shift team must have sufficient knowledge of the plant and systems to be able to extinguish the fire without compromising and preserving safe shutdown capability.

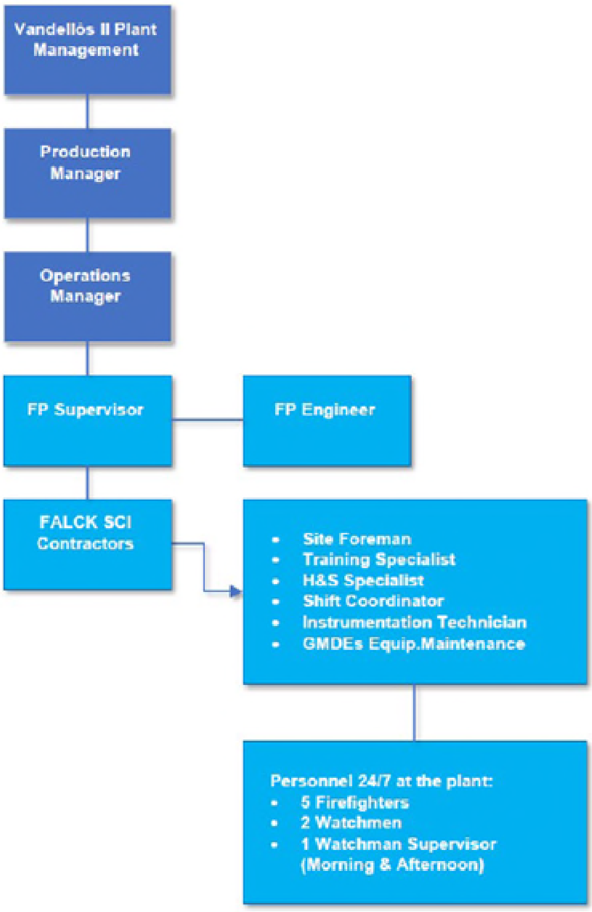
- Second intervention team. It is made up of staff on duty: Operating Assistants, Radiation Protection Technician Assistant, Chemistry and Radiochemistry Analyst. This brigade is responsible for providing logistical support in firefighting, performing the following tasks: deployment of portable equipment, including hoses, foam containers, nozzles, etc., identification of plant areas where action is required, securing access and escape routes, making the necessary alignments for the proper use of the FP system and other water sources, and other tasks of the same nature, on demand and always under the direction of the professional brigade on duty.

The first intervention team is covered by an external service, and reports organically to the Emergency Management and FP unit, i.e. in terms of management and maintenance of service qualifications. There are 6 teams of 5 firefighters, including the Brigade Leader, working 8-hour shifts, and there is also a backup team at all times, available at the site within one hour.

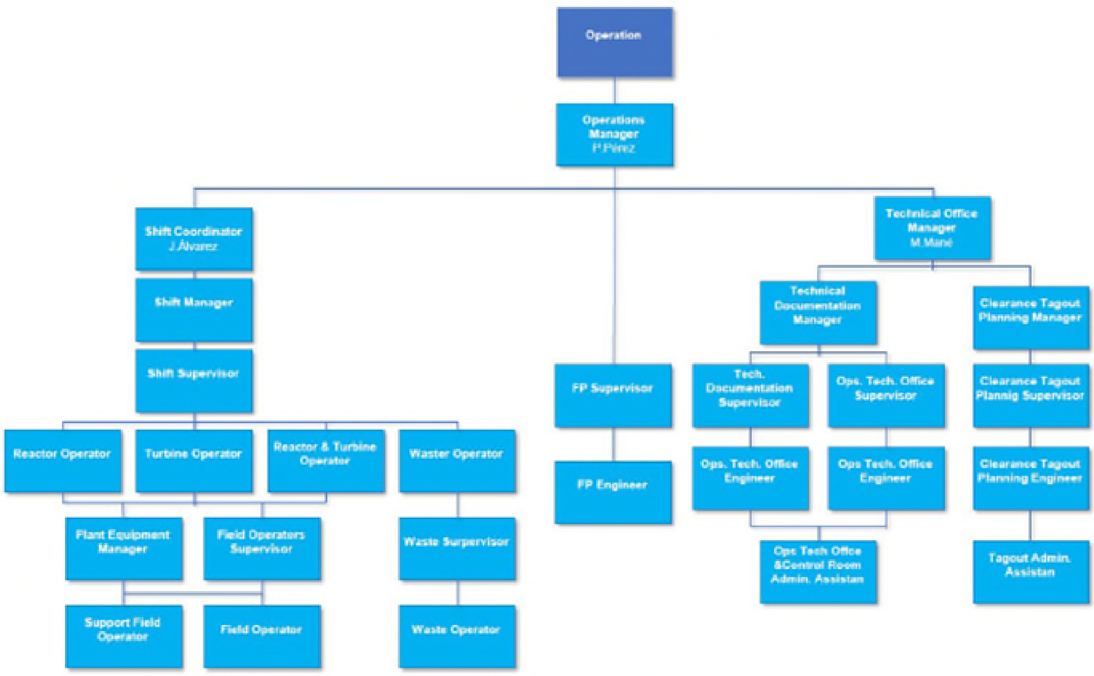
In addition, there is an agreement with the Provincial Firefighting and Fire Prevention Service of Cáceres (SEPEI), whose action would be carried out under the direction and supervision of the Brigade Leader and Shift Leader, and with the Military Emergency Unit, whose activation and actuation is regulated in the Extensive Damage Management Guidelines.

2. Vandellós NPP

The Fire Protection organisation is part of the Operations unit within the Vandellós NPP Management, and specifically belongs to the basic Operation unit in accordance with the organisation charts in the Organisation Manual.



The detailed composition of the Operation Unit is included in the Operation Organisation Manual, which presents the following organisation chart:



The FP section has at least 30 people dedicated exclusively to fire protection and prevention, with training in firefighting, with at least 5 people continuously present at the site.

Its activities are developed on the basis of the FPM criteria following the FP procedures set out in Annex III of the FPM.

The functions of the FP unit, in accordance with the Operating Regulations, are as follows:

- Manage the Fire Protection Manual.
- Control and maintain the Fire Protection System, including testing of the Fire Protection System.
- Respond to fire calls and alarms and implement protective measures where necessary.
- Support Operation in case of a fire alarm and in the management of fire work permits.

The Fire Protection Unit reports to the Shift Manager.

The Fire Supervisor is responsible for the entire unit, and is the person to whom a Fire Technician and the Fire Brigade report.

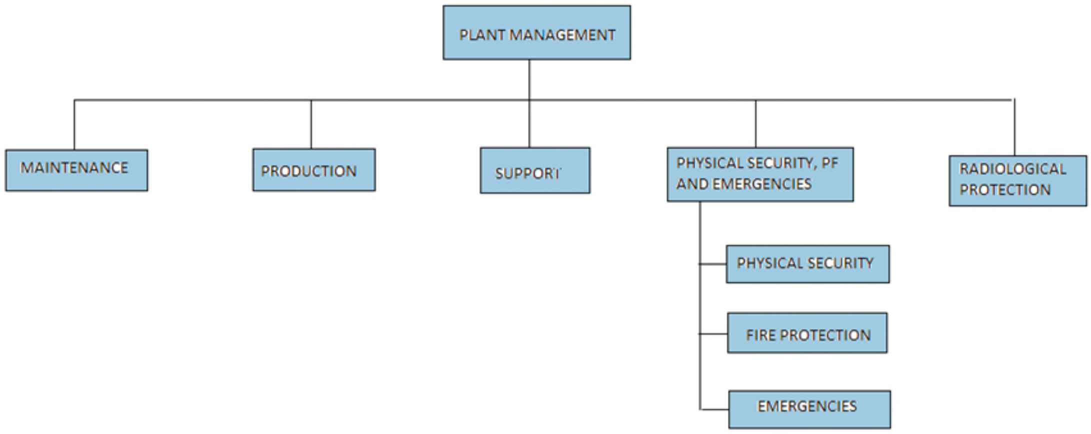
A specialised collaborating company is available for risk prevention, equipment and systems maintenance and for collaboration in firefighting.

The Fire Brigade is made up of five members, all of whom are firefighters: 1 Fire Brigade Leader, 1 Fire Officer, 1 Instrument Firefighter and 2 Firefighters

In addition to this Brigade, which is called the First Intervention Team, there is a Second Intervention Team, made up of personnel from the different services as indicated in the Interior Emergency Plan with sufficient training to support the brigade members in their duties and with training in firefighting, and a Third Intervention Team which is the Fire Brigade of the regional Generalitat as an external support organisation for firefighting. There is a procedure in place that contains guidelines and instructions for joint action by both organisations.

3. Cofrentes NPP

The Fire Protection Organisational Unit carries out its functions in coordination with Iberdrola's Corporate Security Division and is integrated into the organisational chart as follows:



The Fire Protection Manual details the functions and responsibilities of the Fire Protection Organisation (Fire Protection Organisational Unit and other Plant Units) with respect to fire prevention and protection.

The Plant Manager is responsible for the general Fire Protection Programme, delegating the development and implementation of the programme to the Fire Protection Organisational Unit.

The configuration of the fire brigade is as follows:

	MORNING	AFTERNOON	NIGHT	RINFORCEMENT	SURVEILLANCE
OPERATIONAL SERVICE	08:00-16:00h	16:00-00:00h	00:00-8:00h	8:00-16:00h (Weekdays only)	Timetable according to needs
	- 1 person in charge of Operational Service - 1 Brigade Commander - 1 1st Officer - 5 2nd Grade Officers	- 1 Head of Brigade - 1 1st Officer - 5 2nd Grade Officers	- 1 Head of Brigade - 1 1st Officer - 5 2nd Grade Officers	5 firefighters (Chief of Brigade, one 1st officer and three 2nd officers)	FP Watchmen
TECHNICAL SERVICE	07:30-15:00 h.				
	- 1 Technical Service Manager - three PCI Technicians				

The Cofrentes NPP has External Assistance for firefighting, made up of the Valencia Provincial Firefighting Consortium and the Military Emergency Unit. To ensure an adequate response of external assistance, specific training protocols, exercises and drills are provided as required in Article 3.7 of IS-30 [4] and paragraph 6 of SG 1.19 [29].

Procedures

1. Almaraz NPP

Procedures are in place for the operation of the firefighting systems, the performance of the fire brigade on suppression and rescue missions, the safe operation of the plant in a fire situation, the coordination of the support of the outside brigade, and general action in the event of a fire. In addition, procedures are in place in relation to the occurrence of forest fires and large fires (EDMG).

The full list is presented below:

- On-site Emergency Plan
- Firefighting
- Introduction to the operation of the central alarm station management system and the XLS80E central station for operating personnel in the event of various events in the FP system
- Fire Support Operation Guide
- Fire in Any Area of the Power planta
- Oil Leakage and/or Fire in the Turbine Building
- Pre Fire Plans by Zones
- Fire Brigade Organisation and Operations
- Mobilisation of the province public firefighting services
- Reception and action at the Almaraz NPP of the exterior public firefighting services.
- Rescue and life saving plans at Almaraz NPP
- Staff response to an emergency.
- Large Fire Fighting
- Forest fire prevention technical report

2. Vandellós NPP

Vandellós NPP has procedures in place to maintain the safety level of the Fire Protection Programme and to guarantee that, in the event of a potential fire in any fire area of the plant, safe shutdown can be achieved and maintained, minimising the possibility of radioactive releases to the environment. The following operating procedures are in place during power operation and during all plant operating modes:

- Vandellós II NPP On-site Emergency Plan.
- Large fires Firefighting Plan.
- Supervision of Fire Service Activities.
- Action guide for fire brigade interventions.
- Operator's manual actions at fires located outside the control room.

- Oil or hydrogen leakage which may cause fire or fire in turbine building equipment.
- Announcer - Fire services.
- Announcer - Firefighting pump "A" diesel engine.
- Announcer - Firefighting pump "B" diesel engine.
- Announcer - Firefighting pressure pump.
- Announcer - Firefighting electric pump.

In addition, to safeguard the people present in the plant buildings, the Building Evacuation procedure is in place for incidents not related to the OSEP.

3. Cofrentes NPP

In order to maintain the safety level of the Cofrentes Fire Protection Programme, and to ensure that, in the event of a potential fire in any fire area of the plant, safe shutdown can be achieved and maintained, minimising the possibility of radioactive releases to the environment, the following operating procedures are in place during power operation and during all plant operating modes.

- Failure of the fire protection system. The actions to be taken in the event of a FP system failure coinciding or not with an actual fire are set out.
- Procedure for action in the event of fire. It sets out the actions to be taken in the event of a confirmed fire. It also takes into account the possibility of the FP water system causing flooding and thus requiring the use of the pipe rupture procedures.
- Fire coinciding with earthquake. The actions to be taken in the event of a confirmed fire coinciding with an earthquake are established. It also takes into account flooding by the FP water system causing flooding, and thus requiring the use of the pipe rupture procedures.
- Shutdown from remote shutdown panel. Actions are established to bring the reactor to Cold Shutdown in case of Control Room abandonment.
- Forest fire operation. It sets out the actions to be taken in the event of an uncontrolled forest fire in the vicinity of the site.
- Large Fire Mitigation Guide. Defines the organisational system and mitigation actions to be taken after a major fire.
- Procedure for action in forest fires. The organisational system and the actions to be taken in the event of a forest fire in the vicinity of the plant restricted area are defined.
- Activation and action of the firefighting organisation. It sets out the roles and responsibilities of firefighting personnel.
- On-site Emergency Plan. Develops a plan to ensure adequate emergency response.

- Extensive damage mitigation guidelines. Sets out instructions to be used in case everything described in the EOP/SAG and SBO instructions are not sufficient to manage the accident. The EDMGs consider alternative alignments and use portable means.

Training

The specific training is that required by Article 3.7 of IS-30 [4] and paragraph 6.4 of SG 1.19 [29] and is performed as set out in the following procedures.

1. Almaraz NPP

At Almaraz NPP, global FP training covers the following aspects:

- Organisation of the FP at Almaraz NPP: missions and responsibilities of each of its components.
- Applicable standards and regulations, TRM, etc.
- Fire theory and suppression systems.
- Fire hazards and protective measures.
- Plant FP systems and barriers.
- Programmatic controls for fire prevention (control of fire risk works, storages, loss of functionality of systems and barriers).
- Firefighting.
- Behavioural expectations regarding FP systems and barriers.

Each of these aspects applies to the following groups, in greater or lesser detail, depending on their specific responsibilities: first intervention team, second intervention team and other personnel.

The training programme (initial and continuous) in FP is defined, for each of these groups, in the corresponding document, as well as in the FP accreditation and retraining manuals.

The training of Control Room staff and Fire Protection Programme staff is defined in the relevant specific accreditation and retraining manuals.

Personnel assigned to the fire brigade must undergo theoretical and practical training in FP before joining the brigade, as well as continuous training. In addition, at least once a year each member of the brigade must undergo practical training in firefighting methods with the use of protective equipment.

The physical training of the members of the FP brigade is included in the Training programme of the first intervention team, which defines the specific FP training programme for professional firefighters and requires succeeding in the physical tests included in SG 1.19 or those reflected in CSN/ITC/SG/AL0/20/05 [20].

2. Vandellós NPP

The FP training programme is defined in the procedure Personnel training and education in firefighting and rescue and its objective is to establish a periodic training and education programme for the operating personnel, personnel of collaborating companies and the professional fire brigade of the collaborating company, to ensure the effectiveness of fire protection and rescue with the means available at the plant, during normal operation and shutdowns, both for refuelling and maintenance.

The training consists of basic initial training and differentiated continuous training for first and second intervention teams.

Basic initial training includes the following aspects:

- Basic Firefighting Knowledge
- Use of Firefighting Equipment
- First Aid, Life Saving and Rescue
- Automatic Detection and Suppression Systems
- Instrumentation applied to Fire Protection
- Nuclear Power Plant Systems applied to Fire Protection
- Initial training of the Fire Instrumentation expert
- Specific intervention procedures of the FP Brigade
- Firefighting Practices
- Leadership and Fire Emergency Management
- Extensive Damage Mitigation Guidelines.
- Firefighting Operational Experience

The continuous training for the first intervention team is a 4-year cyclical training in which all members will receive the same content including theoretical classes, practical classes and drills. In order to maintain the qualifications of the first intervention team, in addition to continuous training, it will be necessary to pass the physical tests described in the CSN/ITC/SG/VA2/20/01 on the tests to meet the physical fitness requirements of the members of the fire protection brigade [20]. The Fire Protection Service shall send an annual report on the results of these tests to the training unit.

The continuous training for the second intervention team is a 4-year cyclical training that includes theoretical classes, practical classes and drills. Operational RP personnel on closed shifts, as well as RP monitors in OSEP's emergency response team, are not part of the second intervention team. However, in a fire emergency in a radiological area or potentially radioactive areas, they have to carry out their work in support of the Brigades, so they are required to undergo periodic training together with the latter, as well as regular practice in approaching the flame. RP staff: ALARA and closed shift technicians, as well as RP monitors will carry out, biennially and in addition to the above, a theoretical and practical training on the use of self-contained breathing apparatus (SCBA) and other breathing equipment. This course will be attended, every four years, by chemistry staff on closed shifts.

3. Cofrentes NPP

The applicable procedure is that of fire protection education and training for the personnel of the Cofrentes NPP.

The aim of this procedure is to establish the levels of training and the content of the training and education in fire protection and rescue, which must be received by personnel belonging to Cofrentes NPP, promoting a culture of safety.

This procedure does not apply to the training of the professional fire brigade of the the plant (Fire Protection Brigade). Their training is governed by their own specific annual Training Plan and Programme, in order to meet the requirements of IS-30.

External assistance (Valencia Provincial Fire Brigade Consortium and the Military Emergency Unit) will have specific protocols for training, exercises and drills.

Training plan and annual programme

Every year, the Fire Protection Brigade's specific practical training programme is published, which lists the courses to be carried out during the year, relating to on-site firefighting, forest firefighting, accident rescue, first aid, extrication and dangerous goods.

The scope of fitness-for-duty programmes, competencies, training and retraining are commensurate with the potential risks of the installation.

Drills

The drills are those required in Article 3.7 of IS-30 [4] and section 6.4g) of SG 1.19 [29] and are performed as detailed in the following sections at each plant.

1. Almaraz NPP

The applicable requirements, and the objectives of the FP drills and exercises are defined in the FPM. An annual programme of exercises and a report with their evaluation, lessons learned and areas for improvement, together with a corresponding action plan, is prepared every year.

An annual simulation exercise is carried out with the participation of external public fire brigade.

In the case of On-site Emergency Plan drills, they may include a fire scenario and their associated report is evaluated by the Nuclear Safety Committee of the Plant.

One of the four quarterly exercises will always correspond to the deployment of an extensive damage mitigation strategy.

It is common practice to observe a mock evaluation in NEIL assessments and WANO Peer Reviews.

A fire training camp is available on the site, with the necessary means to provide theoretical and practical firefighting skills, under conditions similar to those expected on site.

2. Vandellós NPP

Vandellós NPP also complies with the applicable requirements. The objectives of the drills and FP exercises are defined in the procedures *Education and training of personnel in firefighting and rescue*, *Annual Continuous Training Programme* and *Emergency Training and Education*. An annual programme of exercises and a report with their evaluation, lessons learned and areas for improvement, together with a corresponding action plan, is prepared every year.

Drills are carried out at regular intervals not exceeding three months and so that each member of the brigade participates in at least two drills per year.

At least one drill per year shall be unannounced and rotated so that each year it is conducted on a different shift of the brigade. Persons planning and authorising an unannounced exercise should ensure that the members of the brigade shift concerned are not aware that the exercise is being planned until it begins. Such unannounced drills should not be scheduled at intervals of less than four weeks. Every three years, one of these exercises, chosen at random, shall be evaluated by qualified personnel independent of the plant. It is also common practice to observe a mock evaluation in NEIL assessments and WANO Peer Reviews.

At least one drill is conducted jointly with the second intervention team.

In addition to these two drills, at least one drill is conducted annually for a shift in conjunction with the local fire department.

3. Cofrentes NPP

In compliance with the requirements established in S-30, and so that the brigade can practice as a team, fire drills are carried out at the plant at regular intervals, not exceeding three months, so that each member of the brigade participates in at least two drills per year. At least one drill per year is unannounced and rotated, so that each year it takes place on a different shift of the brigade. In addition, one drill per year is carried out by the second intervention or support fire protection team. And at least one of the annual drills involves the participation of external public fire brigade, in order to obtain adequate coordination between plant personnel and external resources.

Cofrentes NPP carries out annual drills for the activation of the On-site Emergency Plan, in which it is possible that firefighting action may be required, and in which the fire protection organisation is therefore activated.

The drills are evaluated by the Nuclear Safety Committee of the plant. An unsatisfactory outcome will require its repetition.

Drills, emergency drills and training reinforce the safety culture.

Records of drills, training, retraining and practical exercises are archived for at least 5 years.

A training camp is available for training and for carrying out some of the simulations. Both the plant's own brigade and the external public brigade are trained in it, which facilitates the familiarisation of the external support with the plant's hazards, the way to act and the resources available to the internal brigade.

Having this training and practice area was considered a strength in the Periodic Safety Review conducted for the long-term operation.

Provincial fire brigade

The Spanish nuclear power plants have protocols for collaboration with the provincial fire brigade in accordance with Article 3.7.5 of IS-30.

1. Almaraz NPP

Almaraz NPP has the following procedures for the coordination of the external public fire brigade intervention in case of fire, as well as for the maintenance of its adequate training:

- Coordination of the intervention:
  - Mobilisation of the external public firefighting services.
  - Reception and action at the Almaraz NPP by the external public firefighting services.
  - Radiation protection at Almaraz NPP for the personnel of external emergency support groups
  - Management of rapid access to Almaraz NPP by off-site emergency support groups
- Maintenance of training:
  - Training, Exercises and Drills for the external public firefighting support groups.

2. Vandellós NPP

The external public Fire Brigade constitutes the third intervention team, as an external support organisation for firefighting. In the Guide: Procedure for joint action of the external and internal firefighting organizations, the guidelines and instructions for this joint action are included. This guide includes the following procedures:

- Request for assistance.
- Reception of Assistance and Operation of the Mobile Command Center.
- Coordination in intervention.
- Radiation protection for intervention personnel.
- Response capability.
- Training, Practices and Exercises Procedure.
- List of Intervention Materials and Inventory Check-up.

3. Cofrentes NPP

Cofrentes NPP has the following procedures:

- External public fire brigade mobilisation procedure.
- Reception and action of the external public fire brigade at Cofrentes NPP, for interventions requiring external support.
- Radiation protection procedure for outside intervention personnel.
- Training procedure, exercises and simulation.
- Procedure for supporting the actuations.

03.2.1.3.3 Specific provisions, e.g. loss of access

At each of the Spanish plants there is a fire protection brigade for firefighting as established in Article 3.7 of IS-30 [4] and SG 1.19 [29].

The brigade is organised, trained and equipped to deal with the emergency in case of loss of access to the facilities, and therefore of the external assistance.

1. Almaraz NPP

Almaraz NPP has a permanent FP brigade at the site, as well as an initial response guide in the event of loss of large areas due to a major fire. The loss of normal access to the plant is envisaged, and alternative routes are provided for, in the procedures applicable to the case.

Both the initial response guidance and the alternative access routes to the site were developed as a consequence of the issuance of the post-Fukushima CTIs: CTI-1: CNALM/AL0/SG/11/03 and CTI-2: CNALM/AL0/SG/11/15 [23].

In the existing procedures, a preventive activation of the backup team of responders prior to the loss of accessibility is envisaged, which would include the backup staff of the internal FP brigade. In the event of an emergency with effective loss of accessibility to the site, the support of the State Security Forces and Corps, as well as the Military Emergency Unit, may be requested.

Almaraz NPP has signposted escape routes. They are reflected in the Pre fire plans, and in the Fire Areas and Fire Zones Plans of the Fire Hazard Analysis. For each zone, at least two evacuation alternatives are defined, except in cases where this is not possible or not required by the regulations due to the configuration of the zone.

In the event that an area of the plant needs to be evacuated in an emergency situation due to fire or any other cause, the corresponding orders are sent out over the internal public address system.

2. Vandellós NPP

In relation to the development of mitigation strategies to respond to events beyond the design basis related to the potential loss of large fires, Vandellós NPP has the procedure *Large Firefighting Plan*, which defines the organisational system and the human and material resources necessary to carry out mitigation actions, in response to the CTI-1 (CNVA2/VA2/SG/11/06) and CTI-2 (CNVAN/VA2/SG/11/14) [23].

Prior to the application of the previous procedure, as described in the Procedure for actions of the Fire and Rescue Brigade of Vandellós II NPP, when a fire is declared, an assessment of the scenario will be carried out between the Brigade Chief and the Assessor. This analysis should classify the fire into one of 3 levels according to its severity and the resources required. The 3 levels define the organisation chart and coordination during the intervention according to its severity.

The actions to be taken by personnel inside buildings on the Vandellós II NPP site in the event of an event requiring their evacuation, provided that the emergency does not activate the On-Site Emergency Plan in the "Emergency Alert", "General Emergency" or "Site Emergency" phases, are carried out in accordance with procedure PA-316 Evacuation of Buildings due to incidents not related to the OSEP.

In order to facilitate the evacuation of buildings in the event of fire or emergency, Vandellós NPP has adequate signage defined in the procedure Fire Prevention Signage and always located in a clearly visible place, of the existing escape routes, both main (shortest) and secondary (alternative to the main route). These signs indicate the accesses provided as emergency exits from the different buildings or cubicles in the event of fire, as well as the exits that should not be used in the same situation, due to the risks involved. Also included in this section are signs indicating special ways of opening doors in case of emergency (panic bars, push buttons, etc.), location of escape gas masks, emergency evacuation transport elements (rescue stretchers, etc.), etc.

Emergency exits and evacuation routes are marked on the floor with signs on walls and doors (vertical signage), and with lines and arrows on the floor (horizontal signage), indicating evacuation directions.

Escape routes are reflected in the Pre fire plans, and in the figures of the Fire Hazard Analysis (Appendix 9.5B to the SAR).

It is also planned to receive assistance from the Emergency Military Unit (EMU) for the transfer of external resources, both human and material, to the plant via the aerial evacuation platform located in the vicinity of the safe area, in accordance with the following extensive damage mitigation guidelines:

- Procedure for notifying the military emergency unit.
- Procedure for intervention of the emergency military unit inside the nuclear power plant.

3. Cofrentes NPP

In the event of a large fire affecting large areas, in accordance with the requirements of the CTI in relation to the development of mitigation measures to respond to beyond design basis events related to potential losses due to large fires (CTI-1: CSN/COF/COF/SG/11/06 and CTI-2: CNCOF/COF/SG/11/07 [23]), Large Fire Mitigation Strategy is available, which defines the organisational system and the human and material resources needed to carry out mitigation actions.

The On-Site Emergency Plan (OSEP) is also available, consisting of several documents including the following:

- Alternative external routes. The aim of this procedure is to identify alternative external access routes to the Cofrentes NPP site and their viability in the event of extreme events such as earthquakes and flooding.

- Rapid access to the plant of external support organisations. Describe the procedures for rapid access to and exit from the NPP facilities of the External Emergency Support Organisations, both for their personnel and their vehicles and working resources.

The Pre fire plans identify the accesses to buildings that may be used by responders in the event of a fire or emergency.

The Escape routes procedure is also available

The definition of escape routes is set out in the plans FP Fire areas and zones - Escape routes - General arrangement.

To facilitate the evacuation in the event of fire or emergency, the plant has adequate signage, always in a clearly visible place, of the existing escape routes, both main (shortest) and secondary (alternative to the main route).

Emergency exits and evacuation routes are marked on the floor with signs on walls and doors (vertical signage), and with lines and arrows on the floor (horizontal signage), indicating evacuation directions.

Whenever it is necessary to evacuate plant buildings due to a fire or emergency, all personnel will be informed via the internal public address system of the plant.

Once notification to evacuate has been given, all personnel working in the affected area or building shall proceed to the nearest exit without delay, leaving their workstation safely, except for personnel assigned to an emergency strategy (Procedures *Activation of the Emergency Plan* and *Activation of Organisations*) or firefighting activity (Procedure *Activation and Action of the Firefighting Organisation*).

03.2.1.4 Licensee's experience of the implementation of active FP

Nuclear power plants are subject to different assessments by various independent organisations. Inspections are carried out by WANO, the insurance company (NEIL), and the regulatory body (CSN).

WANO sets guidelines for plant performance to promote excellence in the operation, maintenance and management of nuclear power plants, and therefore publishes the WANO "PO&C" document, which is the World Association of Nuclear Operators (WANO) standard of nuclear excellence.

Performance targets help to achieve a set of results that reflect excellence in the important aspects of nuclear power plant operation. These outcomes include maintaining high levels of performance, event-free operation, avoidance of long-term unscheduled outages, safety, well-managed design and operating margins, high levels of worker safety, highly skilled and trained personnel, and preparedness to respond effectively in an emergency situation.

All these objectives are assessed by WANO during inspections.

NEIL provides general guidance and instructions to insured companies in the areas of assessment, design reviews and inspection of equipment at the insured plants. Areas where periodic plant inspections are carried out.

In addition, as a result of the adaptation processes to IS-30 rev. 2 as well as improvements resulting from external inspections, various plant improvements have been carried out in recent years.

The strengths and weaknesses identified through the different assessments carried out at the Spanish nuclear power plants in the area of fire protection and the actions derived to address these areas for improvement are indicated below.

03.2.1.4.1 Overview of strengths and weaknesses

All the Spanish plants have a seismic FP system in addition to that required in section 3.4.8 of IS-30, which requires a seismic suppression subsystem capable of supplying water to the equipped fire hydrants of those fire areas containing equipment necessary for the safe shutdown of the plant in the event of a safe shutdown earthquake (SSE). The FP seismic subsystems installed at the Spanish plants have been analysed to fulfil their function in the event of an earthquake of an intensity corresponding to a seismic margin earthquake SME of 0.3 g (see section 03.2.1.2.2.2).

All Spanish nuclear power plants have a professional fire brigade of at least 5 people permanently on site. Such a fire brigade must be trained and educated and their physical fitness must be periodically tested in accordance with the Complementary Technical Instruction on testing for compliance with the physical fitness requirements for members of the fire protection brigade issued by the CSN to all plants.

1. Almaraz NPP

In the third PSR, Almaraz NPP identified two strengths and one area of improvement:

Strengths:

- Integrated Emergency Preparedness Organisation: The Almaraz NPP organisation promotes the correct monitoring of the emergency preparedness programme and continuous improvement in this field through the integrated Emergency Management and FP section (which also includes the accident management programme) and the Emergency Preparedness and Management Committee.

  Justification: The integration of the three areas (emergency management, accident management and fire protection) allows for joint monitoring and consistency in the interfaces and contents of the different programmes; the committee establishes a link between the emergency preparedness team and the global management of the plant for the identification of weaknesses and the analysis of action plans.

- Provision and signalling of connections for EDMG strategies: Several connections are available for the implementation of each EDMG strategy, identified with pink colour.

Justification: The redundancy in the number of connections available for each strategy increases the likelihood that one will be available in a situation of extensive damage, and the pink colour allows these connections to be easily identified.

Area for improvement:

- Storage EDMG equipment: The EDMG equipment is stored outdoors, so weather protection was considered as a means to improve its availability and thus the plant's response capacity in case of need. A protective canopy has been installed to protect the equipment.

2. Vandellós NPP

In the third PSR, Vandellós NPP identified the following strengths and areas for improvement:

Strengths:

- Vandellós II NPP has maintenance and prevention plans to minimise the consequences of an external fire.

  There is a Plan for the Prevention of Large Forest Fires for the Vandellós NPP site and a Three-Year Plan for the maintenance of the power lines of the Vandellós II nuclear power plant (2017-2019). These plans contain an analysis of the applicable regulations and an action plan for cleaning and clearing areas adjacent to the site to minimise the possibility of damage due to external fires, which go beyond what is strictly required by the applicable regulations.

- Procedures have been modified to avoid the discharge of the fire system in unplanned situations.

  The procedures that have been modified to prevent damage to safety important equipment due to the operation of the firefighting system are:

  - Disassembly, surveillance and reassembly of the charging pumps to include major manipulations, in connection with an event, in which the fire protection system detection in the train A charging pump room was activated as a result of smoke due to a rupture in the oil circuit of the pump.

  - The instructions of the Visual Inspection Procedure for water and water-foam systems have been modified to avoid an erroneous manual actuation, due to an event in which the manual valve of a manual station was manipulated, causing the electric pump to start up. This resulted in a discharge from the spray nozzles in the equipment unloading area of the Turbine Building.

Area for Improvement:

In the review of compliance with SG 1.19, Vandellós NPP identified the following area of improvement:

- Three access doors to rooms protected by gas suppression systems without periodic condition monitoring.

In accordance with paragraph 8.1.5 of SG 1.19, doors to areas protected by gas systems shall be closed and electrically supervised.

At Vandellós NPP, this is implemented in an equivalent manner through the application of the procedure for checking that fire doors are closed and locked, which is applied on a weekly basis. However, 3 access doors to rooms protected with FE-13 systems have been identified, to which this procedure does not apply as these three doors are not fire barriers.

It was proposed as an improvement to periodically check the condition of these three additional doors. The corrective action was implemented in May 2020.

3. Cofrentes NPP

The strengths and areas for improvement identified in the PSR assessment are listed below.

Strengths:

- Fire Protection training area.

  Cofrentes NPP has a training area, highly valued in the inspections carried out by external organisations, where the brigade and all plant personnel are trained.

  The facilities consist of a permanent staff office, changing rooms, theoretical training room, practical training room, live fire practice areas and indoor fire area.

  The availability of these facilities has made it possible to guarantee high quality training in fire protection for all personnel with a wide variety and realism of fire scenarios, and to allow excellent coordination with the external support groups (external public fire brigade, EMU, etc.).

- Resourcing of FP and reinforcement of external support through partnership agreements.

  The fire protection brigade has expanded its fleet of vehicles in order to be able to deal with fires and major disasters. It currently has the following vehicles: 4x4 light intervention vehicle equipped with a pumping system, water and foam tank, heavy intervention truck with variable pumping unit with water and foam tank, 4x4 light intervention vehicle for the transport of materials and personnel, light intervention vehicle for the transport of personnel and light intervention vehicle for the transport of materials and personnel and equipped for the establishment of an advanced command post. In addition, there is a light trailer with emergency lighting and intervention equipment and a foam trailer equipped with two tanks, a foam dispenser and medium and low expansion nozzles.

  In March 2013, the protocol that establishes the framework for actuation between the Government Delegation in the Valencian Community, the Regional Ministry of Governance and Justice, the Cofrentes Nuclear Power Plant and the Valencia Provincial Firefighters' Consortium was renewed to guarantee the efficient and safe action of the external public fire brigade within the scope of its competencies (fire extinction, rescue and collaboration in prevention and training activities). With regard to the actions aimed at improving the intervention capacity of the external public fire brigade in the specific aspects of the plant and their coordination with the plant's personnel, the joint training programme, should be highlighted, which includes initial training, retraining and the performance of joint exercises and drills.

Areas for improvement:

In the third PSR in relation to design aspects, the following areas for improvement were identified and are currently implemented:

- Enhancement of the suppression system in diesel generator rooms.

  Installation of a system to protect generator control panels by means of a gas suppression system that is activated by an incipient detection system.

- Inclusion of instrumentation that could be lost in the event of fire in the Pre fire plans.

  Modification of the procedure to include the instrumentation to assist operation in the event of a fire.

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

1. Almaraz NPP

In the last WANO Peer Review, held in January 2020, no Area For Improvement (AFI) related to the areas of Fire Protection and Fire Safety was identified. Best practices related to these areas were also not identified.

In NEIL's latest inspections (October 2021, March 2023) no non-compliances ("shall", "should") have been identified and there are currently no non-compliances with pending assessment or resolution.

Currently, the possibility of improving the preventive maintenance of the detection is being analysed, in order to minimise corrective spurious actions or anomalies (Engineering, Electrical Maintenance).

Results derived from the NFPA 805 transition project. In the framework of the transition to NFPA 805, the following improvements related to fire suppression were implemented, mainly due to the adaptation to NFPA 805 Chapter 3:

- Automatic pre-action sprinkler system on the FP diesel pump.
- Modification of the hydrant near one of the diesel tanks to prevent the main (water system with foam concentrate) and back-up (hydrant) systems from being out of service due to maintenance simultaneously.
- Modification of the hydrant near a start-up transformer to prevent the main (water spray system) and backup (hydrant) from being out of service due to maintenance simultaneously.
- Installation of Novec 1230 gas suppression systems in cables in the raised floor and false ceiling of the computer room in the control room, as well as in vertical conduits between the raised floor and false ceiling of the control room.
- Double FP connection in containment and in the essential services gallery.

- Incorporation of actuation signals in various FP systems.
- The water supply to the FP System inside the containment building was changed from the demineralised water (DW) system, to the fire protection (FP) system loop.

2. Vandellós NPP

The publication of IS-30 has led to a review of the compliance with the established aspects of defence in depth, both from the point of view of the available analyses and the adequacy of the design.

This review has led to the establishment of an adaptation programme that complements design improvements with requests of regulatory approval of alternative measures where design modifications are unfeasible and the impact of maintaining the current configuration is acceptable. The following actions to reinforce the design of the detection and suppression systems, as well as those relating to improve de development of strategies in the event of fire (emergency lighting and communications), are highlighted:

- Installation of automatic suppression system in 4 fire areas with electrical equipment in the Auxiliary building,
- Implementation of autonomous emergency lighting with 8h additional battery back-up time (EJ gallery and areas where OMAs are planned).
- Improvement of FP water supply capacity by installing two additional tanks to the existing ones, in order to comply with IS-30.
- Installation of an additional hydrant in the Turbine Penetrations area to meet the criteria on the maximum allowed distance between hydrants.
- Fire detection installation with coverage over safety important SSCs (EDG inlet filter area).
- Modification of communications through the implementation of the necessary infrastructure to provide indoor radio system coverage to all building locations in the power block

Within the framework of the post-Fukushima actions, the analyses and actions carried out to provide a seismic margin for the equipment necessary to mitigate the fire and also for those that could potentially cause fires and explosions stand out. Also noteworthy is the preparation of the *Large Fires fighting Plan*, the purpose of which is to establish the organisation and mitigation actions to be followed in the event of an explosion or a large fire generated by large thermal loads originating outside the Vandellós II NPP site. Finally, many other prevention and action plans have been improved.

In the last two WANO Peer Reviews, held in 2018 and 2023, no AFIs related to the areas of Fire Protection and Fire Safety were identified. Best practices related to these areas were also not identified.

In the NEIL assessment that took place in November 2021, no risk scenarios were identified; however, some observations were made that have led to actions in the Problem Identification and Resolution Programme:

- Execute flow and pressure test on hydrants and FHCs of the FP system in outdoor areas protecting the area outside of the restricted area and modify the procedures to establish such flow and pressure tests on a regular basis. Action implemented.

- Periodic review established, that according to NEIL standards should be every 6 months, of the portable air conditioning equipment in the hot lab to check that the equipment has not been tampered with and maintains its manufacturing characteristics, the wiring is not damaged, there is no overheating and the manufacturer's maintenance recommendations are followed. Action implemented by incorporating a weekly inspection of the portable cooling equipment of the Hot Laboratory into the applicable procedure, with the following scope: General condition, cleanliness, state of the electrical connections and the extraction tube.

The NEIL assessment conducted in May 2023 also did not identify any risk scenarios. The implementation of the actions derived from the previous one was checked and areas for improvement were proposed to be incorporated in the test procedures of the FP pumps, in order to increase the frequency of the automatic start-up test according to NEIL standards, and to improve the test procedures for flow rates and pressures of the FP water distribution loop. In both cases these are improvements that will be assessed taking into account that they are above and beyond what is required in the TS of plant operation.

As a result of our own operational experience, two areas for improvement have been identified within the scope of the 3rd RSP, which have already been described in the previous section.

3. Cofrentes NPP

As a result of the processes of adaptation to new regulations, as well as improvements derived from external inspections, the following improvements have been carried out in recent years or will be carried out in the future:

Following the 2019 WANO Peer Review, the Fire Protection Water System Health report was produced. Maintenance job scheduling has been improved to group jobs on the same system, leaving systems inoperable as few times as possible. In addition, the trend of operability is currently being analysed in the FP committee.

No improvements were identified by NEIL at Cofrentes NPP in the active protection area.

Following the last PSR, a gas suppression system, activated by an incipient detection system, has been installed in the control panels of the diesel generators of the three divisions.

In addition, in 2023, the FP system will be extended to outdoor areas within the restricted-access area:

- Installation of an additional connection to feed the FP truck.

- Installation of an additional fire hydrant a vehicle exit.

As a consequence of the edition of IS 30 and its subsequent revisions, Cofrentes NPP has carried out an exhaustive review of its FP system to comply with the requirements of the aforementioned instruction.

In order to comply with point 3.4.1, two design modifications were implemented for the detection and alarm systems. In the first one, for ease of maintenance, boxes were installed attached to several FACP to contain the signal transducers and fibre optic converters and the autonomy of several FACP was also improved. In the second one, fire detection was improved in several areas of the plant. The implementation of these changes was completed in December 2016.

In order to comply with point 3.4.8, regarding the capabilities of the FP water system in case of SSE, through three design modifications, a seismic subsystem was installed, capable of supplying water to the equipped FHC of those fire areas containing equipment required to perform the safe shutdown of the plant. The implementation of these changes was completed in March 2017, February 2017 and February 2012.

In order to comply with point 3.4.9, relating to emergency lighting and access and escape routes, through design modifications, self-contained emergency lighting units with individual batteries of at least 8 hours autonomy were installed in the areas where manual operator actions are performed in case of fire and on the access routes to these SSCs. The implementation of these changes was completed in October 2015 and December 2016.

In order to comply with point 3.4.10 relating to the communication system, an emergency two-way communication system was installed, independent of the normal system and reaching all areas of the plant with safety important SSCs.

In order to comply with point 3.4.13, regarding the requirements for the detection and suppression systems, compliance with these requirements was verified and a design modification was carried out to comply with them.

03.2.1.4.3 Overview of actions and implementation status

1. Almaraz NPP

As part of the change of licensing basis to NFPA 805, the following fire suppression related improvements have been implemented as of the date of this report:

- Automatic pre-action sprinkler system on the FP diesel pump.
- Modification of the hydrant near one of the diesel tanks to prevent the main (water system with foam concentrate) and back-up (hydrant) systems from being out of service due to maintenance simultaneously.
- Modification of the hydrant near a start-up transformer to prevent the main (water spray system) and backup (hydrant) from being out of service due to maintenance simultaneously.
- Installation of Novec 1230 gas suppression systems in cables in the raised floor and false ceiling of the computer room in the control room, as well as in vertical conduits between the raised floor and false ceiling of the control room.
- Double FP connection in containment and in the essential services gallery.
- Incorporation of actuation signals in various FP systems.

- The water supply for FP system inside the containment building was changed from the demineralised water system to the fire protection system loop.

2. Vandellós NPP

On the date of this report, all the actions and design modifications mentioned in the previous section have been implemented:

From NEIL:

- Procedures for periodic pressure and flow testing of the fire protection system outside the restricted-access area.

- Procedure for weekly inspection of portable air conditioning equipment in the hot laboratory.

All are in place except for the possible improvements in procedures identified in the evaluation conducted in May 2023.

From the IS-30:

- Installation of automatic suppression systems in 4 fire areas with electrical equipment in the Auxiliary building

- Implementation of autonomous emergency lighting with additional 8 h battery autonomy (EJ gallery and areas where OMAs are carried out).

- Improve the FP water supply capacity by installing two additional tanks to the existing ones, in order to comply with IS-30.

- Installation of an additional hydrant in the Turbine Penetrations area to meet the requirement on the maximum allowed distance between hydrants.

- Fire detection installation with coverage over safety important SSCs.

- Modification of communications through the implementation of the necessary infrastructure to provide indoor radio system coverage to all building locations in the power block.

Only one request for a regulatory approval of equivalent compliance submitted in December 2022 is under evaluation by the CSN. This request stems from the latest revision of the analysis of compliance with Annex A.7 of IS-30 required by the CSN (CSN/C/SG/VA2/21/05) [125] in relation to the following aspects:

- cable trays required for safe shutdown that have the potential for exposure to fire from low voltage cabinets protected by detection and FHC rather than automatic systems;

- coincidence of conduits with redundant train safety-related cables, complying with RG 1.75 [93], protected by detection and FHC instead of automatic systems; and

- absence of fire detection in safety important SSCs located in fire load free zones in outdoor areas.

3. Cofrentes NPP

At the date of this report, all the actions and design modifications mentioned in the previous section are in place, except for the one described below that is planned for 2023:

Improvements derived from the WANO Peer Review:

- The Fire Protection water system health report was carried out annually.
- The planning of maintenance work has been improved.

PSR-derived improvements:

- Modification already implemented of the gas suppression system in the control panels of the diesel generators of the three divisions.
- Improvement of the FP system in outdoor areas within the restricted area: Implementation is planned for 2023.
- The *Fire Action Procedure* has been modified to include instrumentation that could be lost in the event of a fire.

Improvements resulting from the implementation of IS-30:

As a consequence of the edition of IS 30 and its subsequent revisions, Cofrentes NPP has carried out an exhaustive review of its FP system to comply with the requirements of the aforementioned instruction, carrying out the following design modifications already implemented. (1) Improved autonomy of FACP and fire detection, (2) seismic FP water system, (3) emergency lighting, (4) independent emergency communication system and (5) improved detection.

03.2.1.5 Regulator’s assessment of active fire protection

As mentioned in previous sections, the entry into force of IS-30, in particular its revision 1 of February 2013, has been an important milestone in the regulation of fire protection in nuclear power plants. This has resulted in safety analysis of greater scope and consistency, and interrelation with other disciplines. In addition, the performance of inspections in compliance with procedures PT.IV.204 and PT.IV.205 ensures that the deviations detected are duly resolved by the licensee within the framework of their corrective action plan.

03.2.1.5.1 Overview of strengths and weaknesses in active fire protection

The main good practices of the nuclear power plant licensees identified in the section on active FP are as follows:

- Implementation of FP seismic water systems.
- Increase in FP water supply capacity.
- FP systems in the ISFSI.
- New operational strategies and means derived from the analysis of events beyond the design basis and flexibility of use in design basis situations.

- Availability at all sites of a professional fire brigade with the sole function of preventing fires and responding to such scenarios should they occur.
- Establishment, by regulatory requirement, of protocols for collaboration with external support fire brigades.
- New fitness requirements for fire brigade personnel and their training and that of the external support fire brigades.
- Availability of firefighting training and practice facilities at some sites.
- Compensatory measures in case of non-functionality of active FP systems.

03.2.1.5.2 Lessons learned from inspection and assessment on active fire protection as part of its regulatory oversight

On the regulator's side, the main lessons learned come from the experience of the evaluation and inspection processes.

In this respect, a recent revision of PG.IV.08 has been carried out in order to improve internal processes and interactions with the licensees, as well as to clarify coercive processes in the framework of the evaluation process in case of identification of deviations.

On the other hand, the fire protection inspection procedure, PT.IV.204, is also in the process of being revised to formally incorporate the lessons learned from the inspection process on the subject, including the inspection of the fire PSA. Both this procedure and PT.IV.205 allow monitoring of the operator's actions taken to ensure that adequate active fire protection is maintained.

Finally, particular attention is paid to the maintenance processes in view of the long-term operation and the consequent ageing of fire water materials and components.

03.2.1.5.3 Conclusions drawn on the adequacy of the licensee's active fire protection

In general, it may be concluded that there is an adequate implementation of active fire protection systems in Spanish nuclear power plants, with elements such as the seismic FP system constituting an outstanding strength of the system design.

03.2.2 Active fire protection in FCF

03.2.2.1 Fire detection and alarm provisions

WENRA levels have not yet been developed specifically for fire detection and alarm systems in fuel cycle installations.

The requirements of IAEA SSR-4 *Safety of Nuclear Fuel Cycle Facilities* [73] are:

- Point 6.77, the fire hazard analysis shall include fire detection and fire suppression means.
- Point 8.9, the fire detection and control systems shall be demonstrated at the commissioning of the installation.

The requirements of the IAEA document SSG-5 *Safety of conversion facilities and uranium enrichment facilities* [68], which is the document containing the recommendations for compliance with SSR-4, do not apply to Juzbado because neither the conversion nor the enrichment process is carried out at the plant.

03.2.2.1.1 Design approach

Juzbado has a fire detection and alarm system that provides the means to detect and locate any fire situation in the Manufacturing Hall, in the auxiliary installations where the safety important SSCs are located and in the rest of the buildings of the facility.

The aim of both detection and suppression systems is to comply with the principle of defence in depth against fire, as presented in section 01.2.1.

Fire detection and fire alarm elements are designed and located to minimise the likelihood and effect of fires and explosions in areas where nuclear material is located and in areas where safety important SSCs are located.

The fire detection and alarm system is designed to: detect signs of fire and generate alarm, warning and evacuation signals that are perceived throughout the facility in order to inform, activate intervention teams and evacuate personnel, in order to minimise the possible consequences of a fire.

The applicable regulations are those included in the Installation SAR, where it is defined that the entire fire detection and alarm system is designed in accordance with UNE 23007-14 (EN 54-14) [126], which establishes the criteria for the location, quantity and type of elements that must make up the fire detection and alarm systems, as well as the installation and assembly conditions for the purpose of protecting the system against environmental conditions. In particular for this installation there is detection in 100 % of the fire sectors and the environmental conditions are standard for all of them.

The evacuation of the facility in case of fire is activated by a public address system designed in accordance with UNE EN 60849 [127].

03.2.2.1.2 Types, main characteristics and performance expectations

Detection

The detection of a potential fire situation is carried out by three types of detectors:

1. Detectors or manual pushbuttons

These detectors are distributed throughout the installation so that they can be manually activated by any person who discovers a fire.

2. Automatic direct detectors

This equipment registers, compares and measures directly on the space to be controlled, the parameters or physical variations that may be occurring and which are indicative of the generation of a fire, such as: smoke, gases, heat, flames, etc.

Automatic direct detectors are addressable, intelligent and uniquely identified by providing information on their location and activation or maintenance status.

They are used depending on the characteristics of the area or process to be covered and are as follows:

- Optical-thermal detector: in places where vapours may be present.
- Optical flame detector: in high volume rooms and storage areas.
- Thermovelocimetric detector: in high voltage transformers and process equipment requiring special monitoring.
- Linear smoke detector: in hard-to-reach places.
- Optical smoke detector: in the extraction and air-conditioning ducts and in the rest of the installation.

3. Automatic indirect detectors.

This equipment is installed on water-based fire suppression systems to monitor the operating parameters of these systems that may be indicative of a possible fire situation.

In this category, the following are available:

- Flow switches on pipes feeding FHC and at sprinkler system control stations.
- Pressure switches in the alarm circuit of sprinkler system control stations.

Alarm management (fire main switchboard)

The management of the entire system is carried out by a single Fire Control Panel located in the Manufacturing Hall, which has dialogue interface terminal located in the same Fire Control Panel and a second one located in the Control Room (Management and Emergency Centre).

The Fire Control panel is connected to a computer management system located in the Control Room that allows all the functionalities of the dialogue interface terminal and is also capable of presenting any event that occurs and graphically identifying the location and status of the element that has triggered it.

All detectors are connected to the fire control panel via loop buses with up to 120 elements per bus. These buses pass through different fire sectors, but their loop configuration ensures that in the event of an incident in a given sector, the rest of the system will continue to operate as there is a double communication path to the switchboard. These buses have a permanent status check, automatically detecting any cut-off, shunt or short-circuit situation. The loop bus configuration ensures the isolation of the detection system between the different sectors in hazardous situations.

The detectors are grouped in computerised sections. These sections generally coincide with the fire sectors defined in the Fire Hazard Analysis, except in those cases where their dimensions require more than one section. Each section has its own controls for siren activation, evacuation and interlocks.

Evacuation

As mentioned above, the evacuation of the facility is triggered by a centralised public address system.

Warning sirens are provided in all areas and sound only in the area where the fire has been detected. It is activated 10 s after the activation of a detector and is interrupted just before the first public address message is broadcast, so that spoken messages are perfectly audible in the area.

The public address system has the following types of loudspeakers distributed throughout the installation: fire siren, ceiling loudspeakers, hemi-directional loudspeakers and sound projectors.

This system is activated 60 s after a detector has been activated and generates a pre-recorded message indicating the section where the fire alarm has occurred.

After 240 s the general evacuation message is generated. All public address messages are broadcast to the entire installation and the sequence can be aborted by the Control Room operator at any time.

The public address system has a call station in the Control Room with a microphone and keyboard for manually giving recorded messages or intervention instructions from the Emergency Director if necessary.

Interlockings

The units that condition and extract the air from the ceramic process areas have fire detectors in the exhaust ducts so that, in the event of an alarm from these detectors, the affected ventilation unit (extractor fan and air conditioning unit) is automatically shut down, thus preventing the possible escape of contamination to the environment due to loss of integrity of the final filtering stage. Filter clogging is managed and controlled by the Ventilation and Air Conditioning System, which is independent of the Fire Protection System.

The shutdown of these ventilation units causes the associated process equipment to stop, as they are interlocked, and therefore there is no longer any movement of nuclear material in the Ceramic Zone, which is where the nuclear material is located in dispersible form.

The fire detection system is also interlocked with the hydrogen gas supply to the sintering furnaces so that, if a fire detector is activated in any of the rooms through which a hydrogen pipeline runs, the gas is shut off at the head-end, i.e. at the gas outlet in the gas storage area.

Electrical power supply

The conditions for the supply of electrical energy to the fire protection system are set out in Conditions 29 and 30 of the Construction Authorisation for the Juzbado Factory (Order of 12 December 1980 of the Ministry of Industry and Energy, BOE-A-1980-27667 [109]) and in UNE 23007-14 (EN 54-14) [126].

All display and control devices of the fire protection system are supplied with normal electrical power by an uninterruptible power supply system, firstly to avoid zero-crossing and then by one of the generating sets available in the installation. Likewise, both the switchboard and the dialogue interface terminals, as well as the rest of the interlock detection and control elements, also have their own battery group.

03.2.2.1.3 Alternative/temporary provisions

Whenever any element of the fire detection and evacuation system is not fully operational, the compensatory measures set out in the Technical Specifications are applied in each case. These measures consist of hourly watches of the affected area, carried out by suitably qualified and trained personnel.

The entire detection and evacuation system, according to the Technical Specifications, has to be fully available and fully operational at all times throughout the year. Disconnections of detection and evacuation elements are only allowed for system maintenance or during cutting and welding work. In the latter case, when, as a preventive measure, the deactivation of a detector is required to carry out works, the total inoperability of the detectors can be avoided by putting them in "test" mode. In this mode, the detectors continue to report fire warnings to the Control Room, but do not trigger evacuation sequences and interlocks, thus avoiding false evacuations without giving up the ability to detect possible fires.

03.2.2.2 Fire suppression provisions

Juzbado has both automatic and manual suppression means, commensurate with the characteristics of the fires that may occur and the existing criticality risk, derived from the characteristics of the nuclear material being processed and the physical form in which it is being handled.

The objective of both detection and suppression systems is to comply with the principle of defence in depth against fire, as presented in section 01.2.1.

03.2.2.2.1 Design approach

The suppression systems, both automatic and manual, are designed in accordance with the conclusions of the fire hazard analyses carried out, in such a way as to allow fire mitigation throughout the facility, guaranteeing that their use does not incur other risks. It is worth noting the restrictions on the use of water for firefighting in areas where nuclear material is handled due to the risk of criticality. Fire protection in these areas is based on the use of portable fire extinguishers by the FPB.

This restriction was established in Condition 33d of the Construction Authorisation, Order of 12 December 1980 of the Ministry of Industry and Energy [109].

The applicable standard is the set of NFPA standards indicated in each of the sub-sections and is included in the Installation SAR. Details are given in the following sections.

03.2.2.2.2 Types, main characteristics and performance expectations

Fire water supply system

The fire water supply system ensures the availability of water for both automatic and manual suppression.

There are two water storage tanks with a maximum capacity of 1000 m^3 each with a minimum level set by the TS at 710 m^3. One of these tanks has a motorised valve, open in normal operation, which allows this tank to be isolated in the event of an earthquake, preventing the loss of water from the tank.

There is a pumping group consisting of a 355 m^3/h electric pump and a diesel pump, with the same hydraulic characteristics as the previous one and both with 100% capacity. The network is also equipped with a pressure group.

In order to guarantee the operation of the electric pump in the event of an external supply failure, the electric pump is powered by one of the generators available in the installation.

The water distribution network is a loop around all the buildings in the installation, supplying pressurised water to sprinklers, FHC, hydrants, etc. This network has strategically distributed isolation valves, so that sections requiring intervention can be isolated without affecting the rest of the installation.

There is a water tank, in addition to those described above, with a capacity of 200 m^3, which is not connected to the previous ones but which supplies water to the firefighting vehicles. This tank is the only element designed to withstand the design basis earthquake, and therefore constitutes, together with the vehicles, the fire suppression system in the event of a design basis earthquake.

General extinguishing systems

1. Extinguishers

The number and distribution of fire extinguishers is in accordance with Royal Decree 513/2017, of 22 May, approving the Regulation on Fire Protection Installations [78] and has coverage in all areas of the factory.

There are a total of 555 portable extinguishers throughout the facility, of three different types depending on the material to be extinguished: polyvalent A-B-C, CO_2 and MET-L-X powder (for metal, uranium and zircalloy fires). In addition, in the most sensitive areas of the installation and as support when there is an unavailability of any suppression system, there are trolleys of these three types of agent, which can be taken to the location where they are required.

The surveillance requirements for fire extinguishers, which are defined in the TS, are based on the Fire Protection Installations Regulations and the UNE 23120 standard [128], with quarterly instead of annual weighing.

2. Firefighting vehicles

As extinguishing and support equipment for the interventions that the Fire Brigade can carry out, Juzbado has four firefighting intervention vehicles: two pick-up vehicles with high-pressure pumps with a 500 litre water tank and 20 litres of foam concentrate each, a firefighting truck with a capacity of 8000 litres of water with a pump of 3000 l/min at 10 bar and a vehicle to support the movements of the Fire Brigade.

3. Fire hydrants

There are 21 hydrants in the facility designed according to NFPA 24 [116], which are connected to the general fire water supply network and distributed outside and around all buildings in the facility. The hoses are connected to them, allowing water to be sprayed by different equipment and in a variety of ways (manual nozzles, monitors, foam-generating nozzles or equipment, etc.). Next to each hydrant there is a cabinet for the storage of the intervention equipment.

4. Fire Hose Cabinets

There are 19 equipped FHC in the facility, designed according to NFPA 24, arranged inside the buildings, which allow a quick response to start the intervention by simply opening valve they have. In areas where nuclear material is present there is no FHC in order to avoid criticality risks.

5. Sprinkler system

There are 6 wet column water sprinkler suppression systems, designed in accordance with NFPA 13 [118], covering the vast majority of the facility with the exception of areas where nuclear material is handled, where the use of water is prohibited to avoid any criticality risk.

6. Hydrogen tank cooling

In the Gas storage area, where the hydrogen tanks are located, there are sprayers mounted on several manually operated pressurised water lines, connected to the fire water distribution loop. If necessary, these pipelines can be used to cool each of the two hydrogen tanks in the plant as well as the refuelling station.

Automatic CO_2 suppression systems

There are two automatic CO_2 suppression systems that cover places that require an automatic suppression system and where there are usually no people present: fire pump rooms and generator rooms.

They are designed in accordance with NFPA 12 and are supplied by liquefied CO_2 cylinder batteries.

A minimum of 2 detectors in the same room must be activated for automatic suppression to take place. With the activation of a single detector, the suppression pre-alarm, section alarm (start of the evacuation sequence) and order to close the enclosure ventilation, if applicable, are triggered. Once two detectors have been activated, the suppression alarm siren changes sound to allow the evacuation of people who may be in the area and after 20 seconds the gas cylinder triggering mechanism is activated. It can also be activated manually.

There are also locking buttons that allow the interruption of the suppression process in the event of improper activation, malfunction, mishandling, presence of people inside, etc.

The suppression can also be triggered manually, by means of a lever located on the cylinders themselves, which causes immediate discharge. This device is operational even if there is no power supply to the system.

Automatic suppression systems by FM200

The FM200 automatic suppression system is installed in places where an automatic suppression system is required and where people may be present:

- DAM room, where the Criticality Alarm System controllers and the fire and gas detection switchboards are located.
- Quality assurance filing room.

- Data Processing Centre.

They are designed in accordance with NFPA 2001 [122] and their operation is similar to that of CO_2.

Automatic water spray fire suppression systems

These systems are located in the two High Voltage Transformers and are designed in accordance with NFPA 15 [119]. They consist of a system of pipes, sprinklers or spray nozzles, mounted in a loop configuration surrounding the transformer, on a dry pipe which is connected by a set of shut-off and control valves to the general fire water supply loop.

Electrical power supply

The power supply of suppression equipment is identical to that of detection and alarm devices.

As mentioned above, the electric pump for the firefighting water supply system is powered by one of the generators.

03.2.2.2.3 Management of harmful effects and consequential hazards

All existing water-based suppression systems do not cover areas where nuclear material is handled or stored in order to minimise the risk of criticality. They also have a drainage network duly calculated to be able to evacuate the water in case of operation, thus avoiding undesired accumulations.

The automatic CO_2 suppression systems have all the necessary normative elements, according to NFPA 12 [129], for their operation and additionally, locking buttons have been installed inside the enclosures in case it is not possible to evacuate the area within the system's pre-warning time. The access doors to the areas with automatic CO_2 suppression systems are fitted with approved door retainers that are interlocked with the system, which allow the doors to remain open inside, thus preventing the danger of asphyxiation due to escapes. The extinguishing agent bottles are also located in properly ventilated enclosures outside the protected area and are fitted with shut-off valves for maintenance work to prevent dangerous situations in the event of accidental release.

03.2.2.2.4 Alternative/temporary provisions

In cases where any suppression system is out of service, as a general rule, hourly surveillance watches and alternative means of suppression such as extinguishers trolleys and support hoses are established in accordance with the provisions of the TS.

03.2.2.3 Administrative and organizational fire protection issues

03.2.2.3.1 Overview of firefighting strategies, administrative arrangements and assurance

Fire protection at Juzbado consists of the Fire Protection System that includes all the automatic and manual systems aimed at detecting, suppressing and confining fires and the Fire Brigade that acts in the event of an incipient or developed fire. It also includes a series of actions aimed at fire prevention.

The fire protection system is regulated in the TS and is divided into sub-systems as detailed in the previous points (Detection and Evacuation, water supply, general suppression, etc.). In general, system elements are subject to TS when they cover areas where nuclear material is handled and stored and areas where safety important SSCs are located.

All subsystems are subject to Surveillance Requirements which set out the necessary periodic testing and inspection measures to be carried out on a system, subsystem or element to meet the operability requirements set out in the Limiting condition for operation.

The Emergency Organisation is organised on two horizontal levels of intervention:

- First Intervention Team (FIT) whose function is surveillance and immediate intervention. The scope of this team is to carry out a first intervention in the event of an incipient fire or of a fire with moderate dimensions.

- Second Intervention Team (SIT) whose function is to intervene at all points of the installation, being able to use all the suppression means available. The SIT is organised with a Brigade Leader and different backup team leaders. The Leader of the Fire Brigade is responsible for coordinating the different Fire Brigade Teams in the event of an emergency and, in their absence this function falls to the Leader of the backup brigade, always in coordination with the emergency management centre and the emergency management team.

03.2.2.3.2 Firefighting capabilities, responsibilities, organisation and documentation onsite and offsite

The intervention of the FPB is essential for extinguishing fires in areas where there are no automatic suppression systems and its actions are regulated in 29 Fire Protection Procedures, which establish the criteria and rules for intervention in the different areas of the facility in cases of emergency.

According to the On-site Emergency Plan, there is a minimum number of 3 to 6 members of the Fire Brigade to be able to deal with any fire, depending on the operating mode.

The initial training and retraining of the FPB responds to IS-44 as part of the Emergency Response Organisation. In particular, specific training is provided annually by specialised companies to ensure the full effectiveness and operability of the two firefighting teams and drills are carried out at the facility with the active participation of the SIT.

The training of the FIT and SIT is set out in a procedure developed by OSEP. It is based on basic firefighting training for the FIT and a specific training for industrial fire brigades, training in action procedures and training in the Fire Protection System for the SIT.

The FPB's interventions in emergencies involving risks of contamination, irradiation or a criticality accident are controlled at all times with the permanent guidelines of the specialised technicians in these areas who advise the FPB's actions in these cases.

03.2.2.3.3 Specific provisions, e.g. loss of access

To act in the event of fire, the Factory has a Fire Brigade described in the previous sections.

03.2.2.4 Licensee’s experience of the implementation of active FP

Same as paragraph 03.1.2.3

03.2.2.4.1 Overview of strengths and weaknesses

The second periodic safety review carried out by the factory covered the period from 01/01/2005 to 31/12/2014, obtaining the renewal of the Operating and Manufacturing Authorisations on 05/07/2016.

The findings of this PRS in relation to the Active Fire Protection showed that the Licensing Basis and the Design Basis were complied with and that monitoring and maintenance was carried out according to the established requirements, ensuring its correct operation.

The following improvements were identified and are already in place:

- Fire Water Supply System: Revision of buried carbon steel connections between the main loop and the control stations.
- General Suppression System:
    - Modification of the 4" branch line from the New Component Warehouse to accommodate supply flow and pressure.
    - Modification of the sprinkler system in the Fire Pump Room to make the detection and suppression of the rooms independent.
- CO_2 suppression system:
    - Modify the CO_2 suppression system in the Fire Pump Room to make the detection and extinguishing of the rooms independent.
    - Modify the CO_2 suppression system in the generator room to increase its suppression capacity.

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

Throughout these years, different types of actions have been implemented as a result of incidents occurring at the facility.

The most relevant incidents leading to improvements are the following:

- Partial activation of the FM-200 automatic fire suppression subsystem in an office due to a failure of the electronic card.
- Inconsistency between the TS and the surveillance requirement relating to the verification of the position of the fire suppression system loop valves.
- Activation of a sprinkler of the fire protection system located in an access gate by impact with a forklift.
- Number of operational fire detectors below the minimum admissible by TS without taking the corresponding TS action.
- Activation of the general evacuation alarm during the performance of a surveillance requirement due to an error in the sequence of the performance of the requirement.

- Actuation of the general hydrogen supply valve interlock due to activation of the temperature probe in a furnace cabinet
- Incidence on the performance of watches established as compensatory measures when a minimum number of detectors are not available.
- Incipient fire in a homogeniser when carrying out actuations to remove material accumulated in a cavity of the equipment.

Improvements have also been implemented following incidents at other facilities. The incidents were as follows:

- Loss of water supply because there were problems with the river catchment pipe.
- Reception of capacitors not authorised by internal procedures.
- Activation of an off-site fire alert on a truck.
- Death of a FPB firefighter due to unexpected CO_2 discharge.

03.2.2.4.3 Overview of actions and implementation status

The corrective actions or improvements implemented as a result of the lessons learnt from the Operational Experience, including those extensions carried out because of the event analyses, were:

- Administrative Measures:
  - Reviews of internal procedures governing activities such as the performance of surveillance requirements, execution of fire watches and maintenance activities.
- Design modifications to protect the impacted sprinkler, to improve the operation of the UO_2 static oxidation furnace, to include a new river water intake pipeline, and installations of valves and light signals in areas where they may be risk of suffocation.

In addition, other design modifications have been made that have led to significant improvements in the active FP installation, among which the following are worth highlighting:

- Modification on the location of FHC to improve the handling and utilisation possibilities.
- Replacement of a firefighting vehicle
- Replacement of suppression stations in the fire protection system to modernise the system.
- Seismic- water supply to the fire protection system to prevent the fire water tanks from emptying in the event of an earthquake resulting in a rupture of the water supply network.
- Coverage by the fire protection system for new installations.
- New detection and evacuation system to modernise it.

- Generator sets room new fire suppression in order to ensure the effectiveness of the suppression systems in case of fire.
- New cabin temperature probes, to replace those located in some cabins in the ceramic area with certified detectors for Fire Protection.
- Pressure and flow switch control stations for replacement and redesign.
- Refurbishment of the fire suppression system in the pump room in order to improve the suppression systems (water and CO_2) that cover the Pump Room of the FP system. This improvement stems from the Systems Review of the FP system.
- Installation of a new dedicated seismic fire water reservoir capable of operating after a 0.17g earthquake.
- Removal of the foam suppression system from the steam boilers as the boilers have been dismantled.
- Replacement of the fire control panel.
- Replacement of the diesel pump of the fire protection system.

All these design modifications are in place with the exception of the removal of the foam suppression system from the steam boilers.

03.2.2.5 Regulator’s assessment of active fire protection

03.2.2.5.1 Overview of strengths and weaknesses in active fire protection

The operator is considered to have an adequate implementation of active fire protection in terms of availability of means, personnel, education and training. In this regard, the provision of a seismic fire water tank and the adoption of additional strategies and measures derived from analyses beyond the design basis are considered a substantial improvement on fire protection over the as-built configuration.

03.2.2.5.2 Lessons learned from inspection and assessment on active fire protection as part of its regulatory oversight

From the regulator's point of view, a better integration from an operational and procedural perspective of firefighting teams, emergency management and the occupational risk department is considered desirable. In this respect, in the framework of the next operating authorisation, an analysis for the adoption of a basic regulation incorporating organisational aspects in its fire protection programme is foreseen as an improvement action. Finally, the inspections carried out in accordance with procedure PT.IV.87 ensure that adequate active fire protection is maintained in the installation.

03.2.2.5.3 Conclusions drawn on the adequacy of the licensee’s active fire protection

The licensee is considered to have an adequate implementation of active fire protection in terms of availability of means, personnel, education and training.

03.3 Passive fire protection

03.3.1 Passive fire protection in NPP

The Spanish nuclear power plants apply the principle of defence in depth, the third level of which is to prevent the spread of fires that cannot be prevented or extinguished, in order to ensure and maintain a the plant in a safe condition, maintaining safety functions and limiting the amount of radioactive material that may be released by fire.

As measures to minimise the consequences of fires that cannot be prevented or extinguished, the specification [2] distinguishes:

- Prevention of spread by means of fire barriers.
- Ventilation systems.

03.3.1.1 Prevention of fire spreading (barriers)

The following WENRA reference levels are applicable to nuclear power plants in relation to the prevention of fire spread by means of fire barriers: SV 6.5 and SV 6.11

In Spain, the WENRA reference levels for fire protection are reflected in the national standard for nuclear power plants in IS-30 [4].

The articles of IS-30 [4] relating to the establishment of fire barriers to prevent the spread of fire are as follows: 3.1 Fire safety objectives (3.1.1 principle of defence in depth with its three levels, the third of which is to prevent spread to other areas that may affect safety; 3.1.2 requirement for confinement in fire areas, to prevent damage to at least one of the redundant safe shutdown trains and to minimise the possibility of radioactive releases to the environment); 3.2. Design basis (3.2.1 defence in depth and fire postulation criteria, 3.2.2 requirements for safety important SSCs, 3.2.3 sets out requirements on fire resistance and barriers for buildings containing safety important equipment and/or cable ducts, 3.2.4 sets out requirements for maintaining a redundant safe shutdown train free from fire damage and for having the capability to repair within 72 h those SSCs necessary to achieve cold shutdown, 3.2.5 to 3.2.9 sets out alternatives for meeting the safe shutdown capability, 3.2.10 sets out guidelines for buildings containing radioactive materials and 3.2.11 includes the requirement to have access and escape routes).

The general guidelines for complying with the above requirements are set out in the following sections of SG 1.19 [29], which is a reference guidance: 3 Basic criteria and general design assumptions (3.1, 3.2, 3.3, 3.7, 3.9); 8 General guidelines (8.1, 8.2, 8.3, 8.4, 8.5, 8.6 and 8.7) and 10 Guidelines for specific areas of the plant.

03.3.1.1.1 Design approach

The design of the Spanish nuclear power plants follows the aforementioned IS-30 and SG 1.19 guidelines. Generally, buildings with safety important SSCs have been designed as fire resistant subdivided into separate fire areas by 3-hour fire resistance barriers in order to separate, mainly, redundant trains so that they are not affected by the same fire.

In plants that comply with a deterministic licensing basis (have not transitioned to NFPA 805), in general, R180 separation barriers are additionally provided so that routing of cables through rooms or areas where there is a potential risk from the accumulation of large quantities of fuel (e.g. oil tanks) is prevented. Where such routing cannot be avoided, only the cables of a redundant train are routed through these areas (enclosed in metallic conduits).

When cables are routed in trays, there are no potential hazards in the area due to accumulation of large amounts of fuel and the cables of the different electrical separation groups are located in different fire areas, separated by R180 barriers. Accordingly, in general, the cable trays of safety-related (A and B trains) and non-safety-related (N train) trains are located in separate fire areas, which are separated by R180 barriers.

When the routing of safety-related and non-safety-related trays takes place in the same fire area, the separation and/or protection criteria given in RG 1.75 [93] and IEEE-384 [92] are followed.

R180 fire barriers mean that the walls, floors and ceilings separating the fire areas and the closing devices at the openings to the fire areas, i.e. doors for access to the areas, fire dampers and seals at ventilation openings, and seals at mechanical and electrical penetrations or at joints, have this fire resistance.

For this purpose, structural barriers are designed in accordance with the applicable building standards, while the closure devices are tested and approved by fire tests by approved laboratories.

Where this is not possible, areas combine active and passive elements duly justified in the fire hazard analysis.

Finally, the basic fire protection regulation IS-30 also admits alternative methods of achieving the separation of safe shutdown redundant trains by manual actions or other equivalent measures subject to express approval by the regulatory body.

To ensure accessibility to the affected area to allow complete suppression of the fire and to prevent any re-ignition:

- Emergency exits have been provided in all buildings in accordance with NBE-CPI/82 [94] and CTE:SI [77], the latter for the design of more recent buildings. Escape and access routes are defined for each building and elevation in the Fire Hazard Analysis (FHA) figures and in detail for each fire area in the Pre fire plans.

- Smoke and heat removal is carried out either through the normal ventilation exhaust ducts or through the dedicated smoke exhaust ducts available in the main control room, the control building and the control room and electrical room of the waste building.

- The fire brigade has self-contained breathing apparatus for access to areas in case of fire, as indicated in the FPM.

- Evacuation routes are maintained through annual inspections to ensure that they are clear and properly marked. These inspections are carried out by the fire protection service.

In relation to ISFSI, the Independent Spent Fuel Storage Installation must comply with the applicable regulatory requirements of 10CFR 72 [97] and IS-29 [19], in particular Article 3.5.3 contains design requirements to minimise risk and limit fire damage by confining the fire through the design of appropriate fire-resistant barriers where necessary. According to

3.5.4 the design of the installation shall ensure marked access and escape routes throughout the installation.

1. Almaraz NPP

In plants that have transitioned to NFPA 805, as is the case of Almaraz NPP, section 3.11 of NFPA 805 and its subsections are applicable.

In such plants, those barriers that do not comply with a fire resistance of 3 h are considered as VFDR (Variance From Deterministic Requirements) and are analysed using the risk-informed and performance-based methodology.

In the case of Almaraz NPP, with regard to the analysis of barriers, the applicable articles of NFPA 805 have been analysed, and the following conclusions have been reached:

- Article 3.11.1, on separation of buildings: In cases where the distance separation requirements are not met, the separation walls between buildings are of concrete and of sufficient thickness to provide a 3-hour FR in accordance with ACI 216.1-97 [130].

- Article 3.11.2, on fire barriers: Fire resistant barriers separating fire areas are constructed by:

    - Concrete walls.

    - Brick walls,

    - Fire resistant barriers created with special materials (PANELROC, FIREFILM IV, THERMOLAG, PROMATEC, DARMATT, ...) for specific cases where it is not possible to use concrete or masonry, such as in duct protection (assembly of non-embedded fire dampers), fire resistant walls (separation of FP pumps) and fire dampers. All these barriers are listed in the FHA with an indication of their fire resistance classification.

      These barriers meet the minimum thickness according to ACI 216.1-97 or are approved according to FP standards (ASTM-E-119 [95] or NFPA 251 [131]) for a FR of 3h.

- Article 3.11.3, on fire barrier penetrations: From the specific analysis carried out, it has been identified that some penetrations did not meet the requirement and have been changed (doors in COSS, electrical, auxiliary and fuel buildings; dampers and ventilation ducts in safeguards, auxiliary, purge and electrical buildings). In addition, barriers have been installed on the terrace of the electrical building to prevent communication between areas. In some cases, justified by the duration of the fire, barriers installed in ventilation ducts are R60. There are dampers approved as R90 according to DIN standards which have been shown to be equivalent to R180 according to ASTM-E-119 [95]. Similarly, one door in the controlled area access tunnel is not approved as R180, however, its location has been accepted on the basis of criteria of distance between equipment and/or cables on both sides of the door preventing damage to them as a result of a fire.

- Article 3.11.4, on seals on fire barriers: The specifications of the seals and the models used ensure that the fire resistance rating is 3h, thus fulfilling the requirement of this section.

- Article 3.11.5, on electrical raceway fire barrier systems: The barriers credited in the safe shutdown analyses strictly comply with the requirements of IS-30 Article 3.2.5.1).

  Barriers that do not strictly comply with these requirements are not credited in safe shutdown analyses. They are only given credit in risk analyses.

In relation to the ISFSI, at Almaraz NPP, there is an ISFSI separate from the nuclear island. It is an outdoor slab-type structure with a concrete perimeter wall. The storage slab is remote from other facilities (ISFSI plant and auxiliary buildings).

2. Vandellós NPP

In addition to the general criteria detailed at the beginning of this section, in the case of Vandellós NPP, in those cases in which the extraction ducts are isolated by the closure of fire dampers, smoke extraction is carried out by means of portable fans and flexible ducts connected to the duct registers or doors that communicate with the outside. In this regard, Annex III of the FPM and section 6 of chapter 2 of the FHA describe in detail the smoke removal procedure to be followed for each fire area.

In relation to the ISFSI, these requirements are not applicable to Vandellós NPP as it does not have an ISFSI facility.

The Trillo NPP ISFSI is in one building and constitutes a fire area divided into four zones. The area where the containers are housed does not contain combustible material or sources of ignition. If necessary, as provided for in the Pre fire plans, suppression means in the surrounding areas (fire extinguishers) can be used.

3. Cofrentes NPP

Cofrentes NPP applies the general criteria detailed at the beginning of this section without having detected any exception.

03.3.1.1.2 Description of fire compartments and/or cells design and key features

In plants that comply on a deterministic licensing basis (have not transitioned to NFPA 805), all devices included in the FR barriers (doors, gates, seals, etc.) have the same rating as the barrier in which they are located.

The approval of the barriers is in accordance with the following standards:

- Walls, ceilings and floors: their construction characteristics define their fire resistance in accordance with the NBE-CPI/82. [94]

- Penetrations sealed with silicone foam. The different sealing types have been approved by fire resistance tests according to ASTM E-119 [95].

- Protections for electrical conduits. Passive protections are available, which, depending on the plant, can be Thermo-lag, Interam 3M and Darmatt KM-1. The different configurations of passive protection of electrical conduits have been approved by fire resistance testing according to ASTM E-119 [95] and follow the guidelines of GL 86-10 supplement 1 [132].

- Fire doors and fire dampers. Approved by fire resistance test according to UL-10B [133] and UL-555 [134], respectively.

1. Almaraz NPP

See compliance with NFPA 805 articles 3.11.1 to 3.11.5, in the previous section.

2. Vandellós NPP

At Vandellós II NPP, the barriers delimiting the fire areas comply with the criteria set out at the beginning of this section and are generally R180 with the following exceptions:

- Stairwells (outside containment): R120 with doors R90 min
- Wall separating the Control Room from the adjoining rooms: R60
- Separation walls between fire areas A-26 and A-27.

The fire resistance of the above barriers is adequately justified in the FHA on the basis of the fire severity of the separated areas and that they do not separate redundant safety important SSCs. The calculation of fire severity is based on the guidelines of the NFPA *Fire Protection Handbook* [135].

This curve included in that guideline is based on fire tests conducted by research laboratories, insurance companies, UL, and FM in compartments with cellulosic fuel material such as wood or paper that were equipped with roofs, doors and windows. Nuclear power plants have windowless concrete compartments, few doors, few ventilation openings and a fuel load consisting mainly of cable insulation, plastics and oils, so the use of this curve is considered conservative by the licensee. Under these assumptions, the equivalent fire severity is calculated, which allows the amount of protection required to be determined.

Trillo NPP has a regulatory approval of equivalence for TROX R90 dampers according to DIN 4102 [136] to R180 according to ASTM and NFPA.

3. Cofrentes NPP

At Cofrentes NPP, the barriers delimiting the fire areas meet the criteria set out at the beginning of this section and are generally R180, with the exception of six R90 gates for which the CSN has given a regulatory approval.

03.3.1.1.3 Performance assurance through lifetime

In Spanish nuclear power plants, the guarantee that the fire resistance properties of the barriers remain adequate over time is based on two aspects:

On the one hand, by maintaining fire hazard analyses. Whenever a design modification is made, the impact on the fire load of the area is taken into account in the design documents, with the objective of not changing the equivalent fire severity, so that the fire resistance of the barriers remains sufficient to confine the postulated fires; or to implement additional protection measures if necessary.

Subsequently, once the design modification has been implemented, the fire loads and means of protection for each fire area are updated in the new edition of the SAR, which is issued 6 months after each refuelling outage, thus keeping the fire hazard analysis up to date.

On the other hand, through the execution of monitoring procedures to ensure the functionality of the barriers in accordance with the inspection and testing requirements defined in the TRM. The barrier surveillance requirements are based in the Spanish NPPs on different revisions of the TS Standard NUREG 0452 [137] and on the CSN Technical Instruction for the improvement of the TS. In relation to barriers, this 2010 technical instruction required Spanish NPPs to comply with the following requirements:

- Functional testing of fire dampers by actuating the fire damper tripping mechanism (fuse or electric) (without the need to blow the fuse). Depending on the type of damper, a test was required every 18 or 24 months in case of Trox type dampers and every 10 years, with 10 % per year, for louvre curtain fire dampers.

- A maximum time to restore the FR barriers to operability of 7 days or, if the plant is in outage, 20 days. After these times, fire risk work in the affected fire area must be prohibited. If necessary, this could be done with a continuous fire watch and a special report must be sent to the CSN. If it is not possible to recover the non-functionality within 30 days, a special report to the CSN will also be required.

At present, the operational and monitoring requirements are contained in the fire technical requirements manual (TRM). Fire resistant barriers are required to be functional at all times. By carrying out the required visual inspections and functional tests, the functionality of the equipment is ensured.

The temporary impact on barriers due to maintenance activities and design modifications is managed by means of a procedure that establishes the action guidelines in the event of "non-functionality" of any element subject to the FP TRM, establishing in each case the applicable compensatory measures. In the case of fire barriers, according to the FP TRM, the functionality of the fire detection on one side of the fire barrier shall be verified and hourly fire watches shall be established; in case of failure to verify the functionality of the fire detection or absence of fire detection, a continuous fire watch shall be established. (The aforementioned procedures are the procedure *Standards of action of the fire protection service in the FP system due to non-functionality of equipment related to the FP-TRM* in the case of Vandellós, *Control of breakage of the integrity of fire barriers* in the case of Cofrentes and *Management of loss of functionality of FP systems and barriers* in the case of Almaraz).

Transient fire loads are managed, as described in the section on fire prevention, by means of a procedure as explained in section 03.1.1.2. In this procedure, storages are controlled in such a way that the severities of the FHA are not exceeded except in cases where it is essential and appropriate compensatory measures are put in place. This ensures that fires are confined to the fire areas defined in the FHA.

03.3.1.2 Ventilation systems

According to the specification [2] ventilation systems must be considered in the event of fire in order to prevent the spread of fire and the risks associated with the gases and fumes produced by the fire, and to facilitate firefighting, while preventing the transfer of radioactive aerosols to the environment.

The following WENRA reference levels are applicable to ventilation systems in nuclear power plants: SV 6.6 and SV 6.7.

For Spanish NPPs the WENRA reference levels for fire protection are reflected in the national standard for nuclear power plants in IS-30 [4].

The IS-30 articles relating to the design of ventilation systems are as follows: 3.2 Design basis (3.2.1 accessibility criterion to the affected area; 3.2.10 buildings containing radioactive materials, unless adequately justified in the fire hazard analysis and ensuring no external release of radioactive fumes, shall be fire resistant and have a controlled ventilation system to ensure no external radioactivity release after a fire). Articles 3.4.5, 3.4.6 and 3.4.7 (requirements for ventilation systems).

In plants that have changed their licensing basis to a risk-informed, performance-based methodology (NFPA 805), the adoption of NFPA-805 [5] serves as a method of complying with the IS-30 articles: 3.2.10, 3.4.5 and 3.4.6.

As indicated in section 03.3.1.1 regarding dampers, ventilation ducts are generally fitted with fire dampers with fire resistance equivalent to the fire protection enclosure in their passage between different fire areas. Exceptions have been considered VFDR and have been assessed by the compliance analyses of the nuclear safety criteria of Chapter 4.2 of NFPA-805. The above are completed by the radioactive release analysis performed in accordance with Chapter 4.3, which ensures that potential radioactive releases caused by fire and extinguishing activities are as low as reasonably achievable and do not exceed the limits set by the TS.

At Ascó NPP, in order to comply with article 3.4.7, the risk-informed and performance-based methodology of NFPA-805 has been used to assess the adequacy of the detection and suppression of filters containing combustible material.

03.3.1.2.1 Ventilation system design: segregation and isolation provisions (as applicable)

Articles 3.4.5 and 3.4.6 of IS-30 [4] establish requirements for sectorisation by means of fire dampers or passive protections, as well as requirements for non-affection of safety functions by the isolation caused by the fire, and requirements for radiological control during the evacuation of smoke or gases caused by the fire where applicable.

In addition, Article 3.4.7 establishes protection requirements for safety important filters containing combustible material and adequate sealing in enclosures where a total gas flooding suppression system is used.

The above requirements are explained in the following sections of SG 1.19 [29]: 3.10 Ventilation criteria and 8.13 Ventilation. The recommendations in section 8.13 (1 to 9) are detailed below.

Isolation of air supply

1. Almaraz NPP

In the event of a fire in a fire area of the plant, the air supply system to that area shall be isolated by means of fuse-actuated or electromagnet-actuated fire dampers. For this reason, the ventilation system has been designed in such a way that cutting off the air supply to a defined fire area does not affect the proper functioning of safety SSCs located in other areas of the plant.

The ventilation ducts, both supply and return, when passing through different areas, are fitted with fire dampers with the same fire resistance as the barriers.

The dampers are actuated by a built-in thermal fuse, with the exception of the dampers installed in two cable rooms, which are also solenoid-operated to allow them to close before the fixed automatic suppression system is actuated.

2. Vandellós NPP

With regard to the cut-off of air supply to fire areas due to the closure of fire dampers in the area where the fire is located, a number of fire areas have been identified which the closure of the dampers would result in the isolation of the air supply and/or the extraction of air in other fire areas. From the analysis carried out in relation to the SSCs located in the affected areas, as well as the temperature transients that occur, it is concluded that the correct operation of the equipment is not affected and that, in no case, would the safety functions be lost.

In the specific case of the HVAC ducts for air conditioning in the control room, they have passive protection throughout their route and do not have fire dampers when crossing different fire areas, since in the event of fire in any of these areas, the closure of the dampers would affect the correct ventilation of the control room.

This passive protection has a fire resistance of 1 h, which is sufficient for the postulated fires, given that the severity of the areas to which it is exposed is lower, and has been favourably approved by the CSN by letter CSN/C/SG/VA2/20/09 [138].

3. Cofrentes NPP

Fire dampers separating ventilation ducts from separate fire areas have a fire resistance of 3 hours.

According to BTP APCSB 9.51 [7] on which the design of the HVAC system is based, fire dampers serve to separate fire areas connected by ducts from the ventilation and air-conditioning (HVAC) systems of each building. In addition, they ensure the tightness of an area when a gas flooding suppression system is provided in the area. The dampers are made of metal and have fire resistant insulation material in the slat that acts as a closing barrier.

The dampers at Cofrentes NPP are identified as type FD1, FD2 and FD3. The main features of this equipment are summarised below.

All dampers are equipped with a fuse closure set at a temperature, in addition, type FD1 dampers incorporate a device that allows remote opening and/or closing, type FD2 dampers have a remote closing device and type FD3 dampers do not have any other device apart from the fuse. Type FD1 dampers are used in smoke extraction ducts, so that after closure by the fuse, they can be operated at the operator's will from the FACP of the corresponding area.

Type FD2 are used in cases where gas flooding suppression systems are provided where the dampers must be closed before discharge, even if the temperature generated by the fire is not sufficient to melt the fuse.

Dampers of type FD3 are the most common type and are used in all areas where the duct passes through a fire barrier in order to prevent the spread of a possible fire to other areas.

Therefore, fire dampers separate fire areas that are connected to each other by the ducts of the ventilation and air conditioning (HVAC) systems of each building, preventing a fire from affecting safety components in other fire areas.

Separation of SSC

GS 1.19, section 8.13, point 2 concerns the separation of equipment necessary for safe shutdown and the compartmentalisation in fire areas through ventilation systems.

1. Almaraz NPP

The power plant meets this criterion via NFPA 805. See compliance with Article 3.11.3 in 03.3.1.1.1 above.

2. Vandellós NPP

Ducts for air supply and extraction of the HVAC systems that penetrate the fire resistant barriers (fire area boundary) are provided with fire dampers that have a fire resistance rating equivalent to that of the barrier allowing the fire areas to be isolated, except for one particular case in the Turbine Penetrations building, where HVAC ducts pass through a barrier separating two fire areas without a fire damper. These fire areas have a virtually negligible fire severity and are in the turbine penetrations building which is conventional, i.e. not a radiological area. The CSN has favourably approved the equivalent compliance by letter CSN/C/SG/VA2/20/09 [138].

Trillo NPP has a regulatory approval of the absence of isolation in ventilation systems in certain fire areas in the annulus, electrical and auxiliary buildings, as well as the absence of dampers in certain cases in the electrical, diesel and emergency buildings (section 3.4.5 of IS-30).

3. Cofrentes NPP

Ducts of air supply and extraction of the HVAC systems that penetrate fire resistant barriers (fire area boundary) are fitted with fire dampers that have a fire resistance rating equivalent to that of the barrier allowing the fire areas to be isolated.

Smoke and flue gas control

GS 1.19, section 8.13, point 3 concerns the control of smoke and gases in case of fire, e.g. through NFPA 204M [139].

1. Almaraz NPP

In the event of a fire in any of the fire areas of the plant, the fire dampers located in the air supply and extraction ducts close automatically by fuse melting, isolating that fire area from the adjacent ones and thus preventing the spread of the fire.

In order to access these areas (in accordance with the accessibility criterion for the affected area), smoke extraction equipment (portable motor-fans) and self-contained breathing apparatus are available.

In those areas of the plant where manual operator actions are required, a smoke extraction system is provided: Control Room and train A Switch Rooms.

- In the Control Room: When smoke is produced due to a fire, the ventilation system changes from a recirculation system with renewal to an all outside air system. To achieve this, there are dampers that allow the system to be aligned so that all of the supply air is exhausted from the controlled zone supply system (immediately downstream of the fans) and all of the supply air is exhausted through the uncontrolled zone exhaust system. Eight hourly renewals are guaranteed, ensuring rapid evacuation of the smoke and heat produced by the fire.

- In Train A Switch Rooms: The extraction subsystem is equipped with an axial fan, equivalent to about 2.5 renewals per hour of the volume of the room.

2. Vandellós NPP

The combustion products generated in case of fire will be removed by means of the normal ventilation available in the different buildings except in the Control Room, in the control building, and in the control room of the waste building, where smoke extractors are available. In addition, in certain fire areas, portable exhaust fans and flexible hoses connected to the general exhaust ducts shall be used. The FHA indicates, for each fire area, the system for smoke extraction in the event of fire.

In relation to areas where high smoke density is expected to be removed, there are no separate vents. In the case of the cable distribution rooms and electrical rooms in the control building, a separate system is provided for smoke extraction if necessary. For the rest of the areas, the system provided for normal operation will be the smoke extraction system.

3. Cofrentes NPP

In areas where the possible combustible material contained may generate a large amount of smoke and in order to allow access to the manual firefighting, manually operated smoke extraction means that can be actuated from the FACPs corresponding to each area, are installed and with sufficient capacity to extract the smoke generated under the most unfavourable conditions.

These smoke extraction systems are independent of the normal ventilation system which shall be isolated by the closure of the appropriate fire dampers. Smoke extraction equipment is installed in the following areas of the plant:

- Electrical building: the whole building.

- Services Building: three extraction systems corresponding to the elevations:

- Essential Service water tunnel. Smoke extraction shall be carried out by manually switching the portable foam generating equipment to the fume extraction position.

- Auxiliary Building: three extraction systems corresponding to three levels.

In addition, the fire service is equipped with self-contained breathing apparatus, which complies with the regulations in force in Spain

Control of potentially radioactive smoke and gases

1. Almaraz NPP

Ventilation systems in buildings forming part of a radiological area (auxiliary, containment, fuel, safeguards) are fitted with radiation monitors to prevent the discharge of potentially radioactive fumes without the consent of the radiation protection service.

2. Vandellós NPP

Ventilation systems in buildings forming part of the radiological area (auxiliary, containment, fuel, components and radioactive waste) are fitted with radiation monitors to prevent the discharge of potentially radioactive fumes without the consent of the radiation protection service.

3. Cofrentes NPP

A fire with potential radioactive emissions to the atmosphere will be managed in accordance with the emergency procedures of Cofrentes NPP, which comply with CSN SG 1.03 [140], Nuclear facility emergency management planning and response.

Ventilation systems in buildings that are part of a radiological area are fitted with radiation monitors.

Ventilation systems cables protection

1. Almaraz NPP

Almaraz NPP complies with this criterion through NFPA 805. Ventilation systems as well as their cables have been taken into account in the fire safety analysis. Ventilation system equipment is located in fire areas other than those containing safety SSCs necessary to achieve and maintain safe shutdown.

2. Vandellós NPP

Power and control cables for ventilation units in safety-related areas are, wherever possible, routed outside the fire area they serve. However, the routes of these cables are considered in the fire safe shutdown analyses according to the methodology described in section 02 for all ventilation units that are safety-related or safety important SSCs supports, and the required function is fulfilled in all cases.

3. Cofrentes NPP

The air supply and extraction equipment of cubicles where safety equipment is located, is installed outside of them.

Therefore, the routing of the power and control cables has been carried out, whenever possible, outside the area in which they operate. Cables are included in the fire safe shutdown analysis.

Filters important for safety

GS 1.19, section 8.13, point 6 concerns the protection of safety important filters in accordance with RG 1.52 [96].

1. Almaraz NPP

Filtering units comply with RG 1.52 (in safety areas, Control Room and Fuel Building) or RG 1.140 [141] (non-safety areas).

In areas with safety important filters there is ionisation fire detection, with the main suppression system being FHC and fire extinguishers as a back-up system. In addition, as a further means of prevention, activated carbon beds are equipped with CO detection inside the bed and a flooding system that complies with the above-mentioned RG.

Safety important filtration units are included in the FHA and the FHA is documented in the SAR.

2. Vandellós NPP

Safety important filters containing combustible materials are mainly activated carbon filters, located inside the filter units. According to RG 1.52 [96], all activated carbon filters are equipped with an automatic pre-action sprinkler suppression system and a thermal fire detection system inside the filter unit. These units are also covered by ambient detection of the areas in which they are located. Likewise, section 2 of Appendix 9.5B to the SAR includes the FHA by fire areas, indicating for each area the presence of filters as combustible material and the detection and suppression systems available. The active carbon filters are located in the auxiliary building; in the fuel building; in the diesel buildings and in the turbine building.

The remaining filters belonging to the filter units (HEPA and HEF filters) are made of flame retardant materials and meet UL criteria according to specification M-720C:

- HEF filters: They meet UL Class I requirements (filters that do not burn on exposure to flame and emit a small amount of smoke) according to UL-900 [142];

- HEPA filters: They meet the requirements of UL-586 [143] (the filter frame must be made of metal or non-flame propagating material, the filter media must be made of flame retardant fibreglass and the filter must pass a flame test in which the filter is subjected to exposure to a flame for 5 minutes without burning or sustaining a flame).

In addition, other safety-related filters have been identified that include combustible material. These are the air intake filters of the EDGs which are in an oil bath. The filters are located in individual enclosures separated from the rest of the fire area by walls which, although not rated as fire resistant, retard the spread of fire and the passage of smoke. The enclosures have fire detection and FHC and fire extinguishers are available in adjacent enclosures.

3. Cofrentes NPP

Filters belonging to the standby gas treatment system and the control room heating, ventilation and air-conditioning comply with G.R. 1.52 [96].

Air intake of areas with SSC

GS 1.19, section 8.13, point 7 concerns the location of air intakes in areas containing SSC.

1. Almaraz NPP

At Almaraz NPP, the ventilation designs have considered the confinement of fires by means of fire dampers in each fire area.

In ventilation systems, air intake is generally located at a lower level than air exhaust. In the main systems of the power island, the exhaust air is expelled through plenums that extend vertically through chimneys, expelling the exhaust air at a speed that allows it to be diffused into the atmosphere without the possibility of recirculation.

There are subsystems (battery rooms, diesel generators, emergency subsystems of cable rooms and specific switchgear) whose design consists of suction at a lower level and extraction through ceiling fans, following the same criteria as described above.

2. Vandellós NPP

The guidelines for locating air intakes in areas containing safety equipment away from air vents and smoke exhausts in other areas in this section of SG 1.19 are generally followed. In addition, fire dampers are provided to isolate both supply and exhaust from fire areas.

3. Cofrentes NPP

In order to minimise the chances of contaminating the incoming air with combustion products, the Turbine Building, the Control Room of the Radioactive Waste Building and the Electrical Building have smoke extractors located on the roofs of these buildings. This location allows for maximum diffusion into the atmosphere and prevents the smoke plume from reaching the outside vents of the HVAC systems, which are located on the walls of the plant at a lower level, so the probability of drawing in air that has the potential to cause damage to a safety system is extremely low.

The HVAC system in the Control Room has two independent suction inlets which can be selected at the operator's discretion.

Stairwells design

1. Almaraz NPP

This point of the GS 1.19, section 8.13, has been included in the analyses of compliance with IS-30, rev.2 and SG 1.19.

Stairways included in escape and/or access routes comply with the requirements of Appendix A to BTP APCSB 9.51 regarding the provision of an enclosure with fire resistant walls and doors of a specified rating or the establishment of training plans by operating personnel and fire brigades.

In the electrical building, stairways included in escape and/or access routes are enclosed with fire-resistant walls and doors of a specified rating. The remaining buildings do not have enclosed stairwells, so as an alternative, training plans have been established by the operating staff and fire brigades.

2. Vandellós NPP

Stairwells serving as escape routes are enclosed in concrete towers with walls with a 2-hour fire resistance rating and doors of at least R90 (with the exception of containment, where stairwells do not have doors). Stairwells of the buildings (with the exception of containment) have skylights for smoke evacuation to the outside, which open automatically by means of a solenoid actuated by a detection signal in the loops covering the stairs. This ensures that any smoke present in the staircase is evacuated.

3. Cofrentes NPP

Stairways that are escape and/or access routes are enclosed with 3-hour fire resistant walls to protect them from external hazards, do not contain any combustible materials, and smoke is prevented from entering through the gaps in the doors by means of overpressure produced by fans with external air intakes. The start-up control of these fans shall be triggered in each case either automatically by a fire detection signal from the FACPs in nearby areas of greatest risk, or manually by means of two-position switches located at the stairway accesses at different elevations. Fans shall be stopped either by the disappearance of the automatic fire suppression signal, or by tripping the circuit breaker, according to the origin of the operating order.

The extraction fan house of the Radioactive Gas Disposal System is also pressurised.

Rooms with gas extinguishing systems

GS 1.19, section 8.13, point 9 relates to Guidelines of NFPA 12, *Carbon Dioxide Systems* [129] and NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems* [122], in rooms equipped with such systems to maintain adequate gas concentrations.

1. Almaraz NPP

There are fire zones with CO_2, FE-13, Argon, FM-200 and Novec 1230 suppression systems.

The NFPA-805 licensing reports analysed compliance with NFPA-12 and NFPA-2001 with respect to required gas volume, distribution system, support, detection and actuation, personnel safety and enclosure integrity, and validated their design.

2. Vandellós NPP

The FE-13 and Novec 1230 gas extinguishing systems have been designed in accordance with NFPA-2001. If the door fan test determines that the dampers must close in order to maintain the desired concentration for the required time, the dampers are closed by the fire detection signal.

3. Cofrentes NPP

At Cofrentes NPP, the fire zones with a gas flooding suppression system have FD2 type dampers installed. These are used in cases where the fire dampers must be closed before the gas is discharged, even if the temperature generated by the fire is not sufficient to melt the fuse.

ISFSI

The Independent spent fuel storage installation must comply with the applicable regulatory requirements of 10CFR 72 [97] and IS-29 [19]. Specifically, according to section 3.5.2 of this instruction: the installation shall have, where necessary, a ventilation and gas treatment system to ensure the containment of environmental contamination, both in normal operation and in the event of an accident. All environmental confinement systems at the installation shall be monitored to enable the operator to take corrective actions necessary to maintain safe conditions.

1. Almaraz NPP

The system used is a dry container system with protection and leak detection system and is located in the open air, so no ventilation system is used.

2. Vandellós NPP

Vandellós NPP does not have an ISFSI.

Trillo NPP's ISFSI (dry storage containers with protection and leak detection system) is in a building. The Storage Area is equipped with a Passive Ventilation System by natural convection, designed so that the temperature of the atmosphere inside the area does not exceed a pre-set value and evacuates the thermal load of the containers.

Area radiation monitors are available in various areas of the ISFSI whose upper alarm level is set in accordance with the restrictions of the plant's Radiation Protection Programme.

3. Cofrentes NPP

Storage is in the open air so no ventilation system is applied.

03.3.1.2.2 Performance and management requirements under fire conditions

Given the design provisions described in the previous section, in the event of fire, the fire area in question would be isolated by closing its fire dampers, allowing the fire to be confined.

This would also allow accessibility for the fire brigade for fire confirmation and firefighting actions, since the access and evacuation routes are established by staircases enclosed in concrete towers.

In radiological zone buildings, the ventilation system ensures a hierarchy of pressures that guarantees that air flows from areas of lower radiological concentration to areas of higher radiological concentration and from predictably less contaminated areas to areas of higher contamination and keeps the building depressed. As the stairways are areas of lower radiological concentration and contamination, they will be under overpressure with respect to the rest of the rooms, but under depression with respect to the outside.

In addition, according to Article 3.4.9 of IS-30 [4], the access and escape routes of all fire areas with safety important SSCs also have autonomous emergency lighting with individual batteries of at least 4 h, and 8 h of autonomy in areas where manual operator actions are performed in case of fire.

1. Almaraz NPP

There are access and escape routes, properly marked in all fire areas/zones of the plant.

Emergency lighting networks are distributed homogeneously throughout the plant, facilitating access and evacuation in complex areas, especially in vital areas for local actions.

A communication system is available. There are dedicated terminals for each ERO post in the TSC and OSC emergency centres (duplicated in the EMAC, to ensure availability).

Both the lighting system and the communication system stations can be powered via dedicated distribution boards from EDMG portable diesel generators.

In addition, there are 9 units of portable diesel-powered luminaires located in the safe secure storage slab.

2. Vandellós NPP

Access and evacuation routes are established by stairways enclosed in concrete towers with 2 h fire resistance walls with 90 minutes fire resistance doors (with the exception of containment, where stairways do not have doors) and free of combustible material. These stairwells (with the exception of containment) have skylights in accordance with NBE-CPI/82 [94], which open automatically by means of a solenoid actuated by a detection signal in the loops covering the stairs. This ensures ventilation of the staircase for evacuation.

The opening of the stairwell vents will allow the entry of fresh air for the evacuation of personnel (safe stairway) and for brigade access, but not the exit of fumes, which will be directed to the radiation monitors installed in the exhaust, or will be directed for appropriate treatment prior to venting to the outside. This avoids discharge without the consent of the radiation protection service.

The removal of the combustion products generated by the fire has been provided for in the design. The combustion products generated in the event of a fire are generally removed by the normal ventilation available in the different buildings, except in the Control Room, in the Control Building, and in the Control Room of the Waste Building, where fume extractors are available and there is no possibility of release of radioactive material. In the case of the cable distribution rooms and electrical rooms in the control building, a separate system is provided for smoke extraction if necessary.

In addition, in certain fire areas, portable extractors and flexible hoses connected to the general extraction ducts are intended to be used. The FHA indicates, for each fire area, the system for smoke extraction in the event of fire.

Trillo NPP has a regulatory approval of compliance equivalent to article 3.4.9 of IS-30 to have emergency lighting units with autonomy of less than 8h, based on the time required for actions and the diversity of lighting systems available.

3. Cofrentes NPP

Access and evacuation routes are established by stairways enclosed in concrete towers with 3 h fire resistance walls with 3 and 1.5 h fire resistance doors free of combustible material.

Fans are provided for the evacuation of smoke and combustion heat produced by a fire.

The staircases are pressurised by fans, which take air from outside these areas and blow it into them, pressurising them and infiltrating this air through the different rooms. By pressurising these areas, in the event of a fire, it is easier for personnel to exit or access the area where the fire has occurred. The fans shall be started by automatic signal from the fire stations.

Autonomous emergency lighting equipment is also available for fire management, with 8-hour autonomy for the control room escape route and for areas where manual actions by the operator are required. And equipment with 4h autonomy in all access and escape routes of all fire areas of the power plant.

Battery-powered hand-held watertight torches are available for emergency use by the fire brigade and other operating personnel required to achieve the safe shutdown of the plant. This equipment is located in fire cabinets throughout the plant.

An emergency wireless communication system is provided independently of the normal plant communications system.

03.3.1.3 Licensee's experience of the implementation of passive FP

03.3.1.3.1 Overview of strengths and weaknesses

The Spanish plants have made numerous improvements in passive fire protection as a result of adaptation processes to new regulatory requirements. In a first phase (the 2000s years), improvements derived from the analysis of compliance with paragraph III.G of Appendix R to 10 CFR 50 [6] were implemented. In the last two decades, the adaptation to the IS-30 [4], has led to, numerous design modifications, as well as regulatory approval processes of equivalent compliance for some specific cases, which have been adequately justified.

In addition, exhaustive reviews of the fire barriers have been carried out, verifying aspects of design, condition and testing, aimed at guaranteeing the sectorisation of fire areas and motivated by various operational experiences, as described in the following section.

Periodic safety reviews have also led to improvements as described below.

The Spanish nuclear power plants set up a working group made up of plant engineering staff, with the aim of carrying out a study of the impact of the change from US to European standards. An analysis of the regulations on FP Passive Protections was carried out, concluding the validity of the European standards as equivalent or superior to the American ones. This document was technically certified by an independent laboratory. Although a generic solution has not yet been adopted, certain scenarios for its use have been adopted.

In view of the above, it is not considered that there are any weaknesses relating to passive protection, except for an excessive dependence on American standards that slows down the purchasing processes necessary to resolve non-functionalities and implement improvements relating to passive protection, which would be resolved with the completion of the process of acceptance by the regulator of the comparative document drawn up by the plants and, therefore, with the generic acceptance of the use of passive protection certified with the European standards.

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

1. Almaraz NPP

The following improvements derived from IS 30 have been implemented at Almaraz NPP:

- Emergency lighting: in compliance with section 3.4.9, emergency luminaires with 24h autonomy (to cover also post-Fukushima requirements) were installed in 2015 on evacuation routes and at locations where local emergency actions are required.

- Wireless communication system: In order to comply with article 3.4.10, a dedicated wireless communication system, independent of the public address system, was implemented in 2015 to reach the safety important SSC areas of the plant.

As a result of the adaptation to NFPA 805, the following improvements have been implemented with regard to passive protection (both for risk criteria and for compliance with Chapter 3 of NFPA 805):

- Replacement of doors with certified ones.

- Installation of dampers in ventilation systems.

- Installation of passive protections on dampers and ventilation ducts.

- Installation of additional barriers to prevent communication between areas.

- Installation of FR barriers between FP pumps and other pumps in the intake structure.

- Separation of pumps from the seismic FP system.

- Replacement of ceramic blankets with approved passive protections on cable trays in the safeguards building.

- Installation of approved passive protections for protection of various cables in different fire zones, depending on the results of the fire PSA.

- Rerouting of cables as an alternative to passive cable protection.

- Improvements in cable ducts in false ceilings with the use of conduits.

2. Vandellós NPP

To ensure sectorisation, a systematic review of the barriers delimiting fire areas was carried out in 2006, following a reportable event, in order to verify that all elements are fire resistant and to make a database to ensure that they are all included in the applicable inspection and surveillance procedures. The following actions were carried out as follow-up actions:

- Repair or execution of sealing, including the installation of an R180 sealant in the joints between buildings to ensure the closure of fire areas, as well as in the penetrations of the electrical galleries into the buildings.

- Physical design modification to install two fire dampers in the Auxiliary building, one FR door and one fire damper in the CAT-diesel building, all with 3-hour fire resistance.

- Design modification to replace with R180 the door that connects the auxiliary building with the radiological access control building, previously not FR as it communicated with external areas.

- Documentary design modification to update the catalogue of elements, the fire hazard analysis, etc. with all FR elements, as well as the revision of the applicable procedures to include them.

- Modification, as a consequence of a reportable event, of a drain in the control building that could communicate smoke from different fire areas in the control building and design modification to install R180 seals in buried ducts through which fire areas in the control building and in turbine penetrations could be connected.

The following design modifications have been made in relation to passive protections necessary to ensure safe shutdown capability in the event of fire:

- Replacement of ceramic HEMYC type blankets by Thermo-lag R180 in electrical ducts in 3 fire areas as well as a valve in a fire area of the auxiliary building for compliance with Appendix R to 10CFR50 [6].

- Protection of a train B duct in the control building by Thermo-lag R180, implemented in the framework of the technological safeguards cooling water system (EJ).

- Implementation of a R180 wall for the separation of redundant level transmitters in the condensate storage tank to replace the original ceramic blankets installed.

In recent years, as part of the process of adaptation to IS-30 [4] additional modifications of passive protections have been implemented in some cases to guarantee the separation of redundant safe shutdown train elements in accordance with the alternatives contemplated in IS-30 in its article 3.2.5 or to guarantee the safe shutdown capability taking into account the conclusions of the fire safe shutdown analysis carried out considering multiple spurious operations caused by fire, in accordance with the methodology of the document NEI-00-01 [40]:

- Installation of an R180 wall for the separation of redundant level transmitters from the feedwater system support tank to replace the original ceramic blankets installed.

- Installation of passive protection in an electrical box in the control building.

- Protection of cables to enable the steam generator relief valves to be closed in the event of spurious opening due to fire.

- Protection of pressure transmitter cables in containment to prevent spurious safety injection signal due to fire.

- Cable protection of the charging pump aligned to train A in the train A cable distribution room of the control building.

- Installation of fire-stops in the turbine penetration enclosures on the train N cable trays corresponding to the Steam Generator relief valves.

In 2019, a compilation of the documents supporting the homologation of all sealing types was carried out. It was identified that some of them installed during the construction of the plant required further documentary support in order to verify their fire resistance according to current regulations, so in 2020 fire tests were carried out according to ASTM E-119 [95] in an approved laboratory. As a result, it was found that a specific type of seal did not meet the required fire resistance of 3 h. Therefore, fire tests were performed on other seals that could be used in the same location and a design modification was implemented to supplement or replace the existing seals and guarantee the 3-hour fire resistance.

As a result of the above reportable event, a detailed review of the certificates for each type of sealing device installed identified that the 3M Pass Through devices (intumescent collars) installed in 8 penetrations of the CAT-Diesel building did not comply as R180, but had a certificate of compliance of 2 h for integrity (F rating) and 1.5 h for insulation (T rating). Although in no case was the safe shutdown capability affected, as the deterministic criteria of having R180 fire barriers was not met, a design modification was made to implement approved R180 seals and additionally to install the appropriate sealing in one of the drains of the toilet in the technical support centre building.

Likewise, by means of the analysis of safe shutdown in the event of fire, and as included in the FHA, the availability of a train free of damage in the event of fire has been verified for all the fire areas accounting for all the credited active and/or passive fire protection means available. Where a train free of damage cannot be guaranteed (in accordance with article 3.2.5 of IS-30 [4]), safe shutdown is ensured by the execution of operator manual actions (OMA), properly proceduralised and validated and with the regulatory approval of the CSN. The process followed for the regulatory approval of OMAs is described in the analysis section (02.1.6.1.1).

Additionally, as a result of the analysis of external areas carried out in accordance with RG-1.189 [34] as an improvement action within the scope of the 3rd periodic safety review of Vandellós NPP, a design modification is planned to be carried out in the 2024 refuelling outage to separate the redundant level transmitters from the refueling water storage tank by means of an R180 wall.

3. Cofrentes NPP

No improvements were identified by WANO at Cofrentes NPP in the area of passive protection.

Following a recommendation from NEIL, a fire-resistant separation wall has been installed between the main and standby transformers.

No PSR improvements were identified at Cofrentes NPP in the passive protection area.

As a consequence of the implementation of IS-30, the following improvements were carried out:

- To comply with 3.2.3, 3.2.4 and 3.2.5 concerning the separation of redundant safe shutdown trains, three modifications were implemented to keep at least one of the trains free of damage.

- In order to comply with point 3.4.5 on the design of HVAC systems, it was verified that the ventilation and air-conditioning systems are designed to isolate each fire area from the others in the event of a fire and that cutting off the air supply to each fire area does not affect the proper functioning of safety components located in other areas of the plant. Through a design modification, the fire dampers were replaced with others with 3-hour fire resistance rating.

- In order to comply with point 3.4.9, relating to emergency lighting and access and escape routes, through design modifications, emergency lighting units with individual batteries of at least 8 hours autonomy were installed in the areas where manual operator actions are performed in case of fire and on the access route to these SSCs.

- In order to comply with point 3.4.10, regarding the communication system, emergency communication systems independent from the normal system, two-way, and reaching all areas of the plant with safety important SSCs were installed.

03.3.1.3.3 Overview of actions and implementation status

1. Almaraz NPP

The following improvements derived from IS-30 have been implemented at Almaraz NPP:

- Emergency lighting: in compliance with section 3.4.9, emergency luminaires with 24h autonomy (to cover also post Fukushima requirements) were installed in 2015 on evacuation routes and in places where local emergency actions are required.

- Wireless communication system: In order to comply with article 3.4.10, a dedicated wireless communication system was implemented in 2015 to reach the safety important SSC areas of the plant, independent of the public address system.

As a result of the adaptation to NFPA 805, the following improvements have been implemented with regard to passive protection:

- Replacement of doors with certified ones.

- Installation of dampers in ventilation systems.

- Installation of passive protections on dampers and ventilation ducts.

- Installation of additional barriers to prevent communication between areas.

- Installation of FR barriers between FP pumps and other pumps in the intake structure.

- Separation of pumps from the seismic FP system.

- Replacement of ceramic blankets with approved passive protections on cable trays in the safeguards building.

- Installation of approved passive protections for various cables in different fire zones, depending on the results of the fire PSA.

- Rerouting of cables as an alternative to passive cable protection.

2. Vandellós NPP

Improvements resulting from new regulatory requirements:

- Replacement of HEMYC type ceramic blankets with passive protections approved for compliance with section III.G of Appendix R to 10CFR50:

- Installation of approved passive protections to ensure safe shutdown capability in case of fire derived from the reviews of the safe shutdown analysis for the adaptation to IS-30, complementary to the validation of operator manual actions (OMA):

Improvements resulting from comprehensive reviews of barriers to ensure sectorisation of fire areas and from related operational experience:

- Actions arising from the design and barrier review process

- Actions arising from barrier certification reviews.

PSR-derived improvements:

- Analysis of outdoor areas according to RG-1.189:

- Design modification, expected to be implemented in 2024, to separate the redundant level transmitters from the RWST by means of an R180 wall:

In the case of Trillo NPP, the plant represented by Vandellós NPP, the following actions and analyses have been carried out to adapt the plant to the IS-30 requirements on FR barriers by means of equivalent compliance. All of them have regulatory approvals by the CSN:

- Use of Article 3.2.1.5.d (separation of safety-related SSCs within the same fire area) to the separation between redundant SSCs in different fire areas (communications between different floors in the annulus building through the gap between annulus and containment, as well as barriers with FR less than 180 min in cable routing areas of the diesel building).

- Use of Article 3.2.1.5.c (separation of redundant SSCs in the same fire area) to the separation of SSCs in different fire areas with FR less than 180 min (separation of cable rooms in the emergency building).

- Use of compensatory measures (prohibition of combustible material storages, surveillance watches and testing of suppression systems at higher frequency) in areas near gaps between buildings (gallery joints not R180 or not complete). The aforementioned fire areas have been subject to different improvements with respect to the initial configuration of the plant, having obtained a degree of protection equivalent to a separation with R180 by means of specific configurations (application of section 3.2.5.d of IS-30 and its extension to separation between redundant elements in different fire areas).

- Application of criteria equivalent to 3.2.5.1 to the absence of fire dampers in the annulus atmosphere suction and filtration system (use in LOCA).

- No separation between redundant elements on the tower terraces of the essential service water system (based on low thermal load and suppression means). (Alternative to Articles 3.2.3 and 3.2.5.1.)

- Separation (3.2.3) in essential service water pump houses by partial barriers as well as on the diesel building terrace and in the valve chamber (main steam and main feedwater systems).

- Consideration of the (metal) containment sphere and airlocks as a suitable fire barrier (3.2.3).

- Manual operator action (3.2.9), local trip of an extra borating system train that could lead to an uncontrolled pressure drop in the RCS.

3. Cofrentes NPP

Improvements derived from the Peer Review:

- No improvements were identified by WANO at Cofrentes NPP in the area of passive protection.

NEIL-derived improvements:

- Installation of a fire-resistant separation wall between the main and stand-by transformers already completed.

PSR-derived improvements:

- No PSR improvements were identified at Cofrentes NPP in the passive protection area.

Improvements resulting from the implementation of IS-30:

- Separation of redundant safe shutdown trains by 3 design modifications (DMs) already implemented.

- Replacement of fire dampers, by means of a DM already carried out.

- Emergency lighting on access and escape routes by means of 2 DMs already implemented.

- Independent emergency communication system installed by means of 2 DMs already completed.

03.3.1.4 Regulator's assessment of passive fire protection

The issuance of CSN Instruction IS-30 has also had a strong impact on regulatory activities in relation to fire-resistant barriers, just as the inspections performed in compliance with procedures PT.IV.204 and PT.IV.205 ensure the maintenance of adequate passive fire protection.

03.3.1.4.1 Overview of strengths and weaknesses in passive fire protection

The regulator highlights the following initiatives undertaken by the licensees in general:

- Analysis and improvement of passive barriers (blankets) with fire resistance not certified in accordance with GL 86-10 Supplement 1.

- Approval of fire resistant barriers without documentation.

- Comprehensive review and complete inventory process of fire resistant barriers in the various nuclear power plant buildings.

- Corrective actions in the absence of adequate separation (operator actions, cable routing, reconfiguration of fire areas also through HVAC systems).

03.3.1.4.2 Lessons learned from inspection and assessment on passive fire protection as part of its regulatory oversight

A process of monitoring the inspection procedures for fire-resistant seals at the different nuclear power plants has been in place, as required by letter from the Nuclear Safety Technical Directorate dated 4 March 2021. This tracking has been regularly incorporated into the CSN inspections programme, carried out according to procedures PT.IV.204 and PT.IV.205, verifying the effectiveness of the improvements in the inspection procedures and techniques incorporated by the licensees.

On the other hand, progressive attention is being given to the use of new fire resistant materials and the adoption of non-NFPA European standards as acceptable alternative standards to meet the requirements of the Instruction and to include them in GS 1.19.

03.3.1.4.3 Conclusions drawn on the adequacy of the licensee's passive fire protection

In general, it is considered that the implementation of passive fire-resistant barriers by the licensees is adequate and has been reinforced with numerous actions carried out by the licensees after the implementation of IS-30, such as the replacement of barriers with deficient fire resistance in those areas identified in their detailed review. This process has been monitored through the inspections carried out under procedures PT.IV.204 and PT.IV.205.

03.3.2 Passive fire protection in FCF

03.3.2.1 Prevention of fire spreading (barriers)

03.3.2.1.1 Design approach

In accordance with the general approach to fire protection, safety important structures, systems and components are designed and located so as to minimise the likelihood and effect of fires and explosions, and having particular regard to the criteria derived from the application of the defence in depth concept (and others such as single failure design, redundancy and diversity), the fire resistant elements subsystem is intended to provide confinement by fire sectors which ensure that fire does not spread from one affected area to others for a minimum endurance time as determined in Table 03.3.2.1.2.

To fulfil its function, the system is equipped with:

- Sectorisation of the Ceramics Area, Pump Room and Generator Room.

- Fire resistance capacity of the construction elements and penetrations between sectors during the established time.

The design of the installation responds to the requirements of the regulatory body in its different documents (letters, instructions, inspection reports, etc.), which are included in Chapter 3 of the SAR of the installation, and the following royal decrees and standards have also been taken into account:

- R.D. 2267/2004, of 3 December, approving the Fire Safety Regulations for Industrial Establishments [74].

- R.D. 1942/1993, of 5 November, Regulation of Fire Protection Installations [75].
- NBE-CPI 96 (Building basic standard: Fire Protection Conditions) [144].
- R.D. 314/2006, of 17 March, approving the Technical Building Code (DB SI: Safety in case of fire) [77].
- Royal Decree 513/2017, of 22 May, approving the Regulation on fire protection installations [78].

03.3.2.1.2 Description of fire compartments and/or cells design and key features

In the factory, taking advantage of the existing compartmentalisation due to the construction solution or civil works in the Ceramics Area, Generator Rooms and Pump Room, the following fire sectors have been created:

Table 03.3.2.1.2

AREA	Description	Intrinsic Risk Level	Minimum required fire resistance for the sector
1.3	Chemical Laboratory	LOW 2	R30
1.6	Dust reception	LOW 2	R30
1.7	BWR pressing area	LOW 1	R30
1.8	BWR sintering area	LOW 2	R30
1.9	BWR grinding area	LOW 2	R30
1.10	Dust storage	LOW 2	R30
1.11	PWR pressing area	LOW 1	R30
1.12	PWR sintering area	LOW 2	R30
1.13	PWR grinding and loading area	LOW 1	R30
1.14	UO_2 Solid waste treatment	LOW 2	R30
1.15	BWR mixing area	LOW 1	R30
1.16	BWR General Services	LOW 1	R30
1.17	PWR mixing area	LOW 1	R30
1.18	PWR General Services	LOW 1	R30
1.19	Gd Pressing and Sintering area	LOW 2	R30
1.20	Gd grinding and bar load	LOW 1	R30

AREA	Description	Intrinsic Risk Level	Minimum required fire resistance for the sector
1.21	Gd General services	LOW 1	R30
1.22	Gd Solid waste treatment	LOW 2	R30
2.4	Generator room	HIGH 6	R120
3.1	Electric pump room	LOW 1	R30
3.2	Diesel pump room	MEDIUM 5	R60
11.1	Component Warehouse	HIGH 6	R90

The risk levels and minimum required fire resistance shown in the table above are obtained by applying R.D. 2267/2004 [74]. The determination of the minimum required fire resistance takes into account both the risk of the zone itself and the typology of the building in which the zone is located.

Sectorisation is achieved by the arrangement of elements with a fire resistance higher than that required by the intrinsic risk level. These elements are, in addition to the construction itself, walls, fire doors, internal fire dampers in the ventilation ducts that cross different fire sectors and at the entrance and exit of the secondary filtration units, sluice dampers in the service shafts between different sectors and sealing of the passage of plastic pipes and electrical wiring.

a) Constructive elements:

- The walls of the fire sectors corresponding to the Manufacturing and Auxiliary buildings are constructed with materials of variable fire resistance between 240 and 120 minutes as a minimum, which is much longer than the time required according to the intrinsic risk level.

- The walls of the fire sectors corresponding to the Generator Rooms and Fire Pump Rooms have a fire resistance of at least 180 minutes.

- Electrical power distribution has been carried out with non-flame propagating cable, in accordance with R.D. 2267/2004 [74].

- The installation is protected by a lightning rod system.

b) Penetrations:

- The fire doors for access between the different sectors have a door-closing maintenance capability (closing spring). Their fire resistance ranges from 60 to 180 minutes.

- The process openings in the walls between sectors are fitted with automatic fire dampers, with gravity closing and fuse element. Its fire resistance is 120 minutes.

- The ventilation ducts in the ceramic area connecting different sectors are fitted with fire dampers with automatic mechanical closing by spring and fuse. Its fire resistance is 120 minutes.

- Installation openings between fire compartments, such as plastic pipe runs, cable trays, etc., are sealed with appropriate materials to achieve at least a 120 minutes fire resistance.

c) Others:

- The secondary filters of the extraction system, due to their importance in controlling emissions to the environment, are protected by fire dampers of 120 minutes fire resistance, located between the filters and the engine unit.

03.3.2.1.3 Performance assurance through lifetime

All the elements involved in the passive protection of the installation are verified and controlled according to the Surveillance Requirements established in the TS for operation and are carried out:

- Triennial inspection of fire resistant elements and penetration seals.
- Annual inspection of fire doors.
- Annual inspection of fire dampers.

03.3.2.2 Ventilation systems

03.3.2.2.1 Ventilation system design: segregation and isolation provisions (as applicable)

The Ventilation and Air Conditioning System used for air treatment in the Ceramics Area where there is a risk of environmental radiological contamination is considered a safety system. The functions of the safety system are as follows:

- Keep the Ceramic Zone in depression with the outside in order to prevent the spread of contamination.
- Establish correct air depression and air flow values in glove box cabinets and hoods where radioactive material is handled so as to minimise the risk of contamination of people and materials.
- Maintain air circulation, filtration and renewal in the areas to obtain clean ambient air.
- Absolute filtration (HEPA filters) of all the air coming from this Zone to the outside.

To guarantee the proper functioning of the extraction and air conditioning systems, the system is permanently monitored, generating alarms and warnings in the event of filter clogging, and in case of changes in flow rates and pressures in the working areas and cabins. Filter clogging alarms are detailed in the ventilation system and not in the fire system. Clogging warnings indicate the need for a scheduled shutdown to replace filters or pre-filters. See section 03.2.2.1.2 of this NAR.

03.3.2.2.2 Performance and management requirements under fire conditions

Whether or not to keep ventilation in fire areas in service is decided at the discretion of the Fire Brigade Chief or Fire responders Chief depending on the characteristics and circumstances of the fire (presence or absence of flames, quantity of smoke, risks present in the area, form of intervention of the FP Brigade, etc.).

During a fire, if the ventilation is kept in operation, all air/smoke will continue to be filtered by the absolute filtration stage and, before the filters can be damaged by temperatures, the fire dampers in the ducts will be closed at those points where they cross from one fire sector to another and before and after the second absolute filtration stage. On the basis of the above, aerosols, during a fire, as long as sectorisation is maintained (doors are closed, dampers of openings or ducts are closed, without loss of seals at penetrations), will remain retained in the areas or in the secondary filtration stages without the possibility of escape to the environment.

The only very unlikely circumstances in which aerosols could spread outside the Ceramic Zone would be the failure of any of the elements arranged to achieve sectorisation, failure or collapse of the enclosure structure or fire in the second stage filtration unit itself, followed by the failure or collapse of the downstream fire dampers.

In addition, there is a fire detector located in the ventilation ducts downstream of the second filtration stage that automatically shuts down the unit.

03.3.2.3 Licensee’s experience of the implementation of passive FP

Same as paragraph 03.1.2.3.

03.3.2.3.1 Overview of strengths and weaknesses

The second periodic safety review carried out by the factory covered the period from 01/01/2005 to 31/12/2014, obtaining the renewal of the Operating and Manufacturing Authorisations on 05/07/2016.

The conclusions of this PSR in relation to Passive Fire Protection showed that the Licensing Basis and Design Basis were complied with and that monitoring and maintenance was carried out in accordance with the requirements to ensure proper operation.

No need for improvements was identified.

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

Throughout these years, different types of actions have been implemented as a result of incidents occurring at the facility.

The most relevant incidents leading to improvements are the following:

- An anomaly identified in the implementation of the design criteria for the fire detection system and the special fluids system, which has led to the interlocking between the two systems not being carried out correctly in some sub-areas.
- Anomaly in the implementation of the passive protection criteria of the fire sectors, as it was detected that there is an unsealed process gap and that there are 3 points that are not on the corresponding plan.

- A fire damper covering a forklift shaft lost some of its performance due to work on the construction of a new forklift.
- An empty pellet drum overturned and remained unnoticed under the fire damper that separates two areas, preventing the damper from performing its function.
- Defect of a penetration in a wall due to deterioration of the material.

03.3.2.3.3 Overview of actions and implementation status

The corrective actions or improvements implemented as a result of the lessons learnt from the Operational Experience, including those extensions carried out because of the event analyses, were:

- Administrative Measures:
    - Updates to the plan in relation to seals.
    - Reviews of internal procedures governing activities such as the treatment of penetrations and fire dampers.
- Design modifications to install optical and acoustic stop signals at drum crossings.

In addition, other design modifications have been made that have led to significant improvements in the passive FP, among which the following are worth highlighting:

- Sealing of pipe penetrations in walls
- Automatic double-hinged doors in ceramic. This improves the movement of nuclear material between the different manufacturing areas, improving the quality of the product moved and reducing risk situations by eliminating unnecessary stops for the opening of doors, without reducing fire resistance and maintaining the fire resistance of the doors. This modification is ongoing.

The facility is undergoing a complete modification of the ventilation and air conditioning system, which has affected the passive fire protection system because the fire dampers in the ventilation units have been replaced with new ones of equal performance.

03.3.2.4 Regulator's assessment of passive fire protection

Passive fire protection at the Juzbado factory is supervised mainly by inspection, following procedure PT.IV.87.

03.3.2.4.1 Overview of strengths and weaknesses in passive fire protection

The operator has made improvements to its HVAC units resulting from the replacement of fire dampers.

03.3.2.4.2 Lessons learned from inspection and assessment on passive fire protection as part of its regulatory oversight

In recent years areas for improvement have been identified in relation to the interaction of the Plant processes in compartmentalisation elements (dampers and fire doors) for which the licensee has already initiated the appropriate actions, the performance of which is being supervised by means of the CSN inspections performed according to PT.IV.87.

03.3.2.4.3 Conclusions drawn on the adequacy of the licensee's passive fire protection

The regulatory body observes adequate control of passive protections by the licensee who is in the process of rectifying the minor deficiencies found, modifications that will be supervised according to the inspection procedure PT.IV.87.

04 Overall Assessment and General Conclusions

Generally speaking, the current regulatory framework in Spain for fire protection in nuclear power plants has experienced a great regulatory advance, which has led to a considerable enhancement of the fire protection management by the facilities.

The entry into force of IS-30 has meant, from a methodological point of view, the adoption of complete and systematic methodologies of analysis, by integrating deterministic and probabilistic approaches, thereby dealing with the concept of fire protection in an integral way in order to achieve its objectives. In this regard, the analysis methodologies applied are considered to be among the best international standards of reference.

On the other hand, the supervision process carried out under this regulation has made possible to identify the main areas for improvement and to adequately monitor the actions taken by the licensees of the installations to achieve these improvements. This inspection process is carried out within the framework of the CSN's basic inspection plan through inspection procedures PT.IV.87, PT.IV.204, PT.IV.205 and PT.IV.225.

The inspection and assessment tools and the Periodic Safety Review tools, with their respective procedures, some of which are undergoing very recent or forthcoming revisions, make it possible to carry out this monitoring process more effectively.

This has resulted in a number of improvements in various aspects of FP, such as passive and active elements, as well as firefighting equipment, which have led in general to a top level standards of quality and efficiency.

New innovative elements developed by the licensees relate to:

- Integrated risk-informed FP management processes.
- Carrying out scheduled and monitored fire watches using computerised tools.

In addition, it is necessary to emphasise the importance and relevance of having a professional fire brigade on-site at the plants currently in operation, and dedicated exclusively to fire-fighting tasks. This brigade is supported by external fire brigades if necessary, for which subscription of support protocols with the relevant authorities is mandatory.

However, an aspect has been identified in the operating nuclear power plants that could favour obtaining additional operating experience inputs, which is:

- Encourage the use and active participation of licensees to make a better use of fire operational experience database.

In relation to the fuel assembly factory, the following improvement action is identified:

- As part of the processes of on-going improvement and analysis of the standards that is going to be carried out during the PSR of the operating permit for the Juzbado factory, the licensee will be requested to study specific standards available, including IAEA guidelines, in order to develop a fire protection programme that consolidates and addresses with a global approach all the analyses currently being performed by the licensee and the measures already adopted from the point of view of prevention and passive and active protection.

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[23] CTI to all the NPP: CTI 1, CTI 2, CTI 3 and CTI 4. CTI 1 and 3 specifically related to Fukushima events and CTI 2 and 4 covering the loss of major areas (covering man-made hazards beyond design bases). Similar CTI with an adapted scope to NPP CTI 1 and 3 were also issued to Juzbado FCF. For the represented NPP and for Juzbado, the CTI references are:

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CTI 2: CNALM/AL0/SG/11/15, CNVAN/VA2/SG/11/14 and CNCOF/COF/SG/11/07.

CTI 3: CSN/ITC/SG/AL0/12/01, CSN/ITC/SG/VA2/12/01, CSN/ITC/SG/COF/12/01 and CSN/ITC/SG/JUZ/12/01

CTI 4: CSN/ITC/SG/AL0/12/02, CSN/ITC/SG/VA2/12/02 and CSN/ITC/SG/COF/12/02.

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[69] Order TED/308/2021, 17 march, renewal of the exploitation authorisation of Cofrentes NPP

[70] RG 1.200, rev. 2, An approach for determining the technical adequacy of probabilistic risk assessment results for risk-informed activities, march 2009.

[71] NEI 07-12, Fire probabilistic risk assessment peer review process guidelines

[72] IEEE 383-1974 IEEE Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations

[73] IAEA SSR-4, Safety of Nuclear Fuel Cycle Facilities

[74] Royal Decree 2267/2004 of 3 December 2004, approving the regulation on fire safety for industrial establishments

[75] Royal Decree 1942/1993, of 5 November 1993, approving the regulation on fire protection installations

[76] Royal Decree 279/1991 of 1 March 1991 approving the Basic Building Regulations NBE-CPI/91: Fire protection conditions in buildings

[77] Royal Decree 314/2006, of 17 March, approving the Technical Building Code (TBC)

[78] Royal Decree 513/2017, of 22 May, approving the Regulation on fire protection installations

[79] Royal Decree 400/1996 (Transposition of Directive 94/9/EC) concerning equipment and protective systems for use in potentially explosive atmospheres

[80] Royal Decree 681/2003 (Transposition of Directive 99/92/EC) on the protection of the health and safety of workers exposed to risks arising from the presence of explosive atmospheres in the workplace

[81] Technical guide for the assessment and prevention of risks arising from explosive atmospheres in the workplace, RD.681/2008 of 12 June

[82] NUREG-1513 Rev. 0 Integrated Safety Analysis Guidance Document

[83] NUREG-1520 Rev. 1 Standard Review Plan for the Review of a License Application for a Fuel Cycle Facility

[84] NFPA 30, Flammable and combustible liquids code

[85] ASTM E84, Standard Test Method for Surface Burning Characteristics of Building Materials

[86] Royal Decree 656/2017, of 23 June, approving the Regulation on the storage of chemical products [86]).

[87] Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014, on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres

[88] Royal Decree 1215/97, of 18 July, establishing the minimum safety and health requirements for the use of work equipment by workers

[89] Directive 1999/92/EC of the European Parliament and of the Council, of 16 December 1999, on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres.

[90] Royal Decree 485/1997, of 14 April, establishing the minimum provisions regarding occupational health and safety signaling

[91] ANSI/ASME B31.1, Power piping

[92] IEEE 384, IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits

[93] RG 1.75, Criteria for independence of electrical safety systems

[94] NBE-CPI/82, Fire protection conditions in buildings

[95] ASTM-E119, Standard Test Methods for Fire Tests of Building Construction and Materials

[96] RG 1.52, Design, inspection, and testing criteria for air filtration and adsorption units of post-accident engineered-safety-feature atmosphere cleanup systems in light-water-cooled nuclear power plants

[97] 10CFR72, Licensing requirements for the independent storage of spent nuclear fuel, high-level radioactive waste, and reactor-related greater than class C waste

[98] Royal Decree 842/2013, of 31 October, approving the classification of construction products and construction elements based on their reaction properties and resistance to fire.

[99] NFPA 5000, Building Construction and Safety Code

[100] NFPA 101, Life Safety Code

[101] UNE-EN 13501-1:2004, Classification of construction products and construction elements based on their behavior in fire

[102] UNE-EN 14303, Thermal insulating products for building equipment and industrial facilities. Manufactured mineral wool (MW) products. Specification.

[103] NFPA 51B, Standard for Fire Prevention During Welding, Cutting, and Other Hot Work

[104] Royal Decree 2060/2008, of 12 December, approving the Pressure Equipment Regulation

[106] UNE-EN-1634-1, Fire resistance and smoke control tests of doors and opening enclosure elements, operable windows and building fittings. Part 1: Fire resistance tests of doors, opening closing elements and operable windows

[107] UNE-EN-1598, Health and safety in welding and allied processes - Transparent welding curtains, strips and screens for arc welding processes.

[108] NFPA 72, National fire alarm and signaling code

[109] Order of the Ministry of Industry and Energy of 14 January 1985 granting the entity Empresa Nacional del Uranio, S.A. (ENUSA) the provisional operating permit for the Uranium Oxide Fuel Plant at Juzbado (Salamanca)

[110] Order of the Ministry of Industry and Energy of 14 January 1985 granting the entity Empresa Nacional del Uranio, S.A. (ENUSA) the provisional operating permit for the Uranium Oxide Fuel Plant at Juzbado (Salamanca)

[111] Royal Decree 450/2022, of 14 June, amending the Technical Building Code in the sections associated with fire prevention

[112] CSN/C/SG/JUZ/16/01, Complementary Technical Instructions associated with the Operating and Manufacturing Permits of Juzbado fuel fabrication facility.

[113] 10 CFR 21, Reporting of defects and noncompliance

[114] 10 CFR 70, Domestic licensing of special nuclear material

[115] SG 03.01, Modifications in fuel fabrication facilities

[116] NFPA-24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances

[117] NFPA-14, Standard for the Installation of Standpipe and Hose Systems

[118] NFPA-13, Standard for the Installation of Sprinkler Systems

[119] NFPA-15, Standard for Water Spray Fixed Systems for Fire Protection

[120] NFPA-16, Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems

[121] NFPA-750, Standard on Water Mist Fire Protection Systems

[122] NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems

[123] NFPA-10, Standard for Portable Fire Extinguishers

[124] NFPA-1582, Standard on Comprehensive Occupational Medical Program for Fire Departments

[125] CSN/C/SG/VA2/21/05, CN Vandellós II. Regulatory approval of equivalent compliance with Annex A.7 (requirements onf detection and suppression systems con cable raceways) of IS-30

[126] UNE 23007-14, Fire detection and fire alarm systems. Part 14: Planning, design, installation, commissioning, use and maintenance

[127] UNE EN 60849, Sound systems for emergency purposes

[128] UNE 23120, Maintenance for fire extinguishers

[129] NFPA-12, Standard on Carbon Dioxide Extinguishing Systems

[130] ACI 216.1-97, Standard Method for Determining the Fire Resistance of Concrete and Masonry Construction Assemblies.

[131] NFPA 251, Standard Methods of Tests of Fire Resistance of Building Construction and Materials

[132] GL 86-10 suplement 1, Fire Endurance Test Acceptance Criteria for Fire Barrier Systems Used to Separate Redundant Safe Shutdown Trains Within the Same Fire Area

[133] UL-10B, Standard for Safety - Fire Tests of Door Assemblies

[134] UL-555, Fire dampers

[135] The NFPA Fire Protection Handbook

[136] DIN 4102, Fire test to building materials

[137] NUREG 0452, Standard Technical Specifications for Westinghouse Pressurized Water Reactors

[138] CSN/C/SG/VA2/20/09, CN Vandellós II. Regulatory approval of equivalent compliance of IS-30 articles 3.4.5 y 3.4.6 (HVAC) and 3.4.1 (fire detection)

[139] NFPA 204M, Standard for Smoke and Heat Venting

[140] SG 1.03, Nuclear facility emergency management planning and response

[141] RG 1.140, Standard for Smoke and Heat Venting

[142] UL-900, Safety Requirements for Air Filter Units

[143] UL-586, Standard for High-Efficiency, Particulate, Air Filter Units

[144] NBE-CPI 96, Building basic standard: Fire Protection Conditions

List of acronyms

Acronym	Meaning
AFFF	Aqueous Film-Forming Foam
AFI	Area For Improvement
ANAV	Asociación Nuclear Ascó-Vandellós
ANSI	American National Standards Institute
AOP	Abnormal Operating Procedure
ASME	American Society of Mechanical Engineers
ASDP	Alternative Shutdown Panel
ASTM	American Society for Testing and Materials
ATEX	Explosive Atmospheres
BFL s1	Fire retardant
BIP	Base Inspection Program
BOE	Boletín Oficial del Estado – Official Gazette
BTP	Branch Technical Position
BWR	Boiling Water Reactor
CCW	Component Cooling Water
CD	Alternator oil drainage system
CDF	Core Damage Frequency
CFR	Code of Federal Regulations
CJ	Auxiliary turbines oil drainage system
CNAT	Almaraz-Trillo Nuclear Power Plant
COSS	Computerised Operator Support System
CSN	Nuclear Safety Council (Consejo de Seguridad Nuclear)
CTE / TBC	Código Técnico de Edificación / Technical Building Code
CTI	Complementary Technical Instruction
CVCS	Chemical & Volume Control System
DCH	Direct Containment Heating
DG	Diesel Generator
DM	Design Modification
DW	Demineralised Water
ECCS	Emergency Core Cooling Systems
EDMG	Extensive Damage Management Guidelines
EG	Vandellós NPP water Component cooling water system
EJ	Vandellós NPP Technological safeguards cooling water system
EMAC	Emergency Management Alternative Center
EMU	Emergency Military Unit
ENRESA	Empresa Nacional de Residuos Radiactivos S.A.
ENSREG	European Nuclear Safety Regulators Group
ENUSA	Empresa Nacional del Uranio S.A.
EOP	Emergency Operating Procedure
EPR	Ethylene propylene rubber
EPRI	Electric Power Research Institute
ERO	Emergency Response Organisation
ESC	Emergency Support Center
ESW	Essential Service Water
EURATOM	European Atomic Energy Community
FACP	Fire Alarm Control Panel
FAQ	Frequently Asked Questions
FCA	Fire Contingency Action
FCF	Fuel Cycle Facility
FDF	Fuel Damage Frequency
FDS	Fire Dynamics Simulator

FDT	Fire Dynamic Tools
FINAS	Fuel Incident Notification and Analysis System
FIT	First Intervention Team
FHA	Fire Hazard Analysis
FHC	Fire Hose Cabinet
FP	Fire Protection
FPB	Fire protection Brigade
FPM	Fire Protection Manual
FPP	Fire Protection Procedures
FP TRM	Fire Protection Technical Requirements Manual
FR	Fire resistant
FRWP	Fire Risk Work Permit
FSA	Fire Safety Analysis
FSG	Flex Support Guidelines
GDC	General design criteria
GE	General Electric
GL	Generic Letter
GSR	General Safety Requirements
HEAF	High Energy Arcing Fault
HEF	High Efficiency Filter
HEPA	High Efficiency Particle Arresting
HGLT	Hot Gas Layer Temperature
HPCS	High Pressure Core Spray
HRE	Higher Risk Evolutions
HVAC	Heating, ventilation, and air conditioning
IAEA	International Atomic Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IPE	Individual Plant Examination
IROFS	Items relied on for Safety
IS	CSN Instruction
ISA	Integrated Safety Analysis
ISFSI	Independent Spent Fuel Storage Installation
I&C	Instrumentation and Control
KSF	Key Safety Function
KWU	Kraftwerk Union
LB	Licensing Basis
LERF	Large Early Release Frequency
LOCA	Loss of Coolant Accident
LOOP	Loss of Offsite Power
LPCI	Low Pressure Coolant Injection
LPCS	Low Pressure Core Spray
LPSD	Low Power and Shutdown
LRF	Large Release Frequency
MCC	Motor Control Center
MOV	Motor Operated Valve
MOX	Mix Oxide
MSO	Multiple Spurious Operations
NAR	National Assessment Report
NEA	Nuclear Energy Agency
NEI	Nuclear Energy Institute
NEIL	Nuclear Electric Insurance Limited
NFPA	National Fire Protection Association
NMP	Non Mitigated Probability

NMR	Non Mitigated Risk
NN	Nuclenor
NPP	Nuclear Power Plant
NPSH	Net Positive Suction Head
NRC	Nuclear Regulatory Commission
NUMARC	Nuclear Management and Resources Council
NUREG	US Nuclear Regulatory Commission Regulation
OMA	Operator Manual Action
OSART	Operational Safety Review Team
OSC	Operative Support Center
OSEP	On-site Emergency Plan
PDS	Plant Damage State
PFP	Pre Fire Plan
PI&R	Problem Identification and Resolution Program
PORV	Pressure Operated Relief Valve
POS	Plant Operational State
PO&C	Performance Objectives & Criteria
PSA	Probabilistic Safety Analysis
PSR	Periodic Safety Review
RSDP	Remote Shutdown Panel
PVC	Polyvinyl Chloride
PWR	Pressurized Water Reactor
PWROG	Pressurized Water Reactor Owners Group
RCIC	Reactor Core Isolation Cooling
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RD	Royal Decree
RG	Regulatory Guide
RHR	Residual Heat Removal
RL	Reference Level
RLE	Review Level Earthquake
RP	Radiological Protection
RWCU	Reactor Water Cleanup System
RWST	Refueling Water Storage Tank
SAG	Severe Accident Guidelines
SAR	Safety Analysis Report
SBO	Station Blackout
SCBA	Self-contained Breathing Apparatus
SF	Safety Factor
SFP	Spent Fuel Pool
SFSF	Spent Fuel Storage Facility
SG	Safety Guide
SGTR	Steam Generator Tube Rupture
SIT	Second Intervention Team
SME	Seismic Margin Earthquake
SRL	Safety Reference Level
SRV	Safety Relief Valve
SSC	Structures, Systems and Components
SSE	Safe Shutdown Earthquake
SSG	Specific Safety Guide
SSR	Specific Safety Requirements
STC	Source Term Category
SW	Service Water

TPR	Topical Peer Review
TS	Technical Specification
TSC	Technical Support Center
TRM	Technical Requirements Manual
UHS	Ultimate Heat Sink
UL	Underwriters Laboratories
UNE	Spanish Association for Standardisation
UNESA	Asociación Española de la Industria Eléctrica (Spanish Association of the Electrical Industry)
USA	United States of America
VCT	Volume Control Tank
VFDR	Variance From Deterministic Requirements
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators Association
XLPE	Cross linked polyethylene
ZOI	Zone of Influence

Appendix – Development of the national selection of installations

1. INTRODUCTION

It has been decided that the scope of TPR II should mirror the scope of EC Directive 2009/71/Euratom (Nuclear Safety Directive, NSD), as amended, followed by a down-selection of facilities aimed at an optimal application of resources to ensure that:

- All technologies and types of installations within each typology are suitably represented.
- The process is carried out in such way that all the potential risks derived from any fire in the installation as well as the different approaches to fire protection strategies have been adequately accounted for.
- The final proposed list of candidate facilities envelopes the totality of installations in the scope of the work, in such way that the conclusions achieved for the candidate facilities may be transferrable to the represented ones.
- The contributions from the participating countries are suitably balanced among the actual population of installations within the scope of the TPR.

As endorsed by ENSREG at its meeting held in March 2022, the key criterion to establish the starting scope of installations to be analysed in the TPR II is the set of nuclear installations that, as a general principle, meet the conditions below:

1) *At least one facility of each category addressed by the NSD,*

   IF

2) *present in the participating country*

   AND

3) *likely to present a significant radiological risk in case of fire.*

These conditions are reflected in paragraphs 1, 2 and 3 in Section 00.3. of the Technical Specifications (TS) for the exercise. This procedure, starting from the national installations within the applicability of the NSD (TS, §00.3 paragraphs 1 and 2) and, according to the graded approach based on significant radiological risk criteria to report in paragraph 3, should end with a list of qualifying installations to be covered by the National Assessment Report (NAR).

Section 00.3 of the TS also establishes that the operating status to be considered is that in effect on the cut-off date of the analyses, 30 June 2022. For those facilities that may change their operational status during the study period (July 2022 to October 2023 approximately), a clarification must be included on which of the operational statuses the report refers to, and the expected date of change of operational situation.

One last step aims at using a sampling methodology to optimise resources, thereby allowing a more effective review process by avoiding unnecessary duplications. Adopting a sampling process seeks to achieve the greatest number of lessons learned and good practices, as well as ensuring the detection of areas for improvement applicable to all facilities in the exercise. With this purpose in mind, the interaction between the regulator and the license holders has been planned in terms of a workload balance to get the optimal degree of detail in those aspects with impact on safety. The application of the criteria set forth in the TS section §00.3, paragraph 4, shall lead to the final proposal of a national list of candidate installations on which the analyses of the NAR will be focused. The results of these analyses have to be transferred to the represented installations in the exercise.

Based on their characteristics and operational status, every individual installation in Spain has been evaluated in accordance with the criteria reported in the technical specifications, identifying the qualifying installations for the TPR II exercise and those that could be excluded.

The rationale followed is sketched on Figure 1 below, and details of its application to the individual installations in the different steps are provided on the next section of this document. This process takes into account the comments by the ENSREG Board reviewers transmitted to the national point of contact.

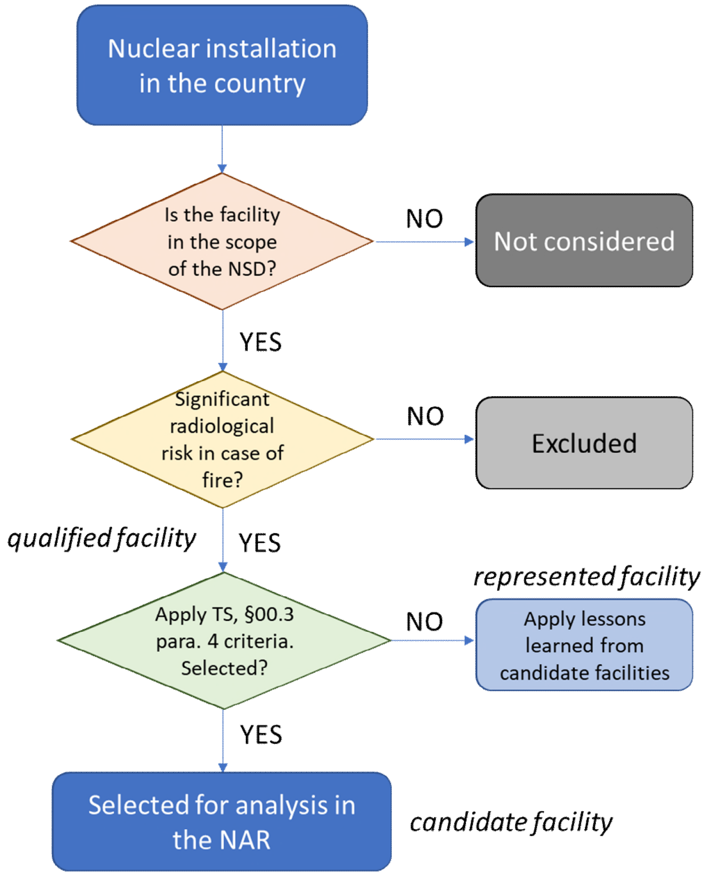

Figure 1. Rationale followed by Spain for the down-selection of nuclear installations in the TPR II.

2. PROCESS FOLLOWED BY SPAIN FOR THE SELECTION OF THE NUCLEAR FACILITIES TO BE INCLUDED IN THE NATIONAL REPORT OF THE SECOND TOPICAL REVIEW ON FIRE PROTECTION

Details of the procedure followed by Spain for the selection of nuclear installations are explained in this section.

2.1 Nuclear installations under the scope of the Nuclear Safety Directive in Spain

The set of nuclear facilities in Spain within the scope of the TPR II –installations for which a nuclear license is granted and in force as of the cut-off date of 30 June 2022- results in the following list:

Name	Type	License status	License holder
CN Almaraz 1	NPP – W-	In operation	CNAT
CN Almaraz 2	NPP – W-PWR	In operation	CNAT
CN Ascó 1	NPP – W-PWR	In operation	ANAV
CN Ascó 2	NPP – W-PWR	In operation	ANAV
CN Cofrentes	NPP - GE-BWR	In operation	Iberdrola
CN Santa María de Garoña	NPP - GE-BWR	In permanent shutdown	NN
CN Trillo 1	NPP – KWU-PWR	In operation	CNAT
CN Vandellós 2	NPP – W-PWR	In operation	ANAV
CN Almaraz	SFSF (*)	In operation	CNAT
CN Ascó	SFSF (*)	In operation	ANAV
CN Cofrentes	SFSF (*)	In operation	Iberdrola
CN Santa María de Garoña	SFSF (*)	In operation	NN
CN Trillo	SFSF (*)	In operation	CNAT
FC Juzbado	fuel fabrication	In operation	Enusa
CN José Cabrera	NPP – W-PWR	In decommissioning	Enresa
CN Vandellós 1	NPP– Graphite-gas	In latency period after decommissioning	Enresa

(*) The issuance of a license for a nuclear activity (e.g. nuclear reactor, dedicated spent fuel storage facility) includes the necessary support activities and facilities at the site and, in particular, the treatment/temporary storage facilities for nuclear/radioactive waste. Hence, these waste storage facilities do not operate in Spain under a specific license but constitute an integral part of the "mother" licensed facility. Consequently, hereinafter the spent fuel storage facilities (SFSF), as well as the waste treatment and/or temporary storage facilities associated to a nuclear power station, will not be considered standalone but will be detailed as a part of the analysis of the nuclear station since both are owned and operated under the same license holder in the Spanish framework.

In addition, since the fire regulation and approach (deterministic), design (dry-cask storage), radiological characteristics and risks derived form a fire, as well as operational procedures at SFSFs are quite similar to one another, the SFSF at the nuclear power plants proposed as candidates are considered to be representative of any of the other SFSF.

2.2 Selection of qualified facilities

In a second step of the selection, the criterion "likely to present a significant radiological risk in case of a fire" is applied. Significant risk is meant to be a hazard for which arrangements for preparedness and response for a nuclear or radiological emergency are established following the safety analysis required to the facility, according to Requirement 4 of the IAEA's GSR-Part 7.

In the case of CN Vandellós 1, the plant has been in permanent shutdown and decommissioned after the fire occurred on 19 October 1989. It is now owned by the national waste disposal company, ENRESA. The spent fuel has been sent to France for reprocessing and interim storage. Decommissioning work is no longer performed at the facility, the decommissioning phase having already finished by January 2005, signalling the starting date of the current latency period. In its present stage, the graphite-gas reactor structure has been removed, all non-fixed contamination has already been withdrawn or confined in fireproof containers and the activities for waste storage and conditioning prior to its final disposal have been completed. Therefore the radiological risk derived from a fire at the facility is considered negligible whereby Vandellós 1 is not suitable to be included in the scope of this TPR.

Concerning other installations, the fuel cycle facility (FCF) at Juzbado (a fuel fabrication plant) was initially proposed for exclusion from the exercise. The rationale behind this decision was the very low consequences of a fire as detailed in the facility's On-site Emergency Plan, which considers the inventory and physico-chemical form of the radiological material in the factory (non-irradiated uranium oxide powder or pellets) and its storage and handling.

On the other hand, concerning the representativeness of the installations throughout the coordinated sampling in the exercise, and particularly because of the very limited set of activities carried out at the Juzbado FCF in comparison with other FCF in the exercise -which may perform enrichment, reprocessing, MOX fuel fabrication, etc.- it has been considered that the potential lessons learned from the analysis of Juzbado would yield limited applicability to other FCF in the scope. Conversely, lessons learnt from the other FCF in the scope of the exercise could be transferred, although with limited applicability for some features. Consequently, lessons to be learnt from the analysis at Juzbado which would be applicable to other FCF in the scope and the lessons transferable to Juzbado are expected to be of little significance and value.

Nevertheless, and after the discussions held during the review and plenary meetings by the ENSREG Board, Spain has finally decided to include Juzbado in the list of qualified facilities as a FCF.

As a result of the previous analysis, the final list of qualifying installations in Spain is as follows:

Name	Type	License status	License holder
CN Almaraz 1	NPP – W-PWR	In operation	CNAT
CN Almaraz 2	NPP – W-PWR	In operation	CNAT
CN Ascó 1	NPP – W-PWR	In operation	ANAV
CN Ascó 2	NPP – W-PWR	In operation	ANAV
CN Cofrentes	NPP – GE-BWR	In operation	Iberdrola
CN Santa María de Garoña	NPP – GE-BWR	Shutdown (reactor) Operation (SFSF)	Nuclenor
CN Trillo 1	NPP – KWU-PWR	In operation	CNAT
CN Vandellós 2	NPP – W-PWR	In operation	ANAV
CN José Cabrera	NPP – W-PWR	In decommissioning	Enresa
FC Juzbado	Fuel fabrication	In operation	Enusa

It must be recalled that each SFSF associated to a nuclear power plant has already been included and will be documented specifically in the mother NPP analyses and will therefore not be analysed separately.

The same will apply to the on-site waste management facilities, as has been highlighted by the reviewers' board of ENSREG in their meeting sessions.

2.3 Selection of *candidate* and *represented* facilities

The third and last step involves the application of a sampling approach considering (1) that the sample shall be representative of the various types of installations and technologies, and that (2) the candidate facilities should be selected considering similarities with regard to the implemented fire safety concept.

Regarding the first aspect, the Spanish nuclear power plants are typical PWR and BWR. Within the PWR in turn there are five Westinghouse designed plants and a sixth of KWU design. Additionally, in the Spanish population of reactors there are both single-unit and two-unit reactor sites. In each of the two-unit sites the two reactors are identical in terms of the analysis; in one of the sites the two reactors share some areas and equipment while in the other case the reactors can be considered independent from each other.

The second criterion is closely related to the implementation of fire regulations and their compliance. Even though all the operating Spanish nuclear power plants are subject to CSN Instruction IS-30, the compliance with this instruction may be justified either in a purely deterministic methodology or via a risk-informed performance-based scheme (namely NFPA 805).

The analysis for the different qualified installations under this perspective is summarised below:

<u>Almaraz NPP units 1 and 2</u>: This is one of the two-unit nuclear sites at Spain, operated by the consortium Centrales Nucleares Almaraz-Trillo (CNAT). The reactors are 3-loop 1050 MWe PWRs of Westinghouse design and have dependencies and systems shared between them. The fire safety approach followed is a risk-informed performance-based (NFPA 805) methodology. Therefore, the proposal for the TPR is to assess one of the CN Almaraz reactors as *candidate* taking into account the common dependencies and systems shared with its twin unit, including their common SFSF, in the fire risk analyses, and being the other unit considered as represented by this one.

<u>CN Ascó units 1 and 2</u>: This is the other two-unit site in Spain, operated by the consortium Asociación Nuclear Ascó-Vandellós (ANAV). The reactors are 3-loop 1030 MWe PWRs of Westinghouse design of the same generation as Almaraz but in this case the two reactors are totally independent from each other. The fire safety approach is also based on compliance via NFPA 805. Consequently, the two reactors of Ascó NPP are proposed as a *represented* installation that will be represented by Almaraz NPP in its full scope, including the SFSF. The transfer of lessons learned is considered to be straightforward.

<u>Cofrentes NPP</u>: Single-unit Mark-III GE-BWR6 1100 MWe reactor, operated by Iberdrola Generación Nuclear. The fire safety methodology is fully based on deterministic analyses. Together with its SFSF, the station is proposed as a *candidate* installation.

<u>Santa Maria de Garoña NPP</u>: This is a single-unit Mark-I GE-BWR3 470 MWe reactor, in permanent shutdown since December 2012 and with all fuel in the spent fuel pool (SFP). It is currently maintained by Nuclenor (NN)[1] waiting for its decommissioning phase. As of the cut-off date of 30 June 2022, only fuel transfer activities from the SFP to the SFSF are foreseen even though involving a limited number of casks initially. According to the current planning of activities, these fuel transfer operations –that are comparable to the ones that

[1] At the date of preparation of this report, the situation of this plant was recorded on the cut-off date of the year (June 30, 2022), in which the ownership of the Sta María de Garoña NPP had not yet been transferred to Enresa. Works of spent fuel cask load prior to decomissioning works mentioned in the text have not yet been started, hence the operational situation of the facility from the FP point of view is considered as not affected by the recent transfer of ownership to Enresa, who will be responsible of these activities. Consequently, the analysis and conclusions in the text are considered still valid.

are carried out at any of the other NPPs in operation, must be completed for the full fuel inventory in the SFP before heavy decommissioning works may start (not expected to happen during the TPR period). Hence, during the TPR II period, the decommissioning works –if any– will be in their very first stages and are not foreseen to put the installation at a significant radiological risk. The only relevant safety function that could be affected in case of a fire in this installation during the peer review period is hence the adequate cooling of the fuel assemblies in the SFP. As a result, this station is proposed as *represented installation* for the spectrum of situations and configurations foreseeable during the TPR exercise by CN Cofrentes, also a GE-BWR.

Trillo NPP: Single-unit site with a 1060 MWe 3-loop PWR reactor of KWU design operated by CNAT. Even though the KWU design is different from the Westinghouse PWRs, a close look to the fire safety concept and features: fire protection elements and systems, safe-shutdown pathways and operating procedures in case of a fire at any area of the station including the control room, alternate shutdown capacity, fire risk analysis, etc. shows that the similarities are large enough that both designs may well be considered in the same category and with equal representativeness. Moreover, the fire regulation to be complied with is identical to that of CN Vandellós 2, and is justified by the deterministic fire analyses performed with the same license basis. Although the plant has a German design, CN Trillo must also demonstrate compliance with Spanish (American-based) fire regulations and standards as well as with accident and fire analysis assumptions, regulations met by both designs with the same fire protection features. Selection of this installation as candidate is not therefore considered to contribute significantly to the exercise any more than other PWR candidates with deterministic fire risk approach. Additionally, the presence of reactors of similar design in other countries is not considered enough reason for its selection since the regulations applicable to Trillo NPP related to fire are not design-specific and are to be complied with like in the Spanish PWR reactors with US design.

Therefore, Trillo NPP is proposed as a represented facility, CN Vandellós 2 being the selected representative candidate facility. Anyway, particular features and differences of Trillo NPP as compared to the candidate one will be highlighted in the corresponding sections of the NAR where applicable and relevant for the analysis. Concerning the SFSF at Trillo NPP, and as was concluded in section 3.1, it is represented by the SFSF at any PWR candidate facility, as is the case of Almaraz NPP.

Vandellós 2 NPP: Single-unit, 3-loop Westinghouse 1080 MWe PWR, operated by ANAV. This reactor started to operate in the late 1980s as Trillo NPP and complied with the same fire regulation (Appendix R to the 10CFR50 and BTP 9.5-1, now the IS-30) as Trillo NPP. Therefore, even though Westinghouse and KWU designs for PWR might differ, differences are not considered relevant for the reasons stated above and Vandellós 2 NPP is proposed as a *candidate installation* in the TPR exercise.

José Cabrera NPP: Single-unit is a single-loop Westinghouse 160 MWe PWR, owned by Enresa. It is currently in its last stages of decommissioning, all its spent fuel has been stored in dry casks at the site SFSF. Therefore, no activities are performed related either to fuel loading, transportation and storage or to cutting or handling radioactive waste, only minor site restoration work in preparation of the site clearance are in progress. Therefore, José Cabrera NPP is included the TPR scope as a *represented installation*, by any of the candidate facilities in the exercise hosting a SFSF. Nevertheless, applicability of lessons learned in the exercise, although feasible, is considered very limited, given the absence of work with radiological risk in the site.

Consequently, the sampling of *candidate installations* proposed to be contributed by Spain in the TPR II on fire protection is:

Name	Type	License status	License holder
CN Almaraz candidate unit	NPP – W-PWR	In operation	CNAT
CN Cofrentes	NPP – GE-BWR	In operation	Iberdrola
CN Vandellós 2	NPP – W-PWR	In operation	ANAV
FC Juzbado	Fuel fabrication	In operation	Enusa

It must be mentioned in this section that observed differences and specificities of the represented installations from the candidate ones will be highlighted in the corresponding sections of the NAR in which the candidate facility will be analysed in detail when applicable and relevant for the analysis.

3. CONCLUSIONS

After previous communications, and following the discussions taken place amongst the team leaders, Spain has decided to review the list of candidate and represented facilities in the TPR-II.

Starting from the initial list of nuclear installations under the scope of the EC Directive 2009/71/Euratom, as amended, a down-selection of facilities has been performed in order to optimise resources as well as ensuring that representativeness of the sampling to keep all the objectives of the exercise applicable to the full set of facilities.

Following the selection process sketched in Figure 1 and the step- by-step approach for the application of the selection criteria explained in sections 3.1, 3.2 and 3.3 of this document, the Spanish proposal of installations in the TPR II is:

Candidate installations that will be analysed in the National Analysis Report (NAR):

Name	Type	License status	License holder
CN Almaraz candidate unit	NPP – W-PWR	In operation	CNAT
CN Cofrentes	NPP – GE-BWR	In operation	Iberdrola
CN Vandellós 2	NPP – W-PWR	In operation	ANAV
FC Juzbado	Fuel fabrication	In operation	Enusa

Represented installations for which lessons learnt from the candidate facilities will be applicable (in terms of similarity of technology, design, fire protection concept, strategy, procedures, approach, etc.) and whose differences and specificities will be highlighted in the corresponding sections of the NAR when applicable and relevant for the analysis are:

Name (represented by)	Type	License status	License holder
CN Almaraz represented unit	NPP – W-PWR	In operation	ANAV
CN Ascó	NPP – W-PWR	In operation	ANAV
CN Santa María de Garoña (CN Cofrentes)	NPP – GE-BWR	Shutdown (reactor) Operation (SFSF)	NN
CN Trillo 1 (CN Vandellós 2, CN Almaraz (only SFSF))	NPP – KWU-PWR	In operation	CNAT
CN José Cabrera (CN Almaraz (only SFSF))	NPP – W-PWR	In decommissioning	Enresa

Excluded installations (out of the scope of the TPR II) that do not meet the three conditions for the key criterion of selection (specifically because of non-significant radiological risk in case of fire):

Name	Type	License status	License holder
CN Vandellós 1	NPP – Graphite-gas	In latency period after decommissioning	Enresa

It must be finally pointed out that on-site installations (namely SFSF and radiological waste treatment and disposal facilities) will be reported as a part of the mother installation (the commercial NPP) they belong to, as long as all of them are licensed and operated by the same licensee.