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Nuclear Regulation

ENSREG Topical Peer Review 2 - Fire Protection

United Kingdom National Assessment Report

ONR Report

United Kingdom National Assessment Report

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Executive Summary

The European Union's Nuclear Safety Directive requires the member states to organise a topical peer review (TPR) every six years. The UK participated in the first topical peer review, which started in 2017 and covered ageing management at nuclear power plants and research reactors as a member of the European Nuclear Safety Regulators Group (ENSREG). Following the UK's departure from the European Union, the UK is an observer country at the European Nuclear Safety Regulators Group (ENSREG) and was invited to voluntarily participate in the second topical peer review, which covers fire protection in nuclear installations. The first stage of the peer review is for each participant country to produce a national assessment report. This is the UK National Assessment Report, which will be used in the later stages of the peer review.

In advance of the second topical peer review, the Western European Nuclear Regulators Association (WENRA) developed a technical specification for the national assessment reports, to ensure that they are all produced to a common standard. This report has been produced in accordance with that specification which includes a well-defined content and identifies report sections to be written by licensees and by regulators. The sections have been amalgamated by ONR into a single UK national report which includes ONR's regulatory assessment and overall conclusions.

The scope of this topical peer review is significantly broader than the first as, in addition to nuclear power plants and research reactors, it extends to spent fuel storage facilities, enrichment plants, nuclear fuel fabrication plants, reprocessing plants, and storage facilities for radioactive waste that are on the same site and are directly related to the aforementioned types of nuclear installations. To preserve the feasibility of the exercise, the technical specification acknowledges the need for a selection rather than all qualifying installations reporting in the second review. It provides guidelines for the selection to cover, where applicable, all the installation types in scope and all stages in the lifecycle including construction, operation and decommissioning. It also expects focus on installations which present significant radiological risks from fire, and the consideration of similarities across installations for transferability of insights when selecting the installations in scope of the report.

The scope of this report is nuclear power reactors owned by EDF Nuclear Generation Limited (EDF NGL), represented by Heysham 2, Hunterston B and Sizewell B including its dry spent fuel store. It also includes the twin reactors currently under construction at Hinkley Point C owned by EDF Nuclear New Build Generation Company (NNB GenCo), Dounreay's Prototype Fast Reactor Complex (including the irradiated Fuel Cave), Urenco UK Ltd.'s Enrichment facilities at Capenhurst, Springfields Fuels Limited's fuel fabrication plants, and Sellafield Ltd.'s Magnox reprocessing plant. Finally, a selection of Sellafield Ltd.'s installations, namely the High Level Waste Plant, Waste Vitrification Plant and Encapsulation Plants, Sellafield Product and Residues Store (SPRS), the Box Encapsulation Plant Product Store - Direct Import Facility (BEPPS-DIF) and Pile 1 are also included.

This report describes each of the companies' fire safety assessment methodologies, and their implementation of the fire protection concept, including fire prevention measures, active fire protection and passive fire protection. ONR has in turn assessed the licensees'

with reference to UK regulatory requirements and expectations, which implement international standards for fire protection in nuclear installations, nuclear fire safety and internal hazards. ONR has also used regulatory intelligence from regulating fire safety from a life protection perspective, and identified useful transferable learning to nuclear safety, namely the importance of proactive management of fire detection and alarm system ageing and obsolescence, and maintainability of fire protection systems such as fire dampers.

Overall, ONR's assessment has found that the UK installations reporting in this second review have adequate fire safety analysis and fire protection arrangements commensurate with their radiological risks from fire, the potential for fire to impact nuclear safety systems and the stages that each installation is in its lifecycle. Nevertheless, beneficial improvements have been found in a number of areas, namely, the implementation of methodologies for proportionate but systematic screening and analysis of hazard combinations, including fire, and the enhancement of linkages between the extant management of fire loading for life protection and the nuclear safety arrangements in decommissioning facilities. ONR has consequently raised actions for the licensees to implement improvements, formally tracked to completion through ONR regulatory issues and regulatory interventions.

ONR considers that the integrated consideration of fire safety for life protection in the report has enabled the sharing of valuable learning in additional areas, such as fire damper maintainability issues and fire detection and alarm system obsolescence. The issues are the subject of formal regulatory follow up through ONR regulatory issues. While they did not impact nuclear safety, they offer insights into fire system challenges which should be highlighted to ensure that high levels of defence in depth are consistently maintained.

This report will be used as the basis for the next stage of the TPR, when it will be peer reviewed by the other states participating in the TPR, after which the programmes for improvement for the licensees will be finalised.

1. General information

1.1. Nuclear installations identification

1.1.1 Qualifying nuclear installations

The United Kingdom's (UK) list of qualifying installations, i.e. installations meeting the criterion of Directive 2014/87/EURATOM, includes nuclear power plants in construction and operation, installations undergoing decommissioning, spent fuel storage facilities, fuel cycle facilities and waste storage and management facilities. The full list of qualifying installations for consideration in TPR is provided in Appendix A.

1.1.2 National selection of installations for TPR 2 and justification

ONR has selected a sample of installations for licensees in Great Britain (GB) to perform self-assessment in accordance with the TPR technical specification and provide submissions for the UK National Assessment Report (NAR). The selection of the UK sample from the full list of qualifying installations was undertaken according to the following approach, developed from the guidelines in section 00.3 of the TPR Technical Specification [1]:

- To include, as far as they are relevant to the UK, all installations types under the Nuclear Safety Directive (NSD): nuclear power plants (NPPs), research reactors (RRs), spent fuel storage facilities, enrichment plants, nuclear fuel fabrication plants, reprocessing plants, and storage facilities for radioactive waste that are on the same site and are directly related to the types of nuclear installations listed.
- To include the variety of stages in the nuclear installations' lifecycles, according to their status as of 30th June 2022, so that installations in construction, in operation and undergoing decommissioning are covered in the NAR.
- To report on installations where fire poses significant radiological risks as outlined in section 00.3 of the technical specification, with reference to radiological risk criteria in the Radiation (Emergency Preparedness and Public Information) Regulations 2019. This GB legislation implements in part the Euratom Basic Safety Standards Directive (Council Directive 2013/59/Euratom).
- To ensure the transferability of insights and lessons learned from the installations selected for TPR to the qualifying installations documented in Appendix A. Due to the wide scope of TPR, the number and variability of installations across GB, and to ensure appropriate focus within the NAR page limit, ONR has considered regulatory intelligence and similarity of fire protection arrangements across installations (e.g. when under the same licensee) to ensure insights, strengths and weaknesses are included. This is captured throughout the regulators' assessment sections of the NAR.

ONR considers that the above approach is in line with the intended spirit of the TPR, as set out in Council Directive 2009/71/EURATOM (as amended by Directive 2014/87/EURATOM), which states: "*the self-assessments followed by international peer reviews are*

neither an inspection nor an audit, but a mutual learning mechanism that accepts different approaches to the organisation and practices of a competent regulatory authority, while considering regulatory, technical and policy issues of a Member State that contribute to ensuring a strong nuclear safety regime. The international peer reviews should be regarded as an opportunity to exchange professional experience and to share lessons learned and good practices in an open and cooperative spirit through advice by peers rather than control or judgement. Recognising a need for flexibility and appropriateness in regard to different existing systems in Member States, a Member State should be free to determine the segments of its system being subject to the specific peer review invited, with the aim of continuously improving nuclear safety”.

A list of installations selected for TPR 2 is presented below with a brief outline. A description of each installation is provided in section 1.1.3.

- **Hunterston B:** representative of an Advanced Gas Reactor (AGR) Nuclear Power Plant (NPP) undergoing defuelling. There are currently three AGR stations undergoing defuelling or preparing for defuelling across the UK.
- **Heysham 2:** representative of an generating AGR. There are currently four operating AGR stations across the UK.
- **Sizewell B:** the UK’s only operating Pressurised Water Reactor (PWR). The Sizewell B dry fuel store is also included in the report as the UK’s only dry spent fuel storage facility.
- The AGRs chosen for the UK sample include a first generation and a second generation AGR, so that the UK NAR explicitly reports on differences in fire protection approaches across the AGR stations. The above nuclear sites are licensed to Electricité de France (EDF) Energy Nuclear Generation Limited (NGL) (a subsidiary of EDF Energy) and reported in EDF NGL’s submission.
- **Hinkley Point C:** the only NPP currently under construction in the UK, under the responsibility of Nuclear New Build Generation Company (NNB GenCo), a subsidiary of EDF Energy.
- While both NNB GenCo and EDF NGL are part of the EDF Energy Group, they are separate companies and have different management systems.
- **Sellafield Site:** the Sellafield Site comprises more than 250 nuclear facilities over 1,000 buildings under the responsibility of Sellafield Ltd. Discrete facilities have been selected to represent a wide range of installation types and lifecycle stages, the significance of fire considerations in design and operation, and the availability and transferability of learning on fire protection, including strengths and weaknesses:
 - Box Encapsulation Plant Product Store – Direct Import Facility (BEPPS-DIF): a New Build waste storage facility for Intermediate Level Waste (ILW) on the Sellafield Site, in commissioning;

- Sellafield Product and Residues Store (SPRS): an operating Special Nuclear Material (SNM) storage facility with alpha-emitting SNM and its associated risks;
 - High Level Waste Plants; Waste Vitrification Plant and Encapsulation Plants: to include High Level Waste waste treatment and storage, and encapsulation operations at the Sellafield Site;
 - Magnox Reprocessing Plant: the only operational fuel reprocessing facility (as of the cut-off date for TPR, i.e 30th June 2022, currently in the early stages of decommissioning; and
 - Pile 1: a graphite air-cooled reactor. The associated chimney is being dismantled and the reactor is under care and maintenance.
- **Capenhurst Works:** the UK’s only operating Uranium enrichment installation, operated by Urenco UK Ltd.
 - **Springfields:** the UK’s only operational fuel fabrication facility, operated by Springfields Fuels Ltd.
 - **Dounreay’s Prototype Fast Reactor complex.** Dounreay was included as the UK’s former centre of fast reactor research and development. The site comprises three former reactor facilities, fuel cycle and storage facilities and other support functions. The PFR complex, which includes the Irradiated Fuel Cave (IFC), was selected for TPR 2 as it contains examples of most operations carried out on site, including a decommissioned reactor (the reactor has been defueled but still contains quantities of sodium), fuel caves, waste storage and waste handling. Following transfer on 1st April 2023, the Nuclear Site Licence for Dounreay is now held by Magnox Ltd., a subsidiary of the Nuclear Decommissioning Authority (NDA).

In the selection of installations for TPR, consideration was given to former Magnox reactors. Nevertheless, the former Magnox stations are defueled and do not require Detailed Emergency Planning Zones (DEPZs), based on the remaining radiological risks quantified in Consequence Reports to meet the requirements of the REPIR 2019. The Magnox sites, for example Berkeley, attract 1km outline zones only, and this is from a very low probability external event (large aircraft impact) which is not the focus of TPR 2 [2]. Given the low radiological risk to the public from Magnox stations, and the number and variety of installations covered in TPR 2, further expansion would be detrimental to the report focus, however, insights from TPR will be shared across all GB licensees including Magnox.

Table 2 summarises the installations reported in TPR2 as part of the UK NAR and the sampling rationale for the list of qualifying installations is further documented in Appendix A.

Table 2: Summary of GB installations for TPR 2 per type

Type of installations	Site/ installation
NPPs (in operation and under decommissioning)	Hinkley Point C, EPR, under construction
	Sizewell B, including the dry fuel store, PWR in operation

	Heysham 2, AGR in operation	
	Hunterston B, AGR undergoing defueling	
Reactor under decommissioning including waste storage	Dounreay's Prototype Fast Reactor (PFR) complex (including the Irradiated Fuel Cave), in decommissioning	
Spent Fuel Storage	<i>The AGR spent fuel ponds and dry storage technology at Sizewell B (SZB) are reported as part of the NPP sites above</i>	
Enrichment plant	Capenhurst works, Urenco UK Ltd, in operation	
Fuel Fabrication	Springfields Fuels Ltd, in operation	
Reprocessing plants	Sellafield Ltd	Magnox Reprocessing, early phases of decommissioning
Waste Storage		High Level Waste Plant, Waste Vitrification Plant and Encapsulation Plants, in operation
		Sellafield Product and Residues Store (SPRS), in operation
		Box Encapsulation Plant Product Store - Direct Import Facility (BEPPS-DIF), in commissioning
Reactor under decommissioning		Pile 1, care & maintenance (and dismantling – Pile chimney)

The licensees' reports have been incorporated into the NAR in accordance with the TPR technical specification. Generally, the licensees' contributions have been copied into the NAR without being modified or with minimal editing. When the licensees' contributions to the NAR have been edited, this has been to remove excessive detail, improve clarity e.g. attribute statements to licensees, and to ensure a broadly consistent style across the report.

1.1.3 Key parameters per installation

1.1.3.1 EDF Energy Nuclear Generation Ltd

Three main types of nuclear power plants are addressed in EDF NGL's TPR 2 fire assessment. These are:

- First generation AGRs: the reference reactor unit used for the purposes of reporting is Hunterston B, but where applicable information from other first generation AGRs has also been used.
- Second generation AGRs: the reference unit used is Heysham 2, but where applicable information from the sister station at Torness (TOR) has also been used.

- The UK's PWR Sizewell B (SZB) (Westinghouse design).

In addition, the AGR spent fuel ponds and the dry fuel store at SZB are addressed.

1.1.3.1.1 Hunterston B

Hunterston B (HNB) is a first generation AGR which stopped generating electricity in January 2022 after 46 years of service. The net electrical output from the two reactors was 1,215 MW; however, since 2007, the reactors were restricted to operating at a reduced output level.

The station is situated about 2.4 miles (4 km) north west of West Kilbride in Southwest Scotland, on the Firth of Clyde coast. It is at the same location as the Hunterston A Magnox nuclear power station (now defueled and being decommissioned). EDF NGL reports that there are no other significant sources of industrial activity in the area that can affect the safety of the plant.

The reactor is cooled by CO₂ gas, but as the unit is being defueled, this is at low pressure and temperature. This significantly reduces the nuclear risk from the fire hazard, although fuel has still to be removed from the reactor.

There is an on-site firefighting team staffed by plant operators and the local fire brigade is called upon where required. There are currently no shared resources or offsite resources.

There are no long-term spent fuel storage facilities on site. Fuel elements are stored in the fuel ponds after removal from the reactor until the decay heat level allows the spent fuel to be shipped to Sellafield. Typically, this is after about 18 months, but it can vary due to logistical considerations.

1.1.3.1.2 Heysham 2

Heysham 2 (HY2) is an improved design and is the latest version of the first generation AGRs. The net electrical output from the two reactors is 1,250 MW.

The station is situated on the coast in the north west of England and about 7 miles (11 km) west of the city of Lancaster. Construction started in 1980 and the station was commissioned in 1988. It is adjacent to the site of the Heysham 1 first generation AGR (commissioned in 1983). Heysham 1 is still in operation, but is expected to close in 2026.

Both stations are situated near Heysham harbour, which is used for supply vessels to offshore gas platforms situated in the Morecambe bay area and is also used for touristic purposes. The harbour is the main source of industrial hazards, although there is also a wind farm in the vicinity.

The reactor is cooled by CO₂ gas, which operates at a high temperature and pressure (640°C and 40 bar). The high gas temperature, and the corresponding high steam temperature (540°C reheat) leads to a relatively high fire potential from any combustible material that is exposed to a reactor gas release or a live steam release.

There is an on-site firefighting team staffed by plant operators and the local fire brigade is called upon where required. Off-site survey capability is shared, and Heysham 1 supports both stations. The security response and off-site strategic co-ordination centres at Preston are shared across the two stations.

As for the first generation AGRs, there are no long-term spent fuel storage facilities on site. Spent fuel elements are shipped to Sellafield on a regular basis. Note that unless otherwise indicated, the descriptions provided for HY2 also apply to TOR.

HY2 irradiated fuel disposal system

The irradiated fuel disposal system consists of three main parts: the decay store, the Irradiated Fuel Disposal cell and the fuel pond. These are discussed below.

Decay store: the irradiated fuel store provides pressurised, cooled and shielded storage in decay tubes for fuel assemblies after their removal from the reactor. The assemblies are stored for a set period, during which fission product heat decays to a level acceptable for discharge into the atmospheric air environment of the irradiated fuel disposal cell.

Each of the 64 decay tubes is made up of an inside pressure tube and an outside water jacket. The pressure tube is pressurised with CO₂ for heat transfer between the fuel and the cooling water in the water jacket, at a pressure of at least 36 bar when handling irradiated fuel and between 5 and 41 bar for storage of irradiated fuel.

Fire risks associated with the decay store are minimised by design, as the fuel assemblies are surrounded by an inert atmosphere with passive cooling to the outside water jacket.

Irradiated Fuel Disposal cell: the Irradiated Fuel Disposal (IFD) cell equipment is used to separate irradiated fuel stringers into their component parts. This includes the irradiated fuel assemblies. The IFD cell does not have a specific safety role, but in performing the required functions, the IFD cell system design ensures doses to operating staff are minimised and critical assembly formation is avoided.

The IFD cell fuel containment comprises a volume held at sub-atmospheric pressure (to prevent leakage of contaminated air to the environment) by the action of an air extraction system. The fuel containment is held at a pressure lower than the surrounding cell whenever irradiated fuel is present in the containment. The surrounding cell is itself held at a slightly sub-atmospheric pressure by the contaminated heating and ventilation system.

The fire loads in the IFD cell are minimal and no fixed fire suppression is installed. Flexible fire hoses are provided. These also provide water for the emergency cooling of damaged fuel within the IFD cell.

Fuel pond: irradiated fuel elements or bottles are transferred from the IFD cell to the two storage pond bays via disposal chutes. Routing of the elements to a particular bay is dependent on operational needs. All fuel movements within the pond take place beneath water, which also acts as radiation shielding. The design fuel cooling period between fuel leaving the reactor and being transported offsite is 90 days. The pond capacity is such that fuel could be stored for up to 167 days. As the fuel is stored under water, there are no direct

fire risks to the fuel and EDF NGL considers the overall fire risk from the irradiated fuel disposal system to be minimal and not quantified as part of the probabilistic safety assessment.

1.1.3.1.3 Sizewell B

Sizewell B is a four-loop Westinghouse PWR. The net electrical output from the single reactor is 1,198 MW. The original US design was extensively modified to meet UK safety requirements.

The station is situated on the south east coast of England, about 40 miles (64 km) south of the city of Norwich. Construction started in 1988 and the station was commissioned in 1995. It is adjacent to the Sizewell A Magnox reactor (now defueled and being decommissioned) and the site of the proposed Sizewell C PWR, which, if built, will be a sister station to the Hinkley Point C PWR.

Apart from Sizewell A, there are no significant industrial facilities in the area of Sizewell B.

Design against the fire hazard is considered to be a strength of this reactor, and fire safety was extensively assessed during the design phase. The reactor is cooled with pressurised water and the four loops are supplied by four independent and fire-segregated trains of equipment.

There is an electrical interconnector between the Sizewell A site and the Sizewell B site, installed at the time that both stations were operating. This is for emergency purposes only and both sites operate as independent units.

There is an on-site firefighting team staffed by plant operators and the local fire brigade is called upon where required. This is independent from the Sizewell A firefighting provisions. In addition, there is a facility about 4 miles (6 km) inland from the site that stores equipment that may be required for beyond design basis events (developed following the Fukushima event). There is a dry fuel store on the Sizewell B site in addition to the standard PWR water-cooled spent fuel pond. This is described in Section A-I-2.4 below.

Sizewell B Dry Fuel Store

EDF NGL designed, built and commissioned a dry spent fuel storage facility, known as the Dry Fuel Store (DFS), which will eventually accommodate all the intact Spent Fuel Assemblies (SFAs) for the extended station life and end of life defueling. The DFS has a design life of 100 years.

The original design concept was to transport fuel elements to Sellafield for reprocessing. The DFS System is an extension of the existing SZB fuel storage facilities and provides a means of storing spent nuclear fuel (and associated core components) arising from SZB operation for up to 100 years, allowing SZB to continue long-term operation.

There are three plant areas where the fire risk has been assessed, which are as follows.

Fuel storage building: the Fuel Storage Building (FSB) is part of the original design of SZB and has been since adapted for the transfer of fuel to long term storage casks. Much of this process is carried out under water, though welding operations are carried out in an air atmosphere.

New equipment items that are introduced into the FSB do not introduce significant additional combustible materials. However, new welding activities do introduce an additional ignition source into the FSB. The design mitigates this by minimising sources of combustible material in the location of the welding activities, so there is no significant fire risk from these activities.

In addition, there is a haulage transporter that enters the fuel building and, although unlikely, a transporter fire within the building is considered in the hazards assessment (combustible loads are the tyres, hydraulic fluid and diesel fuel).

The licensee's fire assessments concluded that there were no significant risks to nuclear safety or personnel arising from fires in the FSB.

Transport route: the fuel casks are then transferred to the new Dry Fuel Store Building (DFSB) using a specialised hauling transporter.

The transport route safety assessment considers a hauling transporter fire and concluded that the temperatures of all the components that constitute the containment barriers remain below their temperature withstand limits.

Dry Fuel Store Building: the DFSB is a large, steel-framed structure with a single clear span supported on a seismically qualified reinforced concrete foundation slab. The walls and roof of the building are clad with a proprietary insulated aluminium standing-seam system that also incorporates contiguous banks of louvers at high and low level. The louvers allow passive air cooling of the fuel casks stored within the building. The DFSB and casks do not depend on active systems for safe operation.

The DFSB contains very limited amounts of combustible material. The only fixed combustibles are the cables for lighting and instrumentation and there are no fixed ignition sources. The main potential sources of fire are transient, i.e. the transporters, which contain diesel fuel, engine oil and hydraulic oil as well as solid rubber tyres. The oil quantities are limited and refuelling of the transporters takes place outside the DFSB. The licensee's fire assessment concluded that there are no significant nuclear risks from fire hazards in the DFSB and, as such, the licensee's probabilistic safety assessment does not quantify it.

1.1.3.2 NNB Generation (HPC) Ltd

This section has been provided by the licensee based on information from the Preconstruction Safety Report 3 (PCSR3 [3] [4]) and Summary Safety Case Document 2 (SSCD2 [5] [6]).

Overview

The EDF NNB Genco Nuclear Installation/representative facility in this report is the Hinkley Point C (HPC) European Pressurised Water Reactor (EPR) Nuclear Power Plant (NPP) Unit 1 and Unit 2, and its associated spent nuclear fuel and radioactive waste facilities.

Each HPC reactor core unit will have a thermal power rating of 4,500 MWth [7]. Each reactor and turbine unit will have a single associated generator capable of producing approximately 1,630 MW of electrical power, giving a total site capacity of 3,260 MW [8].

Description of facility

The HPC site is approximately centred on National Grid reference 320300, 145850. The site is bounded to the north by Bridgwater Bay, part of the Severn estuary, from which it is separated by a low cliff.

HPC comprises a range of buildings above ground, seabed and sub-surface structures and related facilities including two Nuclear Islands (NI) each comprising a reactor and other associated buildings; two Conventional Islands (CI), each including a Turbine Hall (HM [TH]), located adjacent to the Nuclear Island; a Service Water Pump Building (HPA-B-C-D) for each reactor unit with related infrastructure; seabed cooling water intakes and outfall structures together with tunnels connecting these to the Service Water Pump Buildings (HPA-B-C-D) and Turbine Halls (HM [TH]); fuel and waste management facilities; transmission infrastructure including the National Grid 400 kV Sub-station (HEG); staff facilities, administration, storage facilities and other plant; a Simulator Training Centre (HBS) and other off-site buildings; Sea Wall Structures (SWP) incorporating a public footpath; and access and parking facilities for workers, visitors and deliveries for the main nuclear plant and the National Grid 400 kV substation.

The land immediately to the East of the HPC site is occupied by two nuclear power stations, Hinkley Point A and Hinkley Point B, which form the existing Hinkley Point Power Station Complex. Hinkley Point A operated between 1965 and 2000 and is currently being decommissioned following de-fuelling. Hinkley Point B, owned by EDF Energy NGL, operated between 1976 and 2022 and is currently being de-fuelled.

The EPR is a Pressurised Water Reactor (PWR), similar to other EPR units worldwide (for example, within the French nuclear fleet). The nuclear production unit comprises a primary system, a secondary system, and a cooling system.

The primary system is a closed water-filled pressurised system installed in a leak tight concrete enclosure, the Reactor Building (HR [RB]). It comprises a reactor, namely a steel vessel containing the nuclear fuel (reactor core), and four cooling loops, each containing a reactor coolant pump and a steam generator. The heat produced by the nuclear reaction inside the reactor vessel is extracted with pressurised water, which circulates in the primary system. The heated water then passes through the steam generators. Here the heat is transferred to the water of the secondary system, which flows between the steam generator tubes.

The secondary system is a closed system independent of the primary system. It supplies steam to the turbine generator set located in the Turbine Hall (HM [TH]). Water in this system evaporates in the steam generators heated by the primary system. The steam

drives a turbine coupled to the generator which produces electrical energy. After leaving the turbine, the steam is cooled and returned to its liquid state in the condenser, then returned to the steam generator.

The cooling system is independent of the primary and secondary systems. It cools the condenser by circulating sea water drawn via the HP structures and discharged through the outfall system.

Emergency response equipment and vehicles will be stored on the HPC site with supplementary equipment available at strategic off-site locations. The emergency response organisation structure will be developed from the systems currently in place for EDF sites. Station-based roles will be specific to HPC, but some of the corporate level centralised resources and roles will be shared with those currently in place for the generating stations.

Each unit has a dedicated Fuel Building (HK) on its Nuclear Island for the receipt of new fuel and initial storage of spent fuel discharged from the reactor. Spent fuel will initially be stored in the two Fuel Building pools for an initial cooling period of up to ten years, then transferred to the Interim Spent Fuel Store (HHK) for dry interim storage in casks on site, before permanent disposal in repository. The Interim Spent Fuel Store will be shared between the two units.

1.1.3.3 Sellafield Ltd

Overview

The Sellafield Site covers 6km² and contains over 250 nuclear facilities. The site has been operating for over 70 years and manages nuclear waste in all three forms: low, intermediate and high-level waste. The site is the largest nuclear site in Europe and holds the largest inventory of nuclear materials.

Historically, the site housed nuclear power plants, but the focus is now on the safe storage of nuclear waste and decommissioning the historic facilities. The site is split operationally into five main Value Streams:

- Special Nuclear Materials: safe and secure storage and repackaging of materials.
- Spent Fuel Management: receipt, storage and reprocessing of spent fuel.
- Remediation: decommissioning and demolition of end-of-life buildings, including low level waste handling and treatment.
- Retrievals: high hazard reduction work, including retrieving and repacking the nuclear inventory.
- Site Management: provision of utilities and services, such as transport and analytical services.

The licensee's nuclear safety case assessments and analyses recognise requirements of neighbouring and interfacing plants. This includes where a fire could lead to impacts on other facilities and vice versa, which is considered from a nuclear safety perspective. The

conventional fire assessments also assess fire risks from buildings in the vicinity, as per United Kingdom Building Regulations. External hazards assessments for the installations in scope refer to ancillary or neighbouring buildings and the effect of fires from these buildings. For the installations in scope of TPR 2, the assessments do not identify any instances where a fire in an ancillary building or an external fire would have a credible impact on the installations considered.

Sellafield Site Installations

Waste Vitrification Plant

Waste Vitrification Plant (WVP) converts Highly Active Liquor (HAL) into a stable form for long-term storage. HAL is transferred to WVP through feed tanks where it is stored, before being fed to one of three process lines in WVP. HAL is fed to a calciner with sugar and passes through a heated zone to evaporate off the liquor and produce a solid calcine. The calcine then passes into a melter where glass frit is added to produce a molten glass. The glass is then poured into steel containers and allowed to cool before lids are welded on. The vitrification line operations are expected to likely to extend beyond 2030.

Encapsulation Plants

Encapsulation Plants at Sellafield bind nuclear waste products with cement or grout in a stainless steel storage drum. The drums are then sealed, cleaned, monitored and moved to a product store.

There are two main encapsulation plants on the site. One encapsulates Magnox swarf, the remnants of Magnox fuel rod cladding removed during fuel reprocessing. The second plant encapsulates fuel cladding and chemical by-products from the Thermal Oxide Reprocessing Plant (THORP) as well as radioactive sludge from one of the storage ponds. Both plants then send the encapsulated waste to encapsulated product stores, which are also on the Sellafield site.

Magnox Reprocessing Plant

The Magnox Reprocessing Plant was built to reprocess irradiated fuel rods arising from Magnox Reactor stations. Until recently, the main processes carried out within Magnox Reprocessing were the dissolution of spent fuel rods, the removal of fission products, and the separation of uranium and plutonium into component parts in order to be sent downstream for long-term storage.

The facility comprises a main building that houses the flask receipt and despatch area, fuel rod dissolution facilities and the solvent extraction mixer settlers. The facility also houses the mixer settler vessels utilising the solvent extraction process. This plant provides purification facilities for both the uranium and plutonium before the uranium is transferred to another plant for further processing and the plutonium is evaporated in the plutonium evaporator. Plant liquors are transferred from Magnox Reprocessing to the destination plant via adjacent pipe bridges. The plant contains facilities for receiving, storing and mixing reagents prior to use from a tank farm, also situated within the site. Site services are also routed into the building from the adjacent pipe bridges or by ducts and trenches. The plant

also consigns solid waste as Intermediate Level Waste (ILW), Low Level Waste (LLW) and Plutonium Contaminated Material (PCM) to the appropriate destination. Liquid wastes consigned as Highly Active (HA), Medium Active (MA) salt free, Medium Active salt bearing and Low Active (LA) aerial effluents are also directed and sentenced to the appropriate destination via dedicated pipework systems.

Some of the main hazards associated with the Magnox Reprocessing facility are criticality (due to solvent extraction maloperations or loss of geometry control), misrouting of solvents to evaporators, leakage of activity from cells, dissolver pressurisation and fuel flask drops.

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Sellafield Product and Residues Store

The Sellafield Product and Residues Store (SPRS) is a facility designed to store product packages containing residues from finishing lines within reprocessing plants and other areas of the Sellafield Site and National Nuclear Laboratories (NNL) operations.

Box Encapsulation Plant Product Store – Direct Import Facility

Box Encapsulation Plant Product Store Direct Import Facility (BEPPS-DIF) has been designed to receive and store Intermediate Level Waste from donor plants (silos and ponds) and provide services to encapsulation plants and stores. It is a relatively new facility and is due to commence operations and begin receiving waste in late 2023.

Pile 1

Windscale Pile 1 was originally commissioned as a graphite-moderated, air-cooled nuclear reactor in the 1940s that was used to generate weapons-grade plutonium and other isotopes. The facility comprises a reactor core, bio-shield, air inlet and outlet ducts, water ducts and the chimneys. It is currently in a state of care and maintenance and has been in this state since a large fire occurred in 1957. The facility shares a boundary with the Pile chimney, which is undergoing decommissioning (height reduction).

The main operations carried out are basic tasks such as regular operator rounds including the checking and subsequent changing of the High Efficiency Particulate Air (HEPA) filters in the ventilation systems. The ILW store has a ventilation system that draws a continuous minimum flow rate to reduce risks from flammable or explosive atmospheres.

1.1.3.4 Urenco UK Ltd (UUK)

UUK is an international supplier of enrichment services and fuel cycle products for the civil nuclear industry, serving utility nuclear generation worldwide. UUK holds the nuclear site licence for the Capenhurst site, which encompasses a number of facilities including:

- Three nuclear fuel enrichment facilities, the largest of which produces more than 80% of the total site enrichment capacity (see below for further details);
- Cylinder storage rafts;
- Support facilities that include chemical laboratories, site utilities, a fire station and an emergency control centre; and
- Two tenant organisations:
 - Urenco ChemPlants (UCP), operating a Tails Management Facility (TMF), converting depleted uranium hexafluoride to the lower hazard triuranium octaoxide (U_3O_8) material for long-term storage (see below for further details); and
 - Urenco Nuclear Stewardship (UNS), which receives and stores uranium residues and provides decommissioning and solid waste processing and storage services.

Natural uranium hexafluoride (UF_6) containing approximately 0.7% of the isotope ^{235}U , the remainder being the ^{238}U isotope, is transported in solid form to and from site in cylinders that are internationally approved for transport. The ^{235}U isotope is used in nuclear power generation. The UF_6 is weighed upon arrival for uranium accountancy purposes and then stored pending enrichment. Enrichment is carried out using gaseous centrifuge technology. The UF_6 is heated to approximately 40–60°C, which turns the solid into a gas. The gaseous UF_6 flows through a series of centrifuges, known as a cascade, which progressively increases (enriches) the concentration of ^{235}U . The enriched product gas stream is removed from the centrifuges into UF_6 cylinders and cooled to a solid. Enrichment is typically between 4-5% ^{235}U . This product material is sampled, weighed and, if required, blended and then stored on site pending transport to customers worldwide. The centrifuge process results in a gas stream with a lower (depleted) concentration of ^{235}U , typically 0.3%, referred to as tails. This gas stream is also removed from the centrifuges into UF_6 cylinders and cooled to a solid. The tails material is stored on site pending further enrichment, product blending or deconversion in the TMF.

The TMF receives tails from Urenco's European enrichment sites in the Netherlands (UNL) and Germany (UD). The tails cylinders are heated to turn the UF_6 into a gas. The gas enters an electrically heated kiln where it is reacted with steam and hydrogen to produce U_3O_8 and hydrogen fluoride (HF). Both materials are cooled, with the U_3O_8 being stored on site for UUK tails or returned to UNL and UD. The HF is transported in approved road tankers to customers in the chemical processing industry. UCP also carries out ancillary processes such as washing and recertification of UF_6 cylinders, decontamination and maintenance of plant equipment and recovery of uranic residues from these processes.

Installations within each of the three businesses operate with shared resources such as electrical power, gas supplies and firefighting infrastructure. Emergency management and on-site response for all facilities is provided by UUK, including coordination with local off-site resources with pre-determined response plans involving local Fire and Rescue Service and relevant local authorities for mitigating nuclear safety consequences in line with requirements of the Radiation (Emergency Preparedness and Public Information) Regulations 2019 (REPPIR).

UUK and UNS safety cases include safety analyses carried out to identify all sources of radiological exposures and to evaluate radiation doses or hazardous material exposure that could be received by workers and the public, as well as potential effects on the environment. This includes consideration of fire events (design basis fire accidents) from which the engineering design and fire withstand is established, the effectiveness of the safety systems and safety related items or systems is demonstrated, and the requirements for emergency response are established.

Assessments undertaken by UUK and UNS conclude that the installations present a low nuclear fire risk due to the inherent properties of the nuclear materials held and their treatment during operational processes. The basis of safety for the UCP operated facility includes detailed assessments for risk of explosion from natural gas and deflagration of hydrogen, with risks concluded to be broadly acceptable for most areas and as low as reasonably practicable (ALARP) for all other activities. No pyrophoric materials are used or stored within any of the facilities.

In addition to nuclear fire safety, the licensee undertakes conventional fire safety assessments for life protection, which consider the design of the individual areas of the facilities in terms of structural fire safety, means of escape, fire brigade access and the means for raising an alarm in case of fire. As the conventional and nuclear fire safety assessment reports are complementary, the conventional fire safety assessment findings are referenced in the NAR where appropriate. The licensee's assessment also reports that there are no facilities in the direct vicinity of the site that may affect the nuclear fire safety of Capenhurst.

1.1.3.5 Springfields Fuels Ltd

Description of the site

The Springfields site is situated near the outskirts of Preston, Lancashire. The site has been operational since 1946 and covers an area of approximately 83 hectares (205 acres). In addition to the site being a nuclear licensed site under section 4 of the Nuclear Installations Act (NIA) 1965, the site is classified as a 'upper tier' site under Regulation 2(1) of the Control of Major Accident Hazards (COMAH) Regulations 2015, due to the generation and storage of significant quantities of concentrated hydrofluoric acid (CHF). COMAH is the UK-specific implementation of the Seveso III directive, except for land-use planning requirements, which are implemented by changes to planning legislation.

The 2023 COMAH safety report for Springfields identifies one Major Accident Hazard (MAH) related to fire. Mitigation arrangements are in place through plant safety cases. The

site is also subject to an Environmental Permit and Radioactive Substances Act (RSA) authorisation.

Springfields Fuels Ltd's main activities are:

- Design (including transport package designs) and manufacture of nuclear fuels and intermediate products, such as uranium dioxide (UO_2) and fuel assembly components;
- Decommissioning of on-site facilities;
- Management of the Springfields site; and
- Recovery of residues.

Springfields site is also occupied by the National Nuclear Laboratory (NNL), Springfields facilities, who carry out research and development and supply Springfields Fuels Ltd with specialist environment health and safety (EHS) support and testing services.

Installations in the direct vicinity of the site

The only adjacent hazardous installation in the direct vicinity of the site is F2 Chemicals which is a lower tier COMAH site. It is enclosed by a security fence conjoined to the Springfields security fence at the northeast end of the site. F2 Chemicals does not use, store, process or transport radiological materials and the F2 Chemicals site is not part of the Springfields nuclear licensed site.

Plant process activities

The main process activities undertaken at Springfields are:

- The production and assembly of the fuel pellets into fuel elements for AGRs and fuel assemblies for LWRs: AGR finished fuel is held in a separate building, and LWR finished fuel is within an integral fuel store with space limited to around 200 Fuel Assemblies on site prior to transfer elsewhere.
- Recovery of enriched uranium from the various residues that arise from processing plants: these residues are treated to produce new feedstock for recycling in the main process facilities. Uranium residues are also processed to produce new UO_3 feedstock.

Ancillary operations that support the main process are described within the Springfields site full submission to the NAR [9]. A summary of the principal processes is provided below.

Oxide Fuels Complex (OFC)

The Oxide Fuels Complex (OFC) converts enriched uranium hexafluoride (hex or UF_6) from external suppliers into uranium dioxide (UO_2) powder using the Integrated Dry Route (IDR) process. The UF_6 is fed from transport cylinders into an IDR kiln with super-heated steam to form uranyl fluoride (UO_2F_2). The UO_2F_2 is then reduced within the IDR kiln by hydrogen to form ceramic-grade UO_2 powder. This resulting powder may be granulated or pressed into UO_2 pellets. Following sintering, these can then be fabricated into finished fuel pins for

AGRs and fuel rods for LWRs and subsequently fuel elements for AGRs and fuel assemblies for LWRs. Powder, granules, and pellets may also be exported in transport containers as finished products via the Powder and Pellet Export Facility (PPEF).

The main process (conversion) area of the Oxide Fuels Complex houses autoclaves, IDR kilns, powder/granule handling and pellet manufacturing equipment, with facilities for recovering residues and processing waste streams generated by the main processes (for example, the decontamination facility). There are Mechanical Areas (1 and 2) that house equipment used for fabricating fuel pins and elements. A facility for Light Water Reactor (LWR) rod and fuel fabrication conjoins the Mechanical Areas. Specific processes carried out in each area are described in the Springfields site full submission [9].

Service supplies to the whole facility, including hydrogen, compressed air and nitrogen are fed from other facilities on site via a gantry located on the north side of the building. Many of the fault scenarios associated with the Oxide Fuels Complex concern the overheating or the inadvertent heating of UF_6 in either its transport cylinder or in the plant pipe work. OFC has introduced secondary containment autoclaves, thereby reducing the risks associated with heating UF_6 compared to the previous fuel plant.

Fire hazards from a potential radiological consequence perspective involve diesel pool fires. This drives the provision of well-drained purpose-built storage facilities for radiological inventories, so that any accidental diesel spill does not pool but instead drains away to the surrounding drains. All rafts used for storing uranium hexafluoride are designated safety features and are purportedly designed as per above.

Hydrogen is used throughout the Oxide Fuels Complex. Flame traps and other safety systems including inert purging, appropriate trip systems and suitable area classification zoning are used to mitigate the risk of an explosion.

Other fire hazards are primarily conventional such as electrical fires, overheating bearings, or fires due to hot working.

The main process stages carried out in the LWR Fuel Fabrication facility and the Powder and Pellet Export Facility are listed in the Springfields site full submission [9].

Zirconium swarf and turnings are produced as part of the process. Acetone is used primarily for cleaning finished fuel assemblies. Production areas have criticality controls that include restrictions on the use of hydrogenous firefighting agents.

Finished Fuel Store

The finished fuel store is used for the storage of finished AGR fuel produced within the Oxide Fuels Complex in IAEA-compliant transport containers prior to despatch to the appropriate reactor station. Transport containers of each type of fuel are stacked by a forklift truck (or a pedestrian operated version of such) in accordance with the terms of the Criticality Clearance Certificate covering the building.

Enriched Uranium Residues Recovery Plant (EURRP)

The EURRP processing building contains a nitric acid wash facility, wet process areas for dissolvers, precipitators etc, residue's storage areas and an SGC store, a furnace area, UN storage areas and a solvent extraction/nitric acid storage area.

Services include electrical switchrooms, workshops, stores, tank rooms and ventilation input and extract fans with a motor control centre. An amenities building containing offices, changerooms and a canteen conjoins the main processing building.

External areas around the building contain effluent tanks, check tanks, a neutralising vessel and a cooling water tower. There is a separate bunded SGB pumping station for washings. A concrete apron at the east side of the building is used to store filters, Intermediate Bulk Containers and Safe by Geometry Bins (IBCs and SGBs) awaiting processing. An open area to the north is used for the storage of low uranium content residues.

EURRP currently processes materials from the Oxide Fuels Complex (OFC) and the Hex Cylinder Wash plant, as well as historic SFL residues (such as bulk calcined cake material). In the future, the spectrum of materials requiring processing via EURRP may change and other residues from uranium bearing materials may require processing.

Westinghouse has recently undertaken a modification of EURRP to permit the future spectrum of feedstocks to be processed at the desired rates.

Flammable and combustible materials present associated with the process include hydrogen, 20% tri-n-butyl phosphate/odourless kerosene (20% TBP/OK), ammonium hydroxide (NH₄OH), ethylene glycol, hydraulic oil and miscellaneous substances (i.e. consumables and paints). A description of the specific use of each material is provided within the Springfields site contribution to the NAR [9].

New Enriched Powder Store (NEPS)

The New Enriched Powder Store (NEPS) is a single storey building for storing enriched powder in drums on steel racking. Combustible materials in the building are low to negligible and the risk of fire extremely low.

Waste management

The Springfield site activities under the nuclear site licence do not include re-storage of waste and there are no spent fuel storage facilities on site. The main waste management functions on the Springfields site are the storage in designated locations of residues and contaminated materials prior to processing, the recovery of enriched uranium, and the safe disposal of wastes from the site.

A short-term agreement is in place to store Very Low Level Waste (VLLW) on an external raft whilst a new landfill disposal option was found. This is now in place and the Springfields site are working through the backlog of stored waste. All new waste arisings are sent for disposal (as per previous years using the Clifton Marsh disposal facility). Jazz boxes of waste on an external raft are classed as 'Work in Progress' with the site working through their contents with the waste generators to confirm compliance with the waste acceptance criteria (WAC). The safety case for waste storage on the raft is still live and in date.

Research and technology

In addition to the main process routes, research and technology operations are carried out in a purpose-built facility that has the capability to carry out a wide range of development activities, based primarily on uranium processes.

Common and shared resources

Common and shared resources on the Springfields site include:

- Combined Heat & Power Plant (CHPP): provides heat (in the form of steam) and electricity.
- Electrical Distribution: substations located around the Springfield's site.
- Purchased Water System: a site wide underground distribution system.
- Borehole Water System Pumphouse: supplies water into a ring main system from which the fire hydrants, emergency showers and various buildings are supplied.
- Main Hydrogen Store: a trailer of hydrogen cylinders located in an open area of the site that feeds into the hydrogen supply pipework.
- Miscellaneous Services: including the compressed air production and distribution system, mask air, steam, nitrogen and carbon dioxide, telephones and computer networks.
- Pipebridges: these carry services such as steam and nitrogen, caustic soda, nitric acid, hydrogen and CHF.
- Site Fire Service: the Springfields Site has a 24/7 fire service on site providing emergency response to site wide events including fire, ambulance, toxic, criticality and environmental incidents with a back-up response from the Lancashire County Fire and Rescue Service.
- Security: Springfields Fuels Ltd is a Category 3 nuclear site. The role of the security team is to create a safe and secure environment for employees, visitor, and contractors.
- Emergency Control Centre (ECC): the ECC operates 24/7 for all site emergencies and operational arrangements. The ECC is responsible for handling all incidents, including fire, toxic, medical, criticality and any utility alarms.

Offsite resources

Lancashire Fire and Rescue Service (LF&RS) have a response plan for the Springfields Site and liaise with both Site and Springfields Fire and Rescue Service with respect to operational response requirements. Springfields Fire and Rescue Service take part in site emergency exercises to mimic responding to differing scenarios.

The Springfields Off-Site Emergency Plan has been prepared by Lancashire County Council (LCC) in conjunction with Springfields Fuels Ltd and gives comprehensive details for dealing with the off-site consequences of a site incident.

1.1.3.6 Dounreay Site Restoration Ltd

Dounreay, located in the far north of Scotland, is the site of Britain's former centre of fast reactor research and development and is currently being decommissioned. Dounreay is in a remote location and there is no full-time fire service in the local area. A dedicated on-site fire service, trained to deal with the fire hazards on the site, provides full-time cover.

The Dounreay site contains a de-fuelled test reactor, two experimental fast neutron reactors (both de-fuelled), fuel processing facilities, a cementation plant, waste processing facilities and waste stores. None of the reactors are operational however, some facilities related to waste processing and storage remain in operation to support overall site decommissioning. *Following transfer on 1st April 2023, the Nuclear Site Licence for Dounreay is now held by Magnox Ltd., a subsidiary of the Nuclear Decommissioning Authority (NDA). Prior to this the license was held by DSRL.*

Prototype Fast Reactor (PFR)

The PFR commenced construction in 1966, went critical in 1974, and ceased operation in 1994. PFR provided power to the national grid and informed the future design and operation of large commercial fast reactor stations. PFR was a 250 MW(e) pool-type sodium-cooled fast reactor using mixed uranium and plutonium oxide ceramic fuel clad in stainless steel.

The PFR complex includes the reactor plus other facilities such as those for storage of spent fuel, alkali metal and contaminated components, and an Irradiated Fuel Cave (IFC). The PFR complex includes several buildings, some operational in support of decommissioning, some under care and maintenance and some being decommissioned.

While not every task performed at Dounreay is performed in the PFR complex, it can be considered representative of the site as it includes a decommissioning reactor with experience of alkali metal treatment and disposal, waste storage areas, flask operations, Low Level Waste (LLW) and Intermediate Level Waste (ILW) generation and handling, a pond, lifting operations, remote handling (cave) operations, and maintenance tasks including cell entries.

The reactor, housed within the Secondary Containment Building (SCB) in a below-ground vault, has been de-fuelled. The bulk sodium has been destroyed. A heel pool remained and the majority of this was recently removed. Currently only undrainable hold-ups, known as residues, remain. In all cases the sodium stored is now in a solid state at ambient or room temperature and as such its hazardous properties are greatly reduced.

The SCB also includes:

- The IFC, which currently contains irradiated equipment and spent nuclear fuel;

- The Irradiated Fuel Buffer Store (IFBS), where all fuel has been removed from the pond;
- The Wet Area Size Reduction Facility (WASRF) for size reduction and steam cleaning of LLW recovered from the mortuary storage holes; and
- The Effluent Treatment Plant (ETP), which collects active effluent and abates the activity prior to discharge of the liquors.

The Turbine Hall houses the Sodium Disposal Plant (SDP), Caesium Removal Plant (CRP) and Alkali Metal Laboratory (AML), all of which are being decommissioned.

The Generator Transformer House (GTH) is currently used as an alkali metal storage facility. The Ventilation Annexe contains all the air handling equipment for the SCB.

Dounreay Fast Reactor (DFR)

The DFR commenced construction in 1955, went critical in 1959, and provided power to the national grid from 1962 until 1977, when it ceased operation. DFR was a loop-type fast breeder reactor cooled by primary and secondary sodium-potassium (NaK) circuits. The NaK disposal plant has processed 57 te of NaK, and only residual quantities remain in the DFR complex, the majority in the reactor vault.

The reactor core was initially fuelled with uranium metal fuel stabilised with molybdenum clad in niobium. The core was later used to test oxide fuels for PFR and provide experimental space to support overseas fast reactor fuel and materials development programmes. It had over 5,000 breeder elements of natural uranium clad in stainless steel arranged in inner and outer breeder sections. The core (except for one element), one quarter of the breeder fuel, and all the plant and buildings associated with steam raising and power generation have been removed and disposed of.

Fuel Cycle Area (FCA)

The FCA houses the facilities that historically handled and stored the site's nuclear material and waste. Most of the buildings were built during the early construction phase of the site in the late 1950s. The fuel cycle facilities were used for the manufacture of fuel elements, post-irradiation examination of irradiated fuel, fuel reprocessing, waste holding and treatment, and analytical services and research in laboratories.

Facilities constructed in the FCA since the 1980s include a supercompaction plant, a cementation plant, and a number of waste stores, allowing the processing and storage of historical and decommissioning wastes. The stores include a Contact Handled Intermediate Level Waste (CHILW) store for 200 litre drums and Remote Handled Intermediate Level Waste (RHILW) stores for immobilised 500 litre drums, the newest of which is currently being commissioned for use.

Balance of site

A vertical shaft was built at Dounreay in the 1950s to remove rock spoil during excavation of a subsea tunnel for the site's effluent discharge pipes. In 1958, it was authorised as a disposal facility for ILW and is referred to as the Shaft. Disposals ceased in 1977 when a

gas-phase explosion above the waste caused damage to the concrete covers and the area around the head of the Shaft. The Shaft is now freely vented to prevent a recurrence.

The Dounreay Wet Silo was constructed in 1970 as an engineered underground store for RHILW waste items produced on site. The Silo consists of a watertight reinforced concrete box with its roof roughly at ground level. The Silo was filled with water to accommodate heat generation from the waste, and to provide fire protection and shielding. From 1971 until its final closure in 1999, deposits were dominated by waste from the DFR fuel cycle work and activated components from the PFR fuel cycle operations.

The waste is to be retrieved from the Shaft and the Silo and encapsulated within 500 litre drums for on-site storage pending final disposal. The remaining facilities on site are related to the storage, grouting and disposal of LLW within ISO containers.

Key parameters for the PFR facility

For the purposes of the TPR project, only the PFR complex including the IFC is reported on in line with a sampling approach and the justification for installations selected (see Section 1.1.2).

PFR currently has a Decommissioning Safety Case (DSC), which justifies routine activities that support decommissioning. The facility encompasses several buildings in a variety of operational phases – for example, some areas are in care and maintenance, whilst others are operational to support decommissioning. The DSC serves as an umbrella safety case and all future decommissioning such as Reactor Vessel Treatment and Reactor Dismantling will be undertaken as modifications to the DSC. Any implications to fire safety and to the DSC will be assessed as part of due process requirements.

The list below presents a summary of the significant radiological hazards within PFR:

- Bulk alkali metal and alkali metal residues (the bulk sodium from the Reactor Vessel has been destroyed and the heel pool of sodium has been removed; it is currently stored within a dedicated vessel awaiting treatment);
- Bulk sodium and sodium or NaK contaminated components are stored at several locations within the facility;
- Irradiated fuel (pins, assemblies and clusters), absorbers and associated items contained within the IFC;
- Active ex-reactor components currently stored within the West End Mortuary (WEM) and Reactor Hall Mortuary (RHM); and
- Activated steel and equipment.

Routine operations within PFR include:

- Plant surveillance, maintenance, radiological monitoring and housekeeping;
- Operation of the reactor vessel nitrogen gas blanket;

- Waste handling, dismantling and removal of moveable, internal equipment involving use of manipulators, in-cave hoists and posting systems and minor decontamination; and
- Periodic operation of the pond clean-up system.

Further examples of operations undertaken at PFR are provided in the Dounreay submission for TPR [10].

The Decontamination Area is used operationally for a variety of tasks. Within the WEM, active components are stored within mortuary holes. This term is commonly used to refer to spaces used to store spent reactor components normally within biologically shielded areas. The Steam Clean Booth can be used to clean smaller items. Small-scale cleaning and size reduction of components is also carried out in tented areas.

The Wet Area Size Reduction Facility (WASRF) is used for size reduction of LLW items recovered from mortuary storage holes using cold cutting techniques. Intermediate Level Waste (ILW) components will be returned to the mortuaries storage until the ILW Size Reduction Facility (SRF) is available. The ILWSRF will be supported by stand-alone safety case documentation, with the Preliminary Safety Report (PSR) recently completed.

The Decontamination Area is used for the maintenance of manipulators as operational support for the IFC. Within the Turbine Hall and Diesel Generator Building, the only routine operations are storage and routine checks on the condition of ISO containers loaded with drums and components contaminated with alkali metal.

Routine checks are carried out on the condition of bulk sodium and sodium and NaK contamination items stored in the GTH. Within the Sodium Inventory Disposal (SID) facility, sodium contaminated vessels and sodium or NaK contaminated components are cleaned, and the liquid effluents neutralised and disposed of as solid wastes.

Routine operations in the Effluent Treatment Plant (ETP) include collection and treatment of active effluent from various sources including the IFBS pond, the Steam Clean Active Liquor Filter (SCALF), IFC hold tanks, wet area drain and plant area sumps. The activity within these liquors is abated to enable discharge under discharge authorisations. ETP pipework inspection and replacement is also carried out.

The electrical annexe contains all the main switchgear and connections to the site electrical distribution system.

The Dounreay Fire Ambulance and Rescue Service (DFARS) provide a full-time service on site, 24 hours a day. The DFARS personnel are trained and equipped to deal with a range of incidents. In addition to firefighting, the DFARS operates a variety of protective, radiation monitoring and rescue equipment. Further support can be provided by the Occupational Health Department (OHD), Civil Nuclear Constabulary (CNC) and Civilian Guard Force (CGF). Further information on their capabilities and responsibilities can be found within the Dounreay submission for TPR [10].

Close co-operation is maintained with the Scottish Fire and Rescue Service who train and exercise with the DFARS. Assistance is requested from the Scottish Fire and Rescue

Service and Scottish Ambulance Service should the need arise. Arrangements exist for integrating the command structures of the DFARS and the Scottish Fire and Rescue Service. The DFARS would co-ordinate any firefighting teams provided by Scottish Fire and Rescue Service.

1.1.4 Approach to development of the NAR for the national selection

The intention for GB nuclear sites to contribute to the TPR 2 was first communicated by ONR to industry stakeholders in April 2022. A follow-up letter was issued to the participant licensees in July 2022, signposting to ENSREG's Terms of Reference and Technical Specification for TPR 2. The national self-assessment by participant licensees formally started through a stakeholder event hosted at ONR's offices in Liverpool, where ONR presented the timeline for NAR production, the expectations on participant licensees and key considerations from the Technical Specification [1], Terms of Reference [11] and ONR regulatory expectations. ONR also provided guidance on licensee's contributions in terms of compatibility with the technical specification information as well as additional contextual information, in particular the terminology in the specification and intention of each section of the NAR.

Following this initial stakeholder event, monthly one-to-one meetings were held with contributing licensees and ONR TPR 2 team members to provide feedback and clarify points of detail regarding self-assessment expectations. This was supported with multi-stakeholder engagement with licensees facilitated by the Nuclear Industry Fire Safety Coordinating Committee (NIFSCC), a sub-group of the UK Safety Directors Forum (SDF).

The NAR was then assembled from contributions by the relevant licensees, as provided to ONR between November 2022 and June 2023 and assessed by ONR throughout the process.

1.2. National regulatory framework

1.2.1 National regulatory requirements and standards

The principal primary legislation for ensuring the safety of nuclear installations consists of the following Acts of Parliament:

- Energy Act 2013 [12]
- Health and Safety at Work etc. Act 1974 [13]
- Nuclear Installations Act 1965 [14]

The Energy Act 2013 (TEA13) [12] sets out the provisions which set up ONR as a statutory body, establishing its purpose, its powers and functions. ONR's purposes are those relating to regulating nuclear safety, nuclear site conventional (industrial) health and safety, civil nuclear security, nuclear safeguards and the transport of radioactive material.

The Health and Safety at Work etc. Act (HSWA74) [13] applies to all work activities within UK and hence is much broader than nuclear safety. HSWA74 allows regulations to be

made relating to industrial safety and radiation protection. Under HSWA74 a general duty is placed on all employers and the self-employed to conduct their undertaking in such a way as to ensure the health and safety at work of their employees and those affected by their work activities, so far as is reasonably practicable (SFAIRP). The principle of SFAIRP is underpinned by the concept of relevant good practice (RGP). RGP is the generic term used for those standards or approaches to controlling risk that have been judged and recognised by ONR and the industry as satisfying the law when applied to a particular relevant case in an appropriate manner. TEA13 made ONR the enforcing body for HSWA74 on licensed nuclear sites, on any adjacent construction areas, and for the supply chain where structures, systems and components (SSC) are being manufactured that may affect nuclear safety on nuclear licensed sites.

Under the Nuclear Installations Act 1965 [14] no site can be used for the purpose of installing or operating a nuclear installation unless a nuclear site licence granted by ONR is currently in force. Only a corporate body, such as a registered company or a public body, can hold a licence and the licence is not transferable. Those parts of the NIA65 relevant to safety and licensing are 'relevant statutory provisions' of TEA13, which means they are enforced by ONR under that legislation. NIA65 requires and permits ONR to attach such conditions to a site licence as it sees appropriate in the interests of safety or radioactive waste management. It is an offence under the law not to comply with the licence conditions.

To ensure that the regulatory interpretation of the licence conditions is consistent, ONR has published a set of technical inspection guides (TIGs), which provide guidance for ONR inspectors on the planning, content and reporting of inspections to monitor the adequacy of nuclear site licensees' arrangements against legal requirements.

The technical principles ONR uses to judge safety cases are set out in its safety assessment principles (SAPs) [15]. These form a framework of regulatory expectations for ONR inspectors to use when making technical judgments on the adequacy of licensees' safety submissions, including compliance with fire safety requirements. The SAPs are supported by more detailed guidance in a suite of technical assessment guides (TAGs), which provide detailed guidance to ONR inspectors on the interpretation and application of ONR's SAPs when assessing the adequacy of licensees' safety cases and other safety documentation within the nuclear safety regulatory process. While the suite of SAPs includes the Internal and External Hazards (EHA) series, with specific expectations on fire safety, the full suite of SAPs including the Fault Analysis (FA) series, Engineering Key Principles (EKP) series and numerical targets are applied holistically by internal hazards and fire safety inspectors when making judgements on dutyholders' consideration of fire safety in nuclear installations.

Further regulatory expectations on fire protection from a nuclear safety perspective are detailed in ONR's Internal Hazards guide [16]. The SAPs and Internal Hazards TAG [16] incorporate the IAEA safety standards [17] [18] [19] and other relevant international and national standards. More specifically, ONR ensures the implementation of WENRA Safety Reference Levels (SRL) through incorporation in ONR guidance, including referencing them explicitly in the TAGs.

In line with the goal-setting nature of the UK's regulatory framework, dutyholders' demonstration that the risks have been reduced to ALARP is made through safety cases and fire safety provision which implement RGP, including standards and guidance from

other jurisdictions such as those set by the United States Nuclear Regulatory Commission (US NRC), European Utility Requirements (EUR) or other equivalent national standards.

Also relevant to fire safety in nuclear installations in GB is the Regulatory Reform (Fire Safety) Order 2005 (FSO) [20] and the Fire Scotland Act 2005 (FSA) [21]. This suite of secondary legislation sets the regulatory requirements to protect people from fire and specifically covers fire precautions and other fire safety duties. The legislation is, again, goal-setting rather than prescriptive and places duties on the 'responsible person'. The FSO/FSA require fire precautions to be applied 'where necessary' and this therefore covers both the design and occupation of buildings. While this legislation applies to 'life fire safety' rather than nuclear safety, ONR is the enforcing authority of the FSO and FSA at GB licensed sites, enabling holistic and consistent consideration of fire from both nuclear safety and life safety perspectives across GB nuclear installations.

In addition to the FSO and FSA, several complementary sets of regulations overlap with nuclear and life fire safety requirements. These include:

- The Dangerous Substances & Explosive Atmospheres Regulations (DSEAR) [22], which is the GB implementation of the ATEX 99/92/EC directive. Clauses within DSEAR related to the production of risk assessments and provision of control and mitigation measures to prevent harm to personnel from fire also form part of the FSO.
- The Control of Major Accident Hazards (COMAH) Regulations 2015 [23], which places additional requirements on sites which store or use large quantities of defined dangerous substances (including flammables). The extent of the requirements depends on specific substances and the quantities held.
- The Construction (Design and Management) (CDM) Regulations 2015 [24], which places legal duties on dutyholders involved in construction activities. This can include principal contractors, principal designers, and other workers. A more dynamic Fire Risk Assessment (FRA) requiring more regular scrutiny would be expected throughout construction works to ensure compliance with the FSO/FSA and the fire specific clauses of CDM.

1.2.2 Implementation/ application of international standards and guidance

As highlighted in Section 1.2.1, international standards are implemented within the GB regulatory framework including through incorporation into and alignment of ONR SAPs, TIGs and TAGs.

As a regulatory body, ONR is involved in the management of a range of relevant international standards and guidance, including IAEA standards and guides on fire safety and internal hazards, and the WENRA SRLs. ONR ensures all relevant expectations are reflected in the appropriate ONR internal guidance once those international documents are formally published. TIGs and TAGs are updated as necessary to ensure changes to national and international standards are recognised and implemented as appropriate and are reviewed at least every five years.

Responsibility for the maintenance of TAGs is shared between ONR's Professional Leads for individual technical areas and the Regulatory and Technical Standards sub-programme within ONR's Technical Division. This includes the Fire Safety and Internal Hazards expectations in the SAPs, TIGs and TAGs through the Nuclear Internal Hazards and Site Safety Specialism and ONR Professional Lead.

2. Fire safety analysis

2.1. Nuclear power plants

The text in the sections below has been prepared by EDF Energy Nuclear Generation Ltd and NNB Generation Company (HPC) Ltd with minimal editing by ONR. Background information on the sites and the range of installations considered in the scope of the assessment is provided in Section 1.1.3.

I Operating reactors – EDF NGL

I-2.1.1 Types and scope of the fire safety analyses

I-2.1.1.1. Background note

The EDF NGL NPPs selected for the NAR represent the national and international development of fire protection arrangements from the 1970s to the present day. Over this time the philosophy of fire safety has changed from primarily active to mainly passive fire protection. This is reflected in the development of the corporate fire safety guidelines approach since the AGRs were first designed and built in the mid-1960s. This mirrors the development of IAEA Safety Guide 50-SG-D2 and subsequent revisions and updates to the present IAEA Safety Standard SSG-64 'Protection against Internal Hazards in the Design of Nuclear Power Plants' [17].

The change of approach to fire safety followed on from Browns Ferry Fire in 1975 as this fire affected multiple lines of safety equipment and caused difficulties to the operators in safely shutting down the reactor. Prior to the Browns Ferry Fire, fire protection for NPPs was similar to the fire protection at conventional power stations. The Browns Ferry Fire demonstrated that a fire could threaten nuclear safety, and this led ultimately to the current fire safety segregation standards that ensure the designed shutdown arrangements can be carried out in the event of fire.

In the UK in 1977 a fire in a conventional power station (Tilbury B) spread from the control room along cable ducts and demonstrated again that a fire can affect cabling and remove the designed shutdown arrangements. This was one of the reasons why, following the Tilbury B fire, linear heat detecting cable and fast acting sprinklers were installed on the first generation AGRs. The system is a means of detecting a fire quickly by having a heat-detecting cable on top of every cable tray and underneath the lower tray, which is then interfaced with the sprinkler system by having a pyrotechnic actuator on every sprinkler head. If a slight overheat is detected in a cable flat, the relevant nearby sprinkler heads are electrically operated. The response time is typically a fraction of a second to a minute, and the sprinkler system extinguishes the fire very rapidly.

Fast-acting sprinkler systems for detection and suppression of fires, which require fast activation in order to be effective, require that particular attention is paid to design and maintenance details. Of primary consideration are detector selection and placement in processes to minimise the effect of environmental influences. Also important are nozzle placement, water flow density, water supply pressure, and the pattern and sloping of piping.

When all of these design criteria are properly implemented, water application can occur within 100 milli seconds of fire detection.

Where practicable, passive fire protection (typically using durasteel fire barriers – a composite fire panel protection board comprised of fibre-reinforced cement core mechanically bonded to punched steel sheets on both outer surfaces) was also backfitted to the first generation AGRs, but active fire protection was a necessary part of the fire safety case. Following the Browns Ferry fire, safety-related control and power cabling was fully segregated for the second generation AGRs and SZB. For these stations, which are represented in the NAR by HY2 and SZB, the primary claims are on segregation and fire suppression is provided for defence in depth and investment protection.

I-2.1.1.2. Deterministic fire hazard analysis

General: EDF NGL's approach to deterministic fire hazard analysis is documented in internal guidance, which is used for all the AGR stations, including the two AGR stations covered in the NAR, Hunterston B (HNB) and Heysham 2 (HY2). HNB is shutdown and defueling and HY2 is operational, therefore both de-fuelling and normal operating states are considered in this section. The document is summarised below.

Fire protection safety principle: EDF NGL's fire protection safety principle below forms the target basis against which the fire protection provisions provided at the AGR power stations are assessed.

In the event of a fire in any single location with all plant available prior to the fire, sufficient plant should remain available to ensure satisfactory operation of the trip, shutdown and post-trip cooling function, taking into account the effect of any single random active failure of the plant or fire protection systems. Under permissible states of planned maintenance, the effects of a single random active failure do not need to be taken into account.

The overriding EDF NGL requirement is to ensure fitness for purpose in the fire protection provisions and to do all that is reasonably practicable to satisfy the guidance presented in this document. In general, diverse/back-up systems should not be claimed in demonstrating compliance with the safety principle. EDF NGL considers that exceptions may be permissible in some circumstances providing that the overriding regulatory requirement of demonstrating that risks are reduced to ALARP is met.

Fire protection philosophy: EDF NGL requires a fire protection to be provided to meet the safety principle and for it to be achieved through defence in depth concept which should have as its three principal objectives:

1. Preventing fires from starting;
2. Detecting and extinguishing quickly those fires which do start; and
3. Preventing the spread of those fires which have not been extinguished.

The first objective requires that plant operation and any modifications to the plant are such that the probability of a fire starting is minimised. The second concerns the extinguishing of fires by a combination of automatic and/or manual firefighting techniques, and the third generally involves the use of passive fire barriers and segregation of plant to limit the effects of fires.

First generation AGRs (HNB): at the design stage of HNB, the fire protection philosophy was biased towards ‘fire influence’, i.e., fire detection and suppression. After the Browns Ferry fire, the AGR fire containment was improved, i.e., more fire compartmentation was added to prevent fire spread if fire suppression failed. Additional lines of protection were added, including diverse Pressure Vessel Cooling Water (PVCW) and the Back-Up Cooling System (BUCS), which are both physically remote or separated from the other lines of protection such that fire cannot affect both at the same time. As a result, the nuclear fire safety case can tolerate full compartment burn out, such as loss of the contents of entire cable flat due to fire and all the equipment that it supports. Detection, suppression and compartmentation prevents the fire spreading beyond the compartment of origin. Specific plant items were also given dedicated fire protection. In summary, the station started mainly with the fire influence approach, but the deterministic fire safety philosophy is now a mixture of influence and containment. Further detail on the first generation AGRs is provided in the EDF NGL submission [25].

Second generation AGRs (HY2) - EDF NGL’s deterministic fire hazards safety case for HY2 assesses the design for ensuring nuclear safety and provides substantiation for EDF NGL’s claim that, when operated in accordance with the design intent, the station is adequately safe. The HY2 design is based on quadrantisation of the safety systems providing essential safety functions, with either distance or physical barriers between them. The fire barriers separating trains 1 and 2 from trains 3 and 4 are four hour-rated barriers; the fire barriers between trains 1 and 2 are one hour-rated barriers, as are the fire barriers between trains 3 and 4. The overall approach for faults and hazards, including fire, is based on the concept of defence in depth i.e. overlapping provisions that are built into the fundamental design and operation of the plant in order to prevent, protect and mitigate the effects of an initiating event.

At HY2, damage limitation measures against fire hazards have historically been based on passive protection provided through segregation of essential plant by fire barriers and/or separation. It was originally intended that the manual and automatic Fire Detection and Suppression Systems (FDSS) provide an additional layer of defence in the form of fire mitigation, with the safety case stating that these systems were not ‘claimed’ for this duty, owing to the fundamental design philosophy of passive protection. The FDSS were also not considered a necessity due to the ability of the Reactor Protection System (RPS) to detect changes in plant operation which could impact safety and the fault tolerant design of essential safety systems.

However, since going into commercial operation, EDF NGL’s reviews and assessments of the fire hazards safety case e.g. at PSR1 and PSR2, development of the PSA and development of the Station Safety Report, as well as safety case revisions, have placed a small number of claims on the FDSSs. Hence the deterministic approach to fire hazard risk management is based on the passive protection provided by fire barrier segregation to limit

the damage caused by fires, supplemented by claims on active protection. Further detail on the deterministic fire safety case at HY2 is provided in the EDF NGL submission [25].

Sizewell B: the SZB design has four trains of equipment that are segregated from each other by three-hour fire barriers. The combustible loads within these fire barriers were assessed as part of the design process, and EDF NGL confirmed that the fire loads are within the capability of the fire barriers.

The deterministic design against internal hazards, including fire, was based on the so-called 'single failure criterion', which is:

- one train may fail due to the hazard
- one train may be unavailable due to maintenance
- one train may fail to start
- the remaining train is available to carry out the required safety functions

A deterministic fault tree assessment was carried out on the preliminary design, using the above single failure criterion. This confirmed that the design met this criterion, i.e., that adequate Lines of Protection (LoP) are provided to perform the required safety functions in the event of a fire. Lessons learned from the deterministic fault tree assessment were carried forward to the probabilistic fire safety assessment referred to in Section I-2.1.2.

I-2.1.1.3. Operational states

General: for the AGR stations, the fire hazard assessment is not linked to the reactor power operating states or the refuelling outage, as the original AGR design was for on-load refuelling. The fire hazard is treated equally at all times on a conservative basis. However, the assessment criteria to determine the adequacy of available plant differs for at-power and shutdown states. Whether the reactor is at power or shut down, it must be demonstrated that adequate plant remains available to provide essential safety functions including trip, shutdown and post-trip cooling when required to maintain a safe state.

The fire protection strategy does not change with the operating states. Fire safety is managed in accordance with the Technical Specifications and there is no fundamental difference between the reactor operating states.

A deterministic fire hazard assessment for both at-power and shutdown reactor states has been produced for HY2 (as well as TOR). HNB is shutdown and being defueled with a safety case being prepared to allow removal of some fire suppression equipment. Further detail on both HY2 and HNB is provided in the EDF NGL submission [25]. The position for SZB is different, see below.

Sizewell B: the deterministic fire hazard analyses for SZB cover all operating states, i.e., power operation/hot shutdown and cold shutdown/refuelling. The transition between the main operating states is considered to be bounded by the most onerous of the first and second main operating states, and full power operation is considered to be bounding for reduced power operation.

Outage states are assessed in the same manner as the at-power state, i.e., the same fire compartments are considered to be affected, in the same way. The required safe shutdown equipment is defined in the plant Fault Schedule (the required safeguards equipment is different to that for power operation). The EDF NGL submission [25] provides further information on how the SZC approach to operating states is assessed and documented.

I-2.1.1.4. Definition of fire scenarios

General: fire was addressed in the original station safety reports and supplemented by the AGR fire safety programme following the Browns Ferry fire. In addition, EDF NGL's Periodic Safety Reviews (PSR) and the Safety Case Health Review process consider fire hazards.

EDF NGL considers that comprehensive and systematic fire inventory reports have been carried out for all stations. A fire severity assessment was carried out for every compartment, ranging from application of the simplest Ingberg criteria through to Computational Fluid Dynamics (CFD) assessments. However, EDF NGL acknowledges that, in general, fire safety assessments reflect the methodologies in use at the time, and these have been considered acceptable when comparisons with current criteria deem them conservative.

EDF NGL's Design Authority carry out zonal walkdowns for hazards, including fire. The Fire Safety Co-ordinator carries out Fire Risk Assessments (FRA) and Engineering staff carry out plant walkdowns when an issue is suspected. Additionally, the stations are subject to inspections by the World Association of Nuclear Operators (WANO), Insurers and ONR.

First Generation AGRs (Hunterston B): all of the above general considerations apply to HNB and other first generation AGRs. Fire assessments are carried out in accordance with risk to nuclear safety and EDF NGL considers all scenarios to be highly conservative and bounding for shutdown and defueling operations.

Second Generation AGRs (Heysham 2): in the baseline safety case, an assessment was conducted of maximum credible fires on a zone-by-zone basis where nuclear safety related plant is located. These zones effectively define the bounding fire scenarios. The location of equipment, the type and combustible loading is listed for each zone. Electrical cabling and lubricating/fuel oil are the dominant combustible materials. In addition, areas containing substantial quantities of combustible material (mostly oil) in buildings which are not safety related were also assessed.

The existing safety case defines three categories of fires: 'trivial', 'minor' and 'major'. Most fires would be expected to be trivial or 'frequent' and, although not claimed in the safety case, EDF NGL assumes that the vast majority of trivial fires that are not self-limiting will be prevented from escalating by the automatic or manual fire detection and suppression systems. Fires which do escalate, or which are of a greater severity but can be contained by a passive one-hour fire barrier, are termed minor or frequent. A major or 'infrequent' fire is defined as one which is not contained by the one-hour fire barrier but is contained by the four-hour fire barrier. The passive four-hour fire barriers are designed to protect each 'reactor half' (two out of four safety divisions) from a fire of this magnitude.

Based on findings from PSR1, which identified the need for a PSA, a comprehensive Fault Schedule was developed, based on the original fault sequence probability analysis and a Failure Effects Analysis (FEA). Given the systematic approach of the analyses, this gave EDF NGL confidence that all credible faults and hazards with the potential to impact nuclear safety, including fire, had been identified.

Sizewell B: the SZB design typically has four trains of safeguards equipment and well-defined four-way fire segregation (four trains of safety equipment) for power operation/hot shutdown and two-way (two train) fire segregation for cold shutdown/refuelling. The deterministic (and PSA) fire basis is that a fire could affect all of the equipment in one fire segregation area. This is considered to be a bounding and very conservative assumption, but EDF NGL considers that the design of the fire protection provisions is robust enough that no further refinements need to be made. A failure in a Principal Fire Barrier (PFB) separating two of the four trains of equipment is also considered as a bounding scenario.

I-2.1.1.5. Screening

General: three assessment methods are typically used at EDF NGL, depending on the type of fire scenario and the fuel inventory: the Ingberg method, the KTA method and CFAST zone modelling.

EDF NGL considers the Ingberg method as a practical screening tool for quickly assessing a large number of compartments. It uses this method for evaluating the fire barrier resistance rating needed to prevent a fire from spreading from a room if all the combustible contents of the room become involved in the fire. The method has been used at Hinkley Point B (HPB) and HNB, and other AGRs including HY2.

EDF NGL uses the KTA method when it considers that further assessment is necessary e.g. when the fire load is approaching the Ingberg method's applicability limit. In general, this method would be used in compartments with a high height-to-floor area ratio and if the fire loading is over 450 MJ/m².

EDF NGL uses CFAST zone modelling for the most complex cases. Equations of heat and mass transfer are applied to a simplified fire scenario, consisting of an upper hot gas layer and a lower cold gas layer, with no mixing between the two. The CFAST model takes into account fuel type, fire growth, compartment construction and ventilation and can handle multiple rooms. EDF NGL states that CFAST is designed for simulating domestic and commercial fires and it is therefore difficult to simulate complex geometries. In complex cases EDF NGL uses PHAST (Process Hazard Analysis Software Tool).

Comparison of methods and their application to nuclear power plants

The Ingberg method does not take into account ventilation conditions nor the thermal characteristics of the structure, but nevertheless has been widely used in power plant assessments because it can be easily applied to assess a large number of compartments.

However, nuclear plants have few rooms with external openings, and the majority of rooms have mechanical ventilation only or ventilation by infiltration from other areas which are

mechanically ventilated. As the Ingberg method does not cater for forced mechanical ventilation, either the KTA method or CFAST are used.

While EDF NGL considers the KTA method as excellent for estimating fire severity in vertically vented, commercial-type buildings, it urges caution when attempting to assess fire equivalence for compartments with roof ventilation. In those instances, EDF NGL considers that detailed fire modelling would provide better data. EDF NGL considers CFAST as a useful tool for validating hand calculations. However, it states that it should not be solely relied upon without hand calculations. Table 1 in Reference [25] provides EDF NGL's comparison of the three main methods.

First Generation AGRs (HNB): in addition to the general methods described above, EDF NGL used PHAST v6.5.1 (DNV 2006) to assist the fire assessment for critical areas.

Second Generation AGRs (HY2): EDF NGL adopted the Ingberg method at HY2 in the 'Equivalent Fire' assessment to compare the 'real' fire against the test conditions as real fires do not reproduce the same time/temperature relationship used in fire tests. However, areas which have a significant cable loading and a small floor area in comparison to the area of the walls, such as cable risers, are more suited to assessment using the simplified Electric Power Research Institute (EPRI) method developed by Mowrer.

Sizewell B: standard fire assessment tools (i.e., a fuel load per unit floor area and a time temperature method) are used for SZB.

I-2.1.1.6. Fire bounding approach

General: EDF NGL follows the following strategy to remove the potential for cliff edge effects:

- a) The ignition of any combustible material within the nuclear facility is considered;
- b) The fire analysis is performed based on conservative assumptions such as all combustibles and all available oxygen being fully involved in the combustion reaction (inadequate combustion phenomenon in real fire scenarios is ignored); and
- c) Fire area verification ensures that the fire boundary resistance rating of fire zones/areas has sufficient margin. A fire common mode failure analysis confirms that a fire will not lead to unacceptable consequences.

First generation AGRs (HNB): EDF NGL's bounding approach considers all possible scenarios, and using screening criteria, identifies plausible worst cases and retains some very infrequent but very high consequence scenarios. It claims the analysis to be comprehensive, as cliff-edge effects are sought by parametric studies that consider significant variables and conservative assumptions. These include, for example, the assumption that all fuel available is consumed with 100% combustion efficiency. The duration for the fire is considered to determine whether a short powerful fire is more or less damaging than a longer duration, but lower fire power event. This work has been documented for the critical areas.

Second generation AGRs (HY2): EDF NGL used the bounding approach stated above for the second generation AGRs. Note that as a result there are differences in plant design. Where the consequences and/or protection requirements from fire are identified elsewhere in the fault schedule, they are bounded by that plant fault. Where the consequences of a particular fire have not been identified elsewhere, the fire itself is identified as both an initiating event and bounding fault.

Sizewell B: the safety trains at SZB are segregated by three-hour fire-rated Principal Fire Barriers. Penetrations are minimised and, where necessary, all non-segregated cables (such as those required for redundancy purposes) are boxed in with three-hour fire-rated fire barriers. All fires are bounded by the plant faults given in the Fault Schedule.

I-2.1.1.7. Combined events

General: EDF NGL's Design Authority (DA) leads the consideration of combined events through Zonal Walkdowns, PSR and Safety Case Health Reviews in accordance with company processes. In these assessments, DA hazard experts work jointly with fire and seismic hazard experts from the Engineering Division, who undertake the detailed fire assessments.

First generation AGRs (HNB): all the above general provisions apply. EDF NGL notes that the safety case includes a consideration of fire-induced missile hazard and also considers initiation of water spray fire suppression systems as a potential flood hazard.

Second generation AGRs (HY2): for this station some consequential hazards were considered in the design of its protection and mitigation measures, such as post-seismic fires. Further scenarios are currently under consideration; for example, a turbine disintegration event (originally classified as not impacting nuclear safety) can lead to a fire, or a fire with flooding from the condenser cooling system. Similarly, a turbine disintegration event can result in flooding of the Turbine Hall with cooling water as well as releasing significant amounts of lube (lubricating) oil. This has the potential to cause flooding of the reactor basement and a consequential floating oil pool fire. The scenario is being assessed by EDF NGL at the time of writing this report, current operation is supported by an interim justification for continued operation (iJCO) [26]. Fires causing other hazards are considered in the safety case and are included on the Internal Hazard section of the fault schedule.

Sizewell B: consequential hazards were considered as part of the overall deterministic assessment and design, including fires and flooding caused by seismic events. In addition, spurious signals caused by 'hot shorts' and flooding as a consequence of fire were deterministically considered. Any hazard combinations deemed credible were carried forward to the fire PSA and this included combination of independent hazards.

I-2.1.1.8. Consideration of internal fires

General: potential internally induced fires included those arising from turbine disintegration events, oil fires from failure of pump oil pipes, oil leaks and fires caused by dropped loads. EDF NGL assumes that such events would result in a fire rather than relying on ignition analyses.

For seismically induced fires, wherein the seismic event causes failure of the fire barrier, the potential for the fire to spread to the nuclear island is addressed by the design's fire segregation. This ensures the fire would not spread to the backup systems, which are remotely located in separate buildings.

First Generation AGRs (HNB): the above general considerations apply.

Second generation AGRs (HY2): the HY2 (and TOR) PSAs model the full suite of credible internal hazards that have the potential to challenge nuclear safety, and this includes fire. They are identified in the fault schedule and a high-level summary is presented in the PSA's main report.

EDF NGL routinely updates initiating event frequencies (IEFs) as an integral part of the work programme to maintain fidelity between the PSA, plant and operating experience. The PSA is reviewed and updated annually, with a major update produced every three years. The major update is based on interim analyses, engineering changes and station data reviews, hence an update to the PSA fault schedule is included within its scope. It is the intention that the revised initiating event frequencies arising from a major update of the PSA are readily available and accessible for safety case review and assessment.

Three levels of PSA are generally recognised:

- Level 1: the assessment of plant failures leading to determination of the frequency of core damage;
- Level 2: the assessment of containment response, leading, together with level 1 results, to the determination of frequencies of containment failure and release to the environment of a given quantity of the reactor core's inventory of radionuclides; and
- Level 3: the assessment of off-site consequences, leading, together with the results of level 2 analysis, to estimates of public risk.

These levels have been developed with LWRs in mind and are therefore not directly applicable to AGRs.

EDF NGL considers that an AGR PSA lies somewhere between the definitions of a level 1 and level 2 PSA. For an AGR, a direct core damage sequence would be one that stops at pin failures. However, an AGR PSA goes further and provides consequences which distinguish the size of the release. A level 2 PSA includes the protection systems and operator actions that mitigate the consequences of core damage by containing the release and/or reducing the size of the release. This concept applies for reactors which have containment; the AGRs do not have a containment, so this type of analysis is not performed. The size of the release is estimated but it does not qualify as a complete level 2 PSA as it does not model what happens to the core as it degrades. A complete level 2 PSA would require operator actions to be included in the Severe Accident Guidelines (SAGs). A level 3 PSA converts a release size to individual risk due to that release. This has not been specifically performed for AGRs. For an AGR PSA, the success criterion is in meeting the dose band staircase and EDF NGL's Nuclear Safety Principles (NSPs), which in turn met the Health and Safety Executive (HSE) targets [27].

From the data provided in the 2018/19 major PSA update for HY2, the contribution to the overall station risk from hazards (both internal and external) is roughly one fifth of that from plant faults. Of all hazards, the contribution to station risk is 43% from external events and 57% for internal hazards. Amongst internal hazards, fire hazards contribute 10% to the overall station risk. The total predicted frequency for large release sequences is 7.87×10^{-7} per reactor year for all hazard faults.

HY2 has an at-power fire PSA that considers credible fires in all areas which could impact nuclear safety as defined in the PSA Fault Schedule.

The development of a shutdown PSA has been considered for the AGRs in the past. However, EDF NGL considers that the timescales until radiological release are very long when the plant is shut down. This is in contrast to LWR technology where the timescales are typically significantly shorter. For this reason, the AGRs were not designed to have any automatic systems operating during shutdown. The AGRs have several layers of redundancy and diversity for shutdown operations, but the shutdown safety case depends on operator actions to manually start plant. This is considered to be acceptable due to the extended timescales available for necessary operator actions.

Sizewell B: fires are considered in all areas (safety and non-safety areas) containing combustible materials (mainly lube oil and cables, diesel fuel in the diesel generator areas). A reactor trip as a result of a fire is conservatively assumed.

I-2.1.1.9. Consideration of external fires

General: in general, EDF NGL does not consider externally induced fires as major hazard to its fleet of power stations. Nearby forest fires have been assessed, and EDF NGL reports that atmospheric dispersion modelling was carried out from fires affecting an oil storage facility near the Magnox reactor Hunterston A. Similarly, external fires from seismic events are considered.

First generation AGRs (HNB): The above general considerations apply.

Second generation AGRs (Heysham 2): EDF NGL considered seismically induced fires in the safety case but judged them to be confined to the non-seismically qualified buildings such as the administration block, workshops and stores. Other areas including the nuclear island are designed to resist the seismic hazard challenge.

Sizewell B: external fire hazards from adjacent industrial facilities and the surrounding countryside are assessed in EDF NGL's safety case. On detection of an external fire, fire dampers on the HVAC systems close to limit smoke ingress to the safety-classified areas. This provision also protects against on-site fires outside the safety-classified buildings.

I-2.1.1.10. Probabilistic fire hazard analysis

Introduction

General: EDF NGL's position is based on the premise that the application of suitable deterministic nuclear safety principles, defence in depth, diversity, redundancy, independence, failsafe design, testability segregation, provision of lines of protection,

availability of backup systems and control through technical specifications manages the fire risk adequately.

However, a fire PSA was carried out during the Sizewell B licensing process to supplement the deterministic safety case. Since then, other stations in the fleet have also carried out a probabilistic fire assessment, which have confirmed the adequacy of the deterministically derived fire provisions. The contribution of fire to the plant releases (large and small) is typically a small proportion of the contribution from plant faults.

First generation AGRs (HNB): ONR mandated a modern standards fire PSA at HPB in 2007; this was a level 1 PSA. The level 1 PSA was compared with the HPB deterministic case and EDF NGL concluded that there were no significant shortfalls and no major safety case revisions were required at HPB or its sister station HNB. No significant plant modifications were required. Fire contributed to about 10% of the large (DB5) release from the station. This study was taken to be applicable to the other first generation AGRs as well, including HNB. As HNB is now shut down the potential release from fire and the release frequency are judged to be significantly lower than was the case for power operation.

Second generation AGRs (HY2): section I-2.1.1.8 describes the scope of the HY2 PSA (and the review process for the PSA including IEFs). It is the intention that the revised IEFs arising from a major update of the PSA are readily available and accessible for safety case review and assessment. Updates to the safety case which also drive change in the PSA are also included in the Major PSA Update. Changes to the PSA that have been identified in the case are captured in the PSA change log. Three levels of PSA are described in Section I-2.1.1.8.

The at-power fire PSA considers the maximum credible fires on a zone-by-zone basis where nuclear safety related plant is located and includes non-nuclear areas containing substantial quantities of combustible material. Fire in all areas which could impact nuclear safety is captured in the PSA fault schedule and subsequently the fire PSA.

Minor PSA updates are completed on a yearly basis. In addition, a major PSA review and update is completed every three years and it is based on interim analyses, engineering changes and station data reviews. Safety Case Health Review (SCHR) are conducted every three years as well as PSRs every ten years.

From the 2018/19 PSA update for HY2, internal fire hazards contribute 10% to internal hazards risk (please note that in the UK context internal hazards are within the site boundary, not just the safety classified buildings).

Periodic safety reviews have highlighted potential shortfalls such as identification of implicit reliance placed on the reliable closure of fire doors to prevent a single fire affecting multiple trains across both reactors. The 'as found' situation was reviewed for reliability of fire detection and reliability of fire door closure. The frequency of such an event was demonstrated to be adequately low and no further action was required.

Sizewell B: the fire PSA is carried out for PSA levels 1, 2 and 3. This uses the same methodologies as for the plant faults PSA. All operating states are considered for the fire PSA. All plant areas containing safety classified equipment are considered in the fire PSA.

The fire PSA covers all internal plant areas and external fires (equivalent to the deterministic fire assessment, which is used a basis for the fire PSA). The PSA fire sequences are not significant in terms of the overall plant risk. For fires outside safety classified buildings and external to the site the consequences were negligible, and no Plant Damage States were derived. The contribution of fire to the core damage frequency is 1.58×10^{-7} p.a., which is 2.23% of the total (including all faults and hazards). EDF NGL considers this to be a conservative estimate, and both the deterministic fire assessment and the PSA fire assessments were considered in the three PSRs carried out to date. EDF NGL concluded that no significant changes were necessary.

I-2.1.2 Key assumptions and methodologies

The text in this section of the report has been prepared by EDF NGL, with only minor changes by ONR as described in Section 1.1.2.

General: the EDF NGL key fire document considers safety guidelines for the deterministic assessment of fire protection measures on nuclear safety-related plant. The document was developed for existing nuclear safety related systems at AGR power stations and is based on existing EDF NGL practice and updated in line with recommendations from an independent review conducted by the Industry Management Committee (IMC) research programme.

The safety principle that fire protection equipment on nuclear safety-related plant at AGR EDF NGL power stations should aim to satisfy was presented in Section I-2.1.3. The guidelines for assessing the plant against the principle are then provided, and form the basis of deterministic fire protection safety reviews.

Referring back to I-2.1.1 in the Fire Protection Philosophy, EDF NGL developed objectives 3 (ii) and 3 (iii) into a set of eight guidelines against which to assess the plant.

The first five guidelines relate to segregation, redundancy, absence of combustibles and provision of fire protection and suppression systems, while the next three guidelines relate to provision of safety analysis, identification of suitable fire protection measures and potential plant modifications or improvements. Where an assessment of the normal trip, shutdown and post-trip cooling systems against first five guidelines identifies inadequacies, alleviating claims should not be made against the diverse/back-up systems without first addressing the next three guidelines.

In particular, the aim should be to show that all reasonably practicable fire protection measures have been taken. Where all reasonably practicable measures have been taken but the safety principle is not satisfied, alleviating claims against the diverse/back-up systems are permissible. However, the guidelines should also be used to assess the fire protection for the diverse/back-up systems, except that the following safety principle should form the target basis for this assessment:

In the event of a fire in any single location with all plant available prior to the fire, sufficient plant should remain available to ensure satisfactory operation of the diverse/back-up system.

EDF NGL's overriding requirement is to ensure fitness for purpose in the fire protection provisions. Its overall aim is to do all that is reasonably practicable to meet the requirements. Exceptions are permissible if meeting the guidelines is shown not to be reasonably practicable, provided that acceptable alternative arguments are presented, or on the grounds that the risk is tolerable and that any further reduction in the risk is grossly disproportionate to the cost involved. The full detail of the guidelines is provided in the EDF NGL submission [25], which also contains a list of the recent fire safety assessment work carried out at HNB and further engineering guidance (Appendix C to the NAR).

Second generation AGRs (HY2): the objective of EDF NGL's safety case is to demonstrate that, either during a fire or in the period immediately following a fire, sufficient of the plant provided to shut down and cool the reactor remains available to meet the reliability and integrity targets specified in the CEGB AGR Design Safety Guidelines (DSGs). Design of the station against fire is based on separation and segregation as well as a sound design that embodies prevention, failsafe and defence in depth.

The HY2 design is based on quadrantisation of the safety systems providing essential safety functions, with either distance or physical barriers between them. The fire barriers separating trains 1 and 2 from trains 3 and 4 are four hour-rated barriers; the fire barriers between trains 1 and 2 are one hour-rated barriers, as are the fire barriers between trains 3 and 4.

The use of separation and fire barriers prevents the spread of fire and the detrimental impact on more than one quadrant of essential safety systems. This approach ensures the required number of Lines of Protection (required to provide the Essential Safety Functions) remain available.

Although physical controls (i.e., specific fire detection and suppression systems) are not generally claimed at HY2, they are expected to reduce the frequency of fires which will cause damage, with a small number of exceptions.

Sizewell B: SZB was designed to the CEGB standards for PWRs at the time. These were written in 1982 and have now been superseded, and current assessments are carried out to the latest EDF NGL standards.

The fire safety case for SZB is based on passive fire safety, i.e., the fire containment approach. There are no direct claims of active fire protection at SZB, although they are part of the defence in depth. A full fire hazard analysis was carried out at SZB for fire barriers prior to commissioning.

I-2.1.2.1. Fire hazards guidance used

General: EDF NGL are members of the NIFSCC (Nuclear Industry Fire Safety Co-ordinating Committee), a subgroup of the UK Safety Directors Forum, where all the latest fire safety standards are investigated by the committee and shared. ONR is an observer to NIFSCC. In addition to this there are twice yearly committee meetings with all other GB stakeholders as well as some international stakeholders. Lessons learned are incorporated into EDF NGL guidance as appropriate. These committee meetings discussed and supported the UK's self-assessment for TPR2, observed by ONR.

First and second generation AGRs (HNB and HY2): the AGR stations and their safety cases are routinely assessed against the latest company standards (e.g. Nuclear Safety Principles or NSPs) which, as a Company Specification, are in turn routinely reviewed every three years with relevant external assessment standards and guidance on management of risk (for example, guidance from HSE, ONR and IAEA safety requirements and standards) to maintain the requirements' continuing adequacy.

EDF NGL carries out a systematic review of the current safety cases against current standards as part of the PSRs, which are undertaken every ten years. The standards and their requirements against which the stations were designed and operate are set down by EDF NGL to comply with ONR Licence Condition 14 – Safety documentation, and are included within the safety case documentation.

Through the review of these standards contained within the safety case, against various current standards and external guidance (e.g. IAEA safety standards series in fire hazards), the safety case can be assessed to determine its continuing adequacy. Once adequacy of the case requirements is determined, an assessment can be made on the plant's ability to meet those requirements.

Sizewell B: SZB fire requirements took account of guidance from the Nuclear Installations Inspectorate (NII), ONR's predecessor, as well as US NRC requirements and guidelines (e.g., 10 CFR 50.48 and NUREG 0800). Current assessments are carried out to the latest EDF NGL standards.

In addition, the three Periodic Safety Reviews (PSRs) carried out since the construction of the station have assessed the existing fire protection provisions against current national and international standards. Generally, the design still meets current standards.

I-2.1.2.2. Identification of safety functions and SSCs

General: EDF NGL's identification of safety functions and SSCs typically starts with listing of essential SSCs for nuclear safety and lines of protection. These are normally identified by the safety analysis and the components subjected to a target/threat analysis or survivability assessment to determine the plant items that remain available after the postulated fire.

First generation AGRs (HNB): the process was carried out whilst revising the safety cases of critical areas. EDF NGL incorporated lessons from the Dungeness B oil fire in 2009, which took place in the reactor building, and was caused by a jet release of lube oil impinging on hot surfaces leading to ignition and fire. The key consideration was the potential consequential damage to plant of high nuclear safety significance and/or to equipment supporting shutdown cooling. Of particular concern was the potential for consequential failure of reactor stressing tendon ends that protrude from the reactor pressure vessel, with a potential loss of containment (this is unique to Dungeness B). A similar analysis was carried out in HNB critical areas through a programme similar in scope.

Second generation AGRs (HY2): an Essential Safety Function (ESF) is defined as a function that is required following an initiating event to prevent an unacceptable radioactive release. EDF NGL provides diverse Lines of Protection (LoP) for each of the ESFs

identified (e.g. trip, shutdown and post-trip cooling). A LoP is defined as a safety system or combination of safety systems and/or operator actions which provide one means of carrying out an ESF. LoPs are also claimed in order to ensure availability of the plant and therefore provision of the ESF. Each system is made up of (essential) safety systems, structures and components and, where appropriate, incorporate redundancy to tolerate failures and maintenance activities. Where redundancy is not possible (e.g., the pressure vessel in civil structures), the required structural reliability is managed through high standards of design and build. The basic approach and requirements for plant integrity are discussed in the Station Safety Report.

The role of the Fire Detection and Suppression Systems (FDSSs) in the nuclear safety context is to provide defence in depth such that a fire does not affect the ability of the reactor to continue to operate safely, as well as ensure that adequate essential safety systems are available to trip, shut down and cool the reactor. However, since the FDSSs do not provide an ESF themselves, EDF NGL had no requirement for claims to be made against them and the role of FDSSs was therefore considered ancillary. However, since the original design a small number of FDSSs have been claimed as a countermeasure against certain fires. EDF NGL considers that placing a claim on an FDSS should ensure availability in the event of a fire, which in turn provides confidence that the essential safety systems will be capable of providing their essential safety functions. EDF NGL does not expect a change in the safety classification of essential safety SSCs as part of the fire hazards safety case review and update for HY2, which is ongoing at the time of writing this report. However, some FDSSs will effectively become Safety Class 3 equipment. The classification of safety related equipment is detailed in the safety case. The damage potential from a range of fire events and assumptions on barrier performance are detailed in the EDF NGL submission [25].

Sizewell B: the SZB fault analysis identified all the safety functions and SSCs required for safe shutdown. The fire protection provisions were then specified such that no fire affecting one or two divisions prevents safe shutdown. The fire effects and reliability of the remaining safeguards equipment were assessed deterministically and against probabilistic requirements. The overall design acceptability was then confirmed by the fire PSA. The EDF NGL submission [25] explains the process carried out to ensure that the four trains of safeguards equipment were adequately segregated for fire protection, as well as how components were identified and classified to ensure segregation is adequately maintained.

I-2.1.2.3. Fire loadings

General: EDF NGL considers that a conservative approach is applied to fire loading assessments, whereby the assumption is that all the fire load is available for combustion in each compartment. A fire risk assessment is then carried out using the methodologies described in Section I-2.1.1.5. EDF NGL considers that the worst case scenario is consistently the starting point for assessment. The fire loading is quantified in MJ/m², but this is then used to define 'high' 'medium' and 'low' fire loadings for general assessment purposes. Design information from manufacturers (e.g., quantities of lube oil) is used for establishing the fire loadings from equipment. Cable trays were assumed to be filled with cables, and the fire load from the cable insulation was then derived for each room (again using information from manufacturers). EDF NGL judged the fire loading to be conservative,

but acknowledges that the level of conservatism was not quantified. Data sources are held within the power stations, and this includes complete inventories of all combustible fuel inventories used to calculate the fire loading for each compartment.

First generation AGRs (HNB) and second generation AGRs (HY2): as above.

Sizewell B: EDF NGL has recorded the fire loading information in the Asset Management System (AMS) database, which is subject to updates in the event of changes. However, the basic design is stable, and there have been no major changes to the fire loading information.

I-2.1.2.4. Transient combustibles

EDF NGL characterises and controls transient combustibles in accordance with the following approach. Any proposal to store transient combustibles on plant is subject to laydown/storage approval process, ensuring a minimum amount of combustibles are stored for the minimum period of time to complete the work. A proposal is prepared by the work party and reviewed by the location Fire Safety Co-ordinator who will assess a number of factors and determine whether the proposals may be approved and whether additional control measures are required. Once approved, the laydown with its supporting information and control measures is recorded along with the details such as the location and validity period.

On plant, the boundaries of the laydown area are clearly marked and a notice provided giving all relevant details to ensure all controls are adhered to. This procedure applies to all stations. A more detailed description of the arrangements is provided in EDF NGL's submission [25].

I-2.1.2.5. Fire service intervention

EDF NGL does not claim local authority (external) response as part of emergency capability to ensure nuclear safety. This is because EDF NGL acknowledges that external services can be delayed due to local conditions and therefore should not be relied upon for nuclear safety.

As part of Site Licence Condition (LC) 11 – Emergency arrangements, on-site emergency planning, EDF NGL requires that the site will be self-sufficient for up to 60 minutes with no intervention from external services. Due to the fire design of the plants so far presented, EDF NGL does not require substantiation for fire service intervention. EDF NGL holds an emergency scheme training programme for the on-site fire responders. For the design reasons presented and as there are no nuclear safety claims on fire service intervention, it is not an accredited training programme. EDF NGL tests response times during exercises and demonstrations. For HNB, HY2 and SZB, the average response time is approximately 15 minutes.

I-2.1.2.6. Change management

General: plant modifications and fire analysis are linked, and either one may drive the other depending on the circumstances. EDF NGL manages change via the safety case

management and the modifications process. EDF NGL considers all hazards including fire when reviewing new plant or changes to plant or its operation as part of the modification proposal. Depending on the potential fire hazard, additional analysis may be required. The fire is characterised as described in Section I-2.1.1.5.

First generation AGRs (HNB): the analysis of the cable flat loadings at HNB used all the listed methods from Ingberg to CFD to develop a robust understanding of the fire severity.

Second generation AGRs (HY2): no major plant changes have been carried out since HY2 was commissioned, therefore no major modifications have required assessment. However, EDF NGL currently makes claims on the FDSS and plant modifications may be required as result of the ongoing Turbine Disintegration assessment update.

Sizewell B: EDF NGL considers that no major modifications to the fire safety case have been carried out since station commissioning.

I-2.1.2.7. Fire analysis requirements

EDF NGL's criteria for fire analysis tool selection are fit for purpose and include the need for accuracy, consequences of the fire, complexity of the fuel disposition, compartment boundaries and ventilation.

EDF NGL considers that site specific data such as fuel inventories, bund sizes, compartment heights, and louvre sizes are always used. Generic data such as calorific values for wood and oil are used, as are specific burn data for transformer oils. General fire data is taken from the SFPE Handbook [28], text books by Drysdale [29] and Quintiere, methods published by EPRI, National Institute of Standards and Technology (NIST), British Standards and National Fire Protection Association (NFPA) standards.

I-2.1.2.8. Treatment of uncertainties

General: EDF NGL considers fire analysis uncertainties through conservative analysis and using engineering judgment to select reasonable worst cases. EDF NGL applies multiple methods to reduce the levels of uncertainty, and this may include experimental work. Where uncertainties persist, EDF NGL may require additional defence in depth to compensate for the uncertainty.

EDF NGL undertakes sensitivity analysis by running multiple models with varying parameters such as fuel leak rate, burn rate or ventilation changes. Plausible outcomes are explored and the bounding cases of likelihood and consequence are determined. Cliff edges are considered if necessary. There are no relevant fire safety examples for HY2 and SZB.

First generation AGRs (HNB): the design of HNB originally discounted the possibility of a gas circuit lube oil fire on the premise that the lube oil spray would be saturated with CO₂ and would self-extinguish. When the assumption was challenged, EDF NGL conservatively assumed that the oil would ignite and burn rather than conducting tests to address the uncertainty directly.

I-2.1.2.9. Severity and complexity of potential consequences

General – EDF NGL assigns a QA grade to any fire-related work prior to start, and this is based on the collective SQEP¹ understanding of the potential for fire to affect nuclear safety. The level of rigour applied to the work is formally recorded in the task file.

The fit-for-purpose analysis can involve a walkdown of the plant and a review of fire Operational Experience (OPEX) as well as a review of the available methods and capabilities. Frequently, EDF NGL calls for advice and support by expert third parties such as specialist fire engineers. In addition, EDF NGL calls upon specialist UK Government research provision such as the HSE Science Division (formerly known as the Health and Safety Laboratory) and the UK Building Research Establishment (BRE) to conduct analysis and test work on its behalf.

EDF NGL's fire SQEPs are required to understand the needs for fire control, containment and cooling, as well as the plant required for trip, shutdown and post-trip cooling. Working in partnership with the DA, the immediate direct consequences of a fire are estimated, and the potential impact on nuclear safety margins is determined. In general, the fire severity is assessed as described in Section I-2.1.1.5. EDF NGL has rarely accessed CFD due to cost, complexity and lack of incremental benefit over zone modelling. However, note has been taken of the European fire modelling project PRISME, which is validating CFD fire modelling approaches. The UK has contributed to PRISME through ONR research funding levied from GB licensees and analytical work supported by GB licensees and UK engineering consultancies. It should be noted that a pilot study is being carried out at HY2 using learning from PRISME to test and provide a real-world comparison in the application of zone modelling and CFD – both in terms of time, trouble and effort, and also in the accuracy and credibility of the predicted fire conditions.

First generation AGRs (HNB): EDF NGL identified HNB critical areas and generated time-temperature curves through fire modelling. This fire scenario identified potential challenges to plant items relevant to post-trip cooling. As a result, EDF NGL provides the identified plant with passive fire protection to ensure it survives the predicted fire conditions and their post-trip functionality is preserved.

Second generation AGRs (HY2): EDF NGL determined that fire severity calculations for the HY2 were mainly from the design stage and were no longer in line with relevant good practice. EDF NGL nevertheless considered that there were no direct safety case implications from the shortfall; specifically, there was no 'safety case anomaly'. Nevertheless, to confirm the validity of the safety case, EDF NGL is currently undertaking CFAST and Fire Dynamics Simulator (FDS) fire modelling for certain critical areas. The intent is to predict time-temperature profiles and hot gas layer descent primarily using CFAST with secondary comparative work also being carried using FDS. This work will bring the HY2 fire references up to date using modern standards and provide a useful comparison of CFAST and FDS for this fire scenario, which can then inform the FAIR (PRISME) project. EDF NGL does not anticipate the work to result in the need for revisions

¹ SQEP is a term for qualified personnel in a given field and is used in the UK nuclear industry. It stands for Suitably Qualified and Experienced Person.

to the station fire safety case or plant modifications due to initial conservatisms. However, it considers that the work may be useful in the future if relevant safety issues arise.

Sizewell B: fire modelling was carried out for the increased fuel load following the upgrade of the Battery Charging Diesel Generators. See Section I-2.1.6.1 for details.

I-2.1.2.10. Fire consequences

General: EDF NGL's assessments compare the predicted fire conditions, such as a time-temperature curve, with the equipment qualification, for example the materials and design of a fire barrier. This comparison indicates whether failure is likely and whether fire could spread from one safety train to another, and whether fire could affect the ability to perform the reactor trip, shutdown and post-trip cooling functions. EDF NGL supports the assessment of potential consequences through inspection of the plant and plant documentation. Further analysis may be carried out on the likelihood of an initiating event or more detailed modelling of the fire scenario as appropriate. For example, EDF NGL estimated the likelihood of a turbine fire based on internal AGR/SZB fleet OPEX which informed decision-making on the provision of additional protection of cabling to some essential equipment.

First Generation AGRs (HNB): EDF NGL's event tree and fault tree analysis for HNB is based on industry data for pipework system leaks and ignition, predicting a range of release rates and ignition timings. This was used to develop a range of fire scenarios, fire severities and immediate consequences for essential plant.

Second Generation AGRs (HY2): EDF NGL postulates that a fire may occur in any area of the station, and segregation by distance or physical barriers is used to limit the extent and spread of the hazard. Fires have been divided into three categories – trivial, minor and major – dependent upon their damage potential (see the EDF NGL submission for further detail [25]). The damage caused by plant fires at locations which could challenge nuclear safety is subsequently assessed and described in the safety case.

Sizewell B: all equipment within a fire area is considered to fail immediately from the onset of the fire. EDF NGL considers this as an acceptable conservative assumption underpinning the robustness of the design.

I-2.1.2.11. Fire phenomena complexity

General: EDF NGL considers the complexity of fire phenomena through understanding the basic properties of the fuels, the nature of fire, the effect of ventilation on fire (including fire spread), formation of hot gas layers and thermal radiation. The complexity of a fire is graded in the assessment. For example, EDF NGL considers a low pressure release of transformer oil into a sealed bund as a low complexity event, which can be characterised by assuming 'full surface involvement' of the combustible inventory from the point of ignition, a constant regression rate and fire power, culminating in combustion of the entire fuel inventory. EDF NGL undertook this type of analysis for the HNB Turbine Hall. EDF NGL analyses more complex phenomena such as 3D jet fires using more sophisticated approaches (e.g., a range of leak rates) and by making use of the PHAST tool to predict the characteristics of the jet flame.

I-2.1.2.12. Radioactive dispersion and release due to fire

General: EDF NGL's safety cases for radwaste facilities include fire modeling. In general, EDF Energy considers that the following applies:

- There is generally little material on site which is both significantly active and combustible so the number of faults which need to be assessed from a waste fire perspective are limited and many scenarios can be screened out before dose assessments.
- The modelling carried out is in support of the nuclear safety case and so is focused on those faults with sufficient radioactive waste to potentially give rise to a significant dose. Fires with small or modest quantities of radioactive material are not assessed if they do not result in a significant potential dose. An example would be the paper HEPA filters used in the HVAC systems for all sites.
- After faults have been screened a small number remain. Typically the dose levels are such that the necessary safety case justification can be made with one or two pessimistic assessments. The two main scenarios assessed are doses from fires involving oily material with significant radioactive content (e.g., Gas Circulator lubricating oils) and fires in the waste processing facilities which can have large stocks of a range of wastes awaiting processing.
 - For oil fires EDF NGL applies a bounding analysis. Since this analysis was first carried out, the sites have moved away from bulk oil storage and on-site incineration (so while it has remained bounding it is longer representative).
 - For fires in the waste processing facilities EDF Energy also applies a pessimistic assessment approach: actual stocks levels and relevant wastes are doubled and a sensitivity assessment undertaken to establish the contribution from the individual waste streams. With regard to release/dispersion factors a Release Fraction is claimed, no Decontamination Factor is claimed for drum containment and a Decontamination Factor is claimed for building containment based on SQEP judgement.

The above considerations are applicable to both first generation (HNB) and second generation (HY2) AGRs. For Sizewell B, EDF NGL's tools for the PSA level 3 are the same as those used for plant faults. This covers the great majority and all the significant releases. The sources of small releases from internal fires are spent resins, radwaste concentrates tanks, the chemical storage area, and a contaminated drum. Releases from these sources were calculated and shown to be acceptable. Data used was from the bounding design basis values. Decontamination factors and release fractions were the same as used for the plant faults PSA. For the small releases described above no decontamination factors and release fractions were claimed.

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

The main discussion of fire phenomena analyses is included in Section I-2.1.2.9.

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

The main results from the Probabilistic Fire Hazard Analysis and the contribution of fire events to the overall PSA results are described under Section I-2.1.2.

I-2.1.5 Periodic review and management of changes

The text in this section of the report has been prepared by EDF NGL, with only minor changes by ONR as described in Section 1.1.2.

I-2.1.5.1. Overview of actions

EDF NGL applies company procedures to develop and then track actions to close out. A graded approach is taken with minor issues being addressed in normal business and significant issues being assessed via the safety case anomaly process and the engineering change process. Periodic safety reviews and safety case health reviews are performed on a regular basis. Risk and corrective actions are developed and delivered by SQEP personnel in the Design Authority and Engineering functions. National and international standards are reviewed every PSR to identify any changes to best practice since the design was established and the previous PSR (three PSRs have been carried out so far).

General: EDF NGL fire SQEPs are involved in all the fleet PSRs. This involves site walkdowns as required and verification or technical review of the draft PSR reports. As such the fire SQEPs operate within company processes.

First generation AGRs (HNB): as stated previously, the AGR fire safety review following the Browns Ferry fire resulted in numerous plant modifications at HNB and other first generation AGRs. These are detailed further in Sections 2.1.1.1 and 2.1.1.2..

Second generation AGRs (HY2): lessons learned from the first generation AGRs were incorporated into the design from the outset. EDF NGL has concluded that no major changes to the fire protection arrangements have been necessary.

Sizewell B: EDF NGL states that, for the latest PSR (PSR3), the fire PSA was reviewed in detail by an external consultant and a number of conservatisms were identified (which were known). As noted previously, the contribution of fire to the overall Core Damage Frequency is low, and a re-evaluation was not considered necessary. The fire assessment is reviewed in each PSR. The EDF NGL submission [25] contains more detail regarding the PSR process and conclusions.

I-2.1.5.2. Implementation status of modifications/changes

General – EDF NGL manages the implementation of modifications/changes through the engineering change process, which includes milestones for all stages of a modification from inception to conclusion. The process applies to both physical changes to the plant and to changes in the written safety case. Note that changes to the written safety case may not be associated with physical changes on the plant, but the process is the same for all changes that affect the nuclear safety cases.

As a general observation, multiple plant modifications were conducted at HNB and the other first generation AGRs. However, for some modifications the fire hazard was just one of the reasons for the change. An example of this is the addition of Alternative Indication Centres in the event that a Control Room became untenable for any reason – for example, as a result of a fire, flood, electrical fault or some other issue. The lessons learned were carried forward into the design of HY2 and SZB, where there have been few modifications relating to fire hazards over the years.

EDF NGL developed and regularly revises the Nuclear Safety Principles (NSPs) for safety assessment purposes. These include deterministic guidelines for fire and also address the modifications process. Further detail of how the fire analysis has influenced modification decisions and how it has been used to substantiate design changes is provided in EDF NGL's submission [25].

First Generation AGRs (HNB): through the NSPs, EDF NGL identified the need to provide a Diverse Pressure Vessel Cooling Water (DPVCW) supply system at HNB and other first generation AGRs. This was required to be diverse to the existing electrically driven pumps and physically remote from the other areas that contained the original electrically driven pumps. The diesel driven DPVCW pumps were installed in their own fire cells, which separated them from the critical areas by fire barriers. The diesel-driven pumps were also supplied with a fire suppression system. A similar modification was carried out for the other first generation AGRs.

Furthermore, through PSR, EDF NGL identified that some of the safety-related cables in the turbine hall were vulnerable to thermal radiation from nearby large fires. A fire curtain was installed to protect cables located within the Turbine Hall from the postulated large nearby fire. This moved a fire that was borderline frequent/infrequent into the infrequent region, which provided an acceptable safety case. Further detail is provided in EDF NGL's submission [25].

Second generation AGRs (HY2): there have been no significant plant modifications required at HY2 to date based on fire analysis beyond the formal claims on the FDSS described in Section I-2.1.2.2.

Sizewell B: EDF NGL considers that all plant modifications have maintained the design segregation provisions including the Principal Fire Barriers. Apart from new I&C cabling, there have been no significant changes to the design.

EDF NGL considers that the most significant modifications were post-Fukushima, and consists of numerous backup systems. EDF NGL aimed to ensure that the existing fire safety provisions were not degraded, and the installed equipment did not cross any of the Principal Fire Barriers between the four safety trains.

As part of the Fukushima response, the Battery Charging Diesel Generators (BCDG) and supporting equipment were replaced. To extend the mission time, the fuel tank size was increased significantly. The original station fire analysis was compared with new CFAST modelling for the new equipment. EDF NGL showed that, in the event of an oil spillage, the major floor trenches could store the diesel fuel inventory. As a result, fire-rated plating was fitted over the trenches to starve the diesel of oxygen if ignited (ventilation limitation). EDF

NGL considers that this is a good example of how nuclear safety-driven plant modifications and fire hazards analysis can work together to reduce the fire hazard, even though in this case the amount of fuel increased to provide increased mission times. Details on further modifications made and how EDF NGL managed changes to the fire analysis is provided in EDF NGL's submission [25].

I-2.1.6 Licensee's experience of fire safety analyses

The text in this section of the report has been prepared by EDF NGL, with only minor changes by ONR as described in section 1.1.2.

I-2.1.6.1. Overview of strengths and weaknesses identified

EDF NGL's self-assessment concludes that it applies industry standard methods in increasing order of complexity: from qualitative methods, simple quantitative methods (such as Ingberg) and standard hand calculations to zone and CFD modelling. The time, trouble and effort associated with each method is well understood; simple methods are used for rapid but coarse screening activities, whereas CFD is regarded as accurate but time consuming and EDF NGL reserves it for high complexity/high consequence scenarios. EDF NGL selects fire safety analysis methods in accordance with established company guidelines. While no significant insights have been specifically identified by EDF NGL with regards to fire safety analysis, it has noted that a safety case review is underway at HY2 and this is specifically designed to provide insights into the strengths and weakness in zone and CFD modelling in a complex real-world environment.

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

General - EDF NGL uses the specific Fire Event Code (FEC) definitions for categorising fire events based on severity into a major fire, notable fire, minor fire or smouldering fire. EDF NGL created the notable fire category in the last five years to bridge the gap in severity between major and minor fire events. Similarly, the smouldering fire category was created to give greater visibility of events that had not reached the flaming stage but left unaddressed could escalate to a flaming fire.

Each fire event is assigned a category from those above and is investigated in accordance with severity. Trends are identified by regular review of recorded events with actions placed to investigate the trend further and propose corrective and preventive action.

Over the past years, EDF NGL has identified an increasing trend in hot work-related fires, which instigated the implementation of changes to the hot work control process. These include the introduction of hot work independent verification as an additional step to ensure work sites are prepared in accordance with the hot work permits before permission to start work is granted.

Another trend in events related to electrical component and equipment failures and this has resulted in a fleet-wide review of Electricity at Work Regulations [30] compliance and electrical motor maintenance arrangements.

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

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

Guidance

EDF NGL's submission details the fire safety analysis company standards and guidance. These include lists of the key national and international standards and how they are incorporated into its arrangements. ONR SAPs and TAGs are referred to and there is evidence of implementation, including SAPs. EKP.3, EHA. 6 and EHA. 14. Key IAEA standards incorporated by EDF NGL include [17], [31] and [32] and the WENRA reference levels for Existing Reactors [33]. ONR judges that EDF NGL's fire protection philosophy and fire safety analysis processes align with the high-level nuclear fire requirements set in the ONR SAPs [15] and TAG [16] which are also benchmarked and incorporate IAEA standards.

Fire loading and data sources

ONR has routinely assessed the adequacy of EDF NGL's fire load analysis against the internal hazards TAG [16]. Specifically, [16] expects the safety case to be based on systematic and demonstrably complete surveys of combustible materials, including solids, gases, liquids, vapours and transient loads. ONR SAPs AV.3 also expects the data used in the analysis of aspects of plant performance with safety significance to be valid for the circumstances by reference to established physical data, experiment or other appropriate means.

EDF NGL's self-assessment describes how it identifies and considers fixed and transient loads in the analysis. It also states how changes to load data are recorded, and justifies that the underpinning data is based on recognised sources from relevant literature sources, experimentation or validation testing. It also details how this information informs both hazard analysis and operational limits. Based on the information provided, ONR judges that EDF NGL has demonstrated that UK regulatory expectations are met.

Deterministic analysis approach

ONR expectations for fire hazard analysis are set out in the internal hazards TAG and the SAPs. Consistent with the IAEA SSG-64 [17] and WENRA SRLs [33], ONR expects suitable fire consequence analysis methods and models to be applied to estimate severity of fire hazards (SAPs EHA.1, EHA.5, EHA.6) and that the outputs from fire and ignition source identification are taken forward in the consequence analysis so that the impact of fires on SSCs and the performance requirements from fire safety measures are adequately determined.

EDF NGL's self-assessment in section I-2.1.1.5 sets out how fire analysis models are selected to characterise fire events, providing a description of the factors it applies in decision-making. The models include hand calculations, zone models, and, where

appropriate, CFD. EDF NGL described a proportionate, graded approach to tool selection which is broadly aligned with SAP FA.3 para. 619 [15]. EDF NGL has shown that it applies the models making use of site-specific data and detailed building layouts meeting expectations in ONR SAP AV.1.

As described in Section I-2.1.2.2, EDF NGL's safety principles drive its consideration of fire effects on nuclear safety functions, including initiation of fault sequences by fire events and radiological consequences associated with fire initiators. They allow implementation of a deterministic approach that dictates the provision of fire protection to contain the worst foreseeable fire. ONR judges that EDF NGL's approach is generally aligned with key principles for deterministic fire hazard analysis as set out in IAEA SSG-2 [34], SSG-64 [17] and ONR SAPs [15] and TAGs [35]. The safety cases and fire protection provision at the candidate first generation and second generation AGR stations (HNB and HY2) place some reliance upon active fire safety measures, rather than reliance on passive measures in a full fire containment approach. ONR's preference of IAEA SSG-64 [17] is for the provision of passive measures, but it acknowledges that active or procedural measures may also be used to mitigate the consequences of a fire.

EDF NGL's fire analysis for SZB showed that a deterministic analysis approach had led to the implementation of a fire containment approach through passive fire protection that contains the worst foreseeable fire. This is in line with ONR expectations in ONR SAP EKP.3, para. 15 [15], ONR TAG-14 [16], SSR 2/1 requirement 17 [31] and IAEA SSG-64 [17].

EDF NGL also described how on- and off-site fire service intervention was not relied upon for safe shutdown under fault or hazard conditions, which is in line with SAPs EKP.3, para. 155 [15] and IAEA-SSG-64 [17], i.e., the extent of reliance on on-site and off-site fire services should be established at the design stage.

Combined and consequential hazards

WENRA SRL E 6.1 requires that credible combinations of individual events, including internal and external hazards, that could lead to anticipated operational occurrences or design basis accidents should be considered in the design. In Section I-2.1.1.7, EDF NGL states that it addresses hazard combinations in the NPP safety case processes, and analysis is aided by Zonal Walkdowns, PSR reviews and safety case health checks. IAEA SSR 2/1 para. 5.32 (combination of events and failures) [31] sets out the requirement that combinations of events that can lead to accident conditions or design extension conditions should be considered. It also requires that certain events which might be consequences of other events should be part of the original postulated initiating events.

ONR expectations on licensees' consideration of combined hazards including consequential hazards are laid out in TAG-14 [16] and ONR SAPs [15], incorporating IAEA SSG-64 [17] expectations. ONR expects hazard analysis to take into account hazard combinations, simultaneous effects, common cause failures and consequential effects. ONR also expects that a systematic identification and screening process is applied to develop a combinations list that represents a credible and reasonable set of plant challenges. ONR TAG-14 [16] identifies that this often takes the form of a hazard combination matrix, developed from a consolidated list of all internal and external hazards.

Furthermore, it is expected that safety cases record any assumptions made to dismiss hazard combinations or their effects.

EDF NGL's self-assessment recognises hazard combinations such as fire-induced missile hazards, and that these are considered within its safety assessment processes. EDF NGL has explained [25] that combined events are reviewed and, where necessary, updated for every PSR. EDF NGL states that the PSR reviews implement the latest guidance on combined hazards. EDF NGL's self-assessment reporting for HY2 confirms that for this station some consequential hazards were considered in the design of its protection and mitigation measures, such as post-seismic fires. Further scenarios are currently under consideration by EDF NGL; for example, a turbine disintegration event (originally classified as not impacting nuclear safety) leading to a fire, or a fire with flooding from the condenser cooling system. Similarly, a turbine disintegration event leading to flooding of the Turbine Hall with cooling water as well as releasing significant amounts of lube (lubricating) oil. This has the potential to cause flooding of the reactor basement and a consequential floating oil pool fire. EDF NGL is concluding the assessment for consideration of additional measures at the time of writing this report. The work to be completed at HY2 and the on-going PSR at SZB, indicate EDF NGL's commitment towards analysing and further increasing resilience against hazards combinations across the fleet of AGRs. The SZB PSR3 is planned for submission in early 2024 and similarly HY2's analysis, when ONR will make judgements on the adequacy EDF's methodology and reasonable practicability of additional measures.

Probabilistic safety analysis

WENRA SRL SV 6.1 requires probabilistic methods to be applied to complement the deterministic analysis in order to evaluate the fire protection arrangements and identify risks caused by fire.

Sections I-2.1.1.9 and I-2.1.1.10 reported how EDF NGL uses probabilistic arguments in support of fire hazard analyses. In summary, AGR stations do not have separate level 1, level 2 and level 3 PSAs (which are developed for LWRs and therefore are not directly applicable to AGRs). The fire PSA modelling for AGR stations is based on the stations' deterministic fire safety case and does not adhere to standard industry guidance (e.g., NUREG-6850 [36]). ONR mandated a pilot fire PSA to be undertaken for HPB (the sister station to HNB) following the standard industry guidance (e.g., NUREG-6850 [36]) No significant gaps were identified between the results from this pilot fire PSA and the existing fire PSA modelling. Therefore, given the limited remaining operating life for AGRs, EDF NGL concluded that the development of new fire PSA models for other AGR stations following current industry guidance would be grossly disproportionate, a position accepted by ONR.

SZB's fire PSA is based on the station deterministic fire safety case and does not follow modern industry guidance (e.g., NUREG-6850 [36]). Report Section I2.1.1.10 states under Sizewell B:

The deterministic fire assessment and the PSA fire assessment have been considered in the three PSRs carried out to date. EDF-NGL states that no significant changes have been considered necessary.

SZB's PSR3 is expected to be submitted to ONR in early 2024. ONR will assess the PSR at that point and it is therefore premature to make a judgement at the time of writing this report.

Periodic safety review

EDF NGL conducts PSRs on a ten-year cycle to meet ONR requirements in Licence Condition 15. ONR has assessed EDF NGL's PSR arrangements and concluded that fire as an internal hazard is adequately considered in the licensee's PSR and in line with IAEA Safety Guide SSG-25 [32]. The most recent PSR submission for a candidate facility assessed by ONR was HY2's PSR in 2020. ONR's assessment of the top-level suite of PSR documentation for HY2 relating to fire judged that the PSR adequately considered.

Learning from experience

Section I-2.1.5.2 set out EDF NGL's approach to recording and categorising fires at the candidate installations to extract learning relevant to the facility and the fleet of EDF NGL installations. EDF NGL demonstrated how this learning has led to specific improvements in arrangements, specifically the addition of Alternative Indication Centres, developments to the EDF NGL Nuclear Safety Principles, provision of a DPVCW at HNB and other first generation AGRs and installation of a fire curtain in the HNB Turbine Hall. EDF NGL also shares this OPEX through participation in the OECD FIRE project and database. ONR judges that EDF NGL's analysis and learning from fire events meets the expectations of ONR SAPs, specifically MS.4 [15], IAEA SSG-64 [17].

EDF Energy NGL identified in its self-assessment that review of its fire safety hazard analyses is ongoing Fire Hazards Safety Case Review and Update, second generation AGR fire modelling, safety case analysis at HY2 and the turbine disintegration assessment at HY2). The additional analyses undertaken by EDF NGL indicate that EDF NGL proactively identifies changes in fire modelling tools, practice and experimental data, checking the ongoing validity of its safety cases, identifying gaps and addressing them in line with ONR SAP EHA.14 [15].

Summary

In summary, the main conclusion from ONR's assessment is that EDF-NGL's has adequate arrangements for undertaking nuclear fire hazard analysis.

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

ONR provides regulatory oversight of licensees' activities through inspection and assessment. Regulatory oversight is coordinated by the ONR nominated site inspector for each of the candidate installations and the project inspectors assigned to coordinate the assessments and inspections associated with plant modifications, construction, defueling and decommissioning activities. Specialist technical inspectors including fire and internal hazards specialists support the nominated site inspectors and project inspectors in these projects.

ONR assessed the internal hazards aspects of HY2 during the HY2 and TOR PSR3 in 2020 [37] and concluded that the PSR adequately considered fire and no fire-related regulatory findings were raised. Similarly, ONR carried out assessments of Heysham 1 (HY1) and Hartlepool A (HRA) (PSR3) in 2019 [38]. Fire-related findings and issues were identified HY1/HRA where the fire hazards safety case had not been the subject of a safety case health review prior to PSR3. The internal hazards inspector recommended that the fire safety case should be subject to a detailed review to demonstrate that fire risks are reduced ALARP. In addition, ONR's assessment identified degradation and reliability issues with fire suppression systems, raising a recommendation for the licensee to carry out the necessary refurbishment, as identified in the project assessment report, to ensure that the plant continues to meet the requirements of the safety case with regard to the overall integrity, reliability, performance and continued qualification of the plant against the relevant hazards.

ONR carried out internal hazards assessments, including fire, ahead of the defueling of HNB, HPB [39] and DNB [40]. ONR concluded that the operations, plant and equipment used in defueling the installations are similar to those during refueling operations and, as such, hazard sources including fire are not materially different. ONR noted the main difference is that during defueling, reactor temperatures and pressures are much reduced, thus reducing the number and strength of potential ignition sources present which could lead to a fire. In summary, ONR was satisfied that internal hazards associated with defueling were bounded by the operational refueling case.

ONR has recently conducted fire-focused system-based inspections covering all active fire protection systems at HNB (2019) [41], HRA (2020 [42]), SZB (2019) [43], HPB (2019) [44] and TOR in 2023 [45]. The NPPs listed here includes installations outside the candidate installations list. In addition, the TOR and DNB inspections covered life fire safety matters, including emergency lighting, escape route systems and fire safety systems that are not part of the nuclear safety case. All inspections were generally rated as 'green' (no formal action) across all license conditions except for TOR and HRA. ONR raised a Level 4 Regulatory Issue (with 4 being the lowest level of significance and 1 the highest) for the licensee to improve the logging of maintenance activities associated with fire doors at HRA. ONR raised a Level 3 Regulatory Issue to ensure that appropriate supervision is in place for the logging and recording of maintenance activities at HY2. Finally, ONR raised Level 3 and Level 4 Regulatory Issues at TOR relating to the training requirements for the civil engineer to undertake their fire-related tasks, the maintenance of fire equipment and deficiencies in fire compartmentation in non-nuclear buildings and the review of fire risk assessments.

In November 2022, ONR undertook a Control of Major Accident Hazards Regulations 2015 (COMAH) inspection at HNB [46]. ONR observed that the licensee has removed flammable gases from the site and a significant proportion of COMAH major accident scenarios (as defined in the HNB Major Accident Prevention Policy) were no longer credible. An inspection rating of green (no formal action) was assigned for compliance against this topic.

In addition to fire safety interventions for nuclear safety, ONR inspects EDF NGL facilities for life fire safety. This comprises regular inspections against the requirements of the Regulatory Reform Fire Safety Order 2005, Fire (Scotland) Act 2005 and/or the Construction Design and Management Regulations 2015. Findings from the inspections and incident investigations relate primarily to fire protection and are reported in that section.

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

For EDF NGL, ONR concludes that the licensee developed and implemented processes and guidance for fire hazard analysis so that safety cases and fire analyses remain fit for purpose across the fleet of installations. In assessing these arrangements and their implementation, ONR concludes that they are generally consistent with international good practice, demonstrating that the licensee has adequate fire safety analyses and supporting arrangements in place. Nonetheless, the assessment in this report has identified that there is a secondary area where further review would be beneficial and proportionate: the licensee's adoption and implementation of the latest IAEA guides SSG-64 and SSG-77 regarding systematic consideration of fire in combination with other hazards. This will be carried out through ONR's assessment of PSR3 and safety case modifications through normal business.

II New build reactors – NNB GenCo

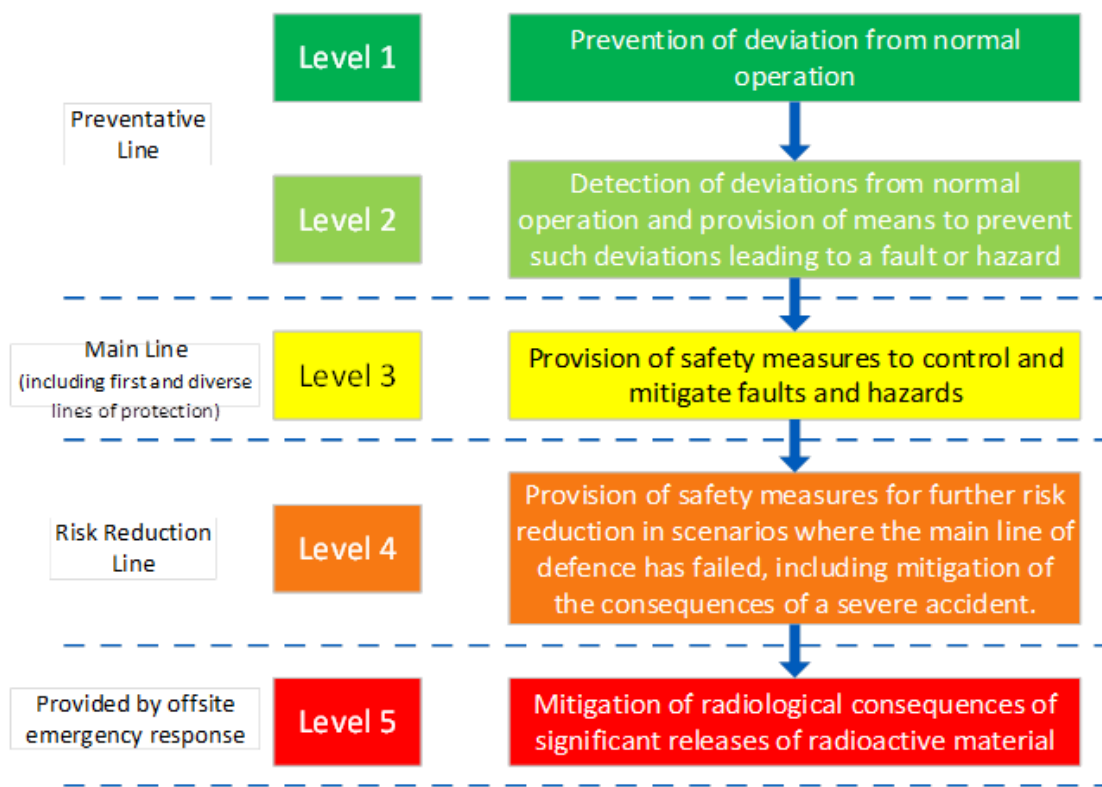
The methodologies described in Section II-2.1 below apply to all parts of the HPC site where there are nuclear or radiological hazards, including fuel storage and waste storage facilities, and the associated waste management processes such as gaseous and liquid effluent treatment, solid waste sorting and waste packaging, handling and on-site transport.

II-2.1.1 Types and scope of the fire safety analyses

The text in this section of the report has been prepared by NNB GenCo, with only minor changes by ONR as described in section 1.1.2.

The HPC safety assessment uses a five-step defence in depth (DiD) process for prevention and mitigation of accidents, which NNB GenCo considers to be aligned with national and international RGP. The HPC DiD levels are shown in Figure 1 (reproduced from the HPC Safety Case Manual [47]). The numbering of the levels influences the order of preference of choosing safety measures, so preventative measures such as elimination of ignition sources are used wherever possible instead of relying exclusively on risk reduction measures such as fire suppression systems.

Figure 1: NNB levels of defence in depth



The overall objective of NNB GenCo’s fire assessment for nuclear safety [48] (Section 5.1.1) is to ensure that the safety functions which enable achievement and maintenance of the safe state of plant are performed in the event of a fire inside the installation. This objective implies that:

- A fire must not cause the loss of more than one redundant system whose safety function is required to reach and maintain the safe state of the plant.
- A fire must not compromise the control room; habitability must be assured. If the control room cannot be accessed, the accessibility and habitability of the Remote Shutdown Station (RSS). Access must also be possible for local actions that are needed.
- A fire must not lead to the loss of safety equipment whose failure is not accounted for in the safety case. This applies to the enclosures of major components of the primary circuit, and piping for which break preclusion applies.
- A fire must not cause the loss of non-redundant safety equipment required to reach and maintain the safe state of the plant. If loss of such equipment cannot be ruled out, the potential for a fire must be eliminated or the equipment must be protected.
- A fire must not cause loss of equipment where loss would lead to core melt, large releases following core melt (severe accidents) or a further event with an anticipated frequency of occurrence less than 0.01 per year, as far as reasonably practicable.

The following description is based on the HPC Safety Assessment Principles for Internal Faults [42] and the Assumptions and Criteria for Internal Faults Safety Analysis. The overall framework for all faults and hazards is presented first for context, and details of how fire assessments fit into the overall case are covered later.

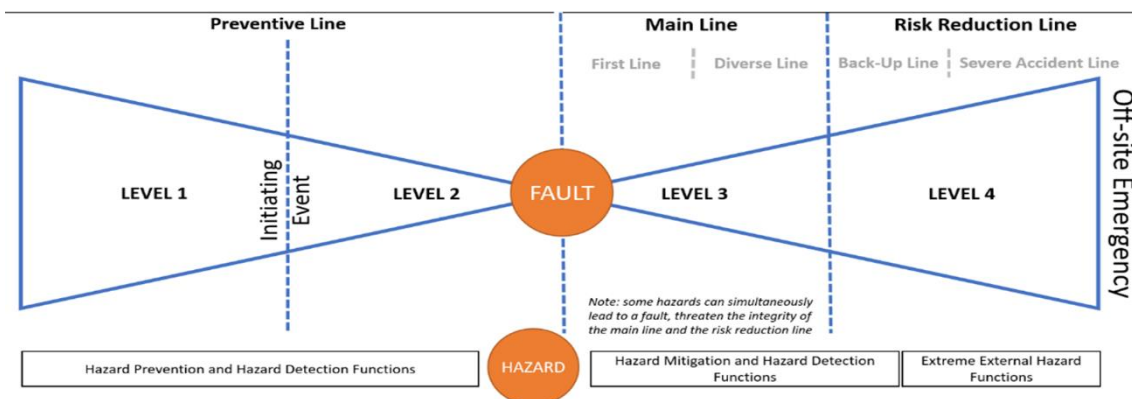
II-2.1.1.1. Deterministic fire hazard analysis

The EPR design is based on the demonstration of a set of Main Safety Functions (MSF) for all design basis faults and hazards. The MSF, used in the deterministic assessment are as follows:

- Control of Fuel Reactivity;
- Fuel Heat Removal;
- Confinement of Radioactive Material; and
- Other: Hazard prevention and mitigation, or plant monitoring or auxiliary support to the above three MSFs.

The MSFs are used to derive Plant Level Safety Functions (PLSF), which are then decomposed into Lower Level Safety Functions (LLSF) until they can be applied to specific scenarios and levels of DiD. The relationship between different types of Safety Function (SF_n) and the DiD concept is shown in Figure 2 (from [47]).

Figure 2: Relationship between different types of Safety Function and levels of defence in depth



NNB GenCo carries out deterministic assessment of faults separately to hazard assessment, and produces:

- A set of SFns and Safety Features (SFs) which reduce the frequency of faults;
- A set of Design Basis Initiating Faults (DBIFs) and their frequencies, consequences, the SFns and SFs required to mitigate them such that a Non-Hazardous Stable State (NHSS) and Safe Shutdown State (SSS) can be reached and maintained following a DBIF, and that doses meet safety objectives (level 3 of DiD);
- The number of lines of protection to be provided by SFs, identified based on the DBIF frequency, consequences, and the potential for Common Cause Failure (CCF) of SFs (i.e., the failure of two or more SFs to fulfil their function due to a single specific event/cause, such as fire in one room); and
- Analysis to demonstrate that lines of protection can meet their safety objectives, with the level of conservatism appropriate to the frequency of the fault, the potential consequences, and the line of protection being considered.

NNB GenCo then links the deterministic assessment of hazards to the fault assessment by analysing whether a hazard could cause a DBIF and/or adversely affect one of the SFs required to mitigate a DBIF. The overall process is shown in Appendix B (from SCM [47]), with the hazards assessment process highlighted in green.

NNB GenCo achieves the hazard assessment through the creation of a list of design basis hazards, with their corresponding design basis hazard levels, and defining a set of Hazard Safety Functions (HSFNs) and Hazard Safety Features (HSFs) so that the plant is designed to fulfil the MSFs during and following these hazards. Further detail on the hazard assessment process is provided in NNB GenCo's submission [49].

The HPC operational plant states included in the safety assessment for all faults and hazards are:

- reactor at power, hot shutdown, and intermediate shutdown on Steam Generators (SGs)

- intermediate shutdown on SGs
- intermediate shutdown on Safety Injection (RIS)/Residual Heat Removal System (RRA)
- normal cold shutdown
- refuelling cold shutdown and reactor completely discharged

The plant states are based on reactor power level, pressure and temperature, and availability of cooling systems. The Fault Schedule entries for each DBIF show which plant state(s) the fault sequence is applicable to, and which SFs are claimed. The hazard assessments include consideration of the plant state and which SFs are claimed and available in that plant state.

II-2.1.1.2. Identification, screening and justification of bounding scenarios

External fire

External hazards, including fire, are defined by NNB GenCo as natural or human-caused hazards that originate externally to the plant that have the potential to adversely affect plant safety. The severity and characteristics for assessment of external fire are set out in the Site Data Summary Report [50], which identified the industrial hazards below and concluded that natural fire hazards such as woodland fires did not need to be considered because of the nature of the surrounding land. The industrial scenarios considered for the external fire hazard assessment are:

- hydrogen gas explosion associated with a delivery to HPC generating a fireball
- ethanolamine (ETA) pool fire associated with a delivery to HPC
- diesel pool fire associated with a delivery to HPC
- kerosene pool fire associated with a delivery to Hinkley Point B (HPB)

NNB GenCo considers that the minimum design basis thermal radiation value at the HPC site has been conservatively chosen, to be applicable to safety-classified buildings and structures to protect the SSCs.

Internal fire

NNB GenCo defines internal hazards, including fire, as hazards that originate within the site boundary and have the potential to adversely affect plant safety. Internal fires can originate inside or outside a building.

Internal hazards in NNB GenCo's assessments do not have a site Design Basis Hazard Level (DBHL) in the same way as external hazards. The characterisation of hazards clarifies when and where the fire hazard is assumed to occur, the severity of the fire hazard, and any other failure assumptions relevant to the fire hazard. For each fire hazard, NNB GenCo identifies multiple potential HIEs/DBIHs where appropriate.

Internal fire inside buildings [51]

NNB GenCo has identified the fire load of each room or area from design information about the materials, plant and equipment that will be inside the room during the plant states described previously. Typical examples of fire load include storage areas for flammable or combustible materials, and machinery oils and hydraulic fluid, and cables. The reference fire for assessment is the fire which has the most severe consequences and duration, involving all the available fuel in the room.

NNB GenCo's fire hazard verification studies consist of:

- Assessment of the robustness of the fire compartmentation – most buildings and their rooms are assessed for robustness using the EPRESSI methodology [52] but NNB GenCo has adopted alternative methods (described in Appendix B of the NAR) for large volumes inside the reactor building because of limitations to the applicability of EPRESSI;
- Fire Risk Analysis (FRA), which studies potential common mode failure scenarios;
- Fire Hazard Vulnerability Analysis (HVA), which considers the potential for a fire in a Hazard Safety Volume (HSV) to generate DBIFs, and the effects of the fire on the protection systems claimed in the DBIF; and
- Complementary studies covering other fire hazard analysis that may be required, including the study of Combined and Consequential Hazards (CCH).

The technical aspects of the fire hazard analysis carried out as part of the CCH typically use the results of the EPRESSI studies and the FRA. The information provided in Appendix B explains how NNB GenCo carries out the fire hazard analysis for both the EPRESSI studies and the FRA.

II-2.1.1.3. Event combinations

NNB GenCo considers three types of hazard combination for all types of hazard:

- Independent combined hazards – the coincident occurrence of non-correlated hazards and/or plant related faults;
- Dependent combined hazards – combinations of hazards which result from the same origin and so have a proven dependence, such as natural hazards resulting from exceptional climatic events; and
- Consequential combined hazards – combinations of hazards where one hazard is induced as a consequence of another initiating hazard.

NNB GenCo initially derived the sets of combined and consequential hazards to be analysed on a site-wide screening basis and reports it in [53]. NNB GenCo reports that independent hazard combinations as screened out in [53] were based on the very low combined frequency of independent events or hazards occurring at the same time. The

remaining hazard combinations were assessed to determine whether further safety analysis of specific targets against the combination is required in the hazard verification studies.

The methodology was developed further after [53] was issued and is captured in the CCH methodology document [54]. This includes a matrix of all the applicable hazard combinations, noting that no hazard combinations have been identified for off-site fire, only for internal (on-site) fire. Further detail on these hazard combinations and how these are categorised is provided in the licensee's submission [49].

II-2.1.1.4. Probabilistic fire hazard analysis

NNB GenCo's PSA methodology used for all faults and hazards including fire is described in the Safety Case Manual [47] and summarised here. NNB GenCo uses PSA, including fire, to confirm overall risk levels against quantitative objectives, and to inform the design. NNB GenCo's PSA includes:

- Modelling fault and hazard sequences, including credible failures of structures, systems, and components as well as human-caused failures, to determine:
 - The frequency of fuel melt for each sequence;
 - The frequency and characteristics of credible significant releases of radioactive material; and
 - The risk to workers and the public.
- Comparing the PSA output with the Safety Design Objectives (SDOs) to support the demonstration that the design reduces risk to ALARP:
 - Identifying where improvements to the design can be made; and
 - Confirm or directly informing the DBIF frequencies.

NNB GenCo considers that the deterministic safety case demonstrates there are adequate lines of protection based on the frequency of a fault, but the PSA can develop a more realistic, best estimate insight into the risk of a facility. This includes modelling of non-classified systems where these are used and using reliability data based on component design and performance rather than classification.

NNB GenCo's PSA considers all initiating events in all reactor states. The reactor states in the PSA are based on the plant states described above but split into sub-states to add further detail where this is necessary. Initiating events can affect fuel in the core, fuel in transit between the fuel building and the reactor building, fuel stored in the Spent Fuel Pond (SFP) and radioactive waste operations and handling.

There are three main aspects to NNB GenCo's use of PSA:

- Establishing that the risk associated with the design is ALARP and complies with NNB's targets;

- Making risk-informed changes to the design and the operation of the plant; and
- Identifying risk-significant initiating events, components, and human actions.

The SDOs (which are presented in the NSDAPs) provide a UK-specific set of objectives that can be used to inform whether the fundamental principles which require ALARP have been met. The final PSA will compare the risk from the facility against SDO targets 5, 6, 7, 8 and 9. Level 3 PSA forms the endpoint of PSA analysis and is based on a level 1 and level 2 PSA, which in NNB's case are integrated into the same PSA model.

In addition, to support achievement of the SDOs and to ensure a design that meets RGP, NNB GenCo sets an additional probabilistic target for fuel melt at 10^{-5} per year. This is a cumulative frequency target for all fuel melt events within the nuclear island, including melt of the fuel in the core, melt of fuel assemblies being handled in the reactor building or fuel building, and melt of the fuel inventory in the fuel pond. This includes melts caused by hazard sequences.

- Additional details specific to fire are included in [51]. The analysis is being carried out in phases as follows: Phase 0 – The definition of the scope of the study and the fire compartments that will be considered for screening for all onsite buildings;
- Phase 1 – Qualitative screening of fire compartments;
- Phase 2 – Quantitative screening of fire compartments; and
- Phase 3 – Detailed analysis of single fire compartments for the compartments screened as part of phase 2, the analysis of multi compartment fire scenarios and fire scenarios in the MCR. NNB GenCo states that this phase will only be carried out for compartments that are still considered to be relevant following a review of the output of phase 2. The overall process is summarised in Appendix F.

II-2.1.1.5. MCR habitability

NNB GenCo's fire hazard assessment also considers habitability of the Main Control Room (MCR) and Remote Shutdown Station (RSS). NNB GenCo considers that:

The safety case associated with the MCR habitability must demonstrate that the habitability of the MCR should generally not be affected by internal hazards. In the event of unavailability of the MCR due to an internal hazard (particularly a fire), the habitability of the Remote Shutdown Station (RSS) must be ensured. In the event of external hazards, the safety functions of systems and equipment that are required to bring the plant to a safe condition and to prevent and limit radioactive releases, as well as MCR habitability, should not be affected. MCR habitability must be ensured during all types of events that might result in radioactive release in the environment.

NNB GenCo's fire hazard assessments therefore consider the effect of the fire on habitability of the MCR as well as the direct effects of fire on safety systems. NNB GenCo considers that habitability is ensured when acceptable conditions of temperature, humidity, air quality, toxicity, smoke, and radiation levels etc are maintained [55]. The habitability

assessments consider the effects of a fire inside the MCR, a fire in a volume adjacent to the MCR, and a fire outside the building housing the MCR. The preventive and protective measures are discussed in Section 3.

II-2.1.2 Key assumptions and methodologies

II-2.1.2.1. Deterministic fire hazard analysis guidance

The key concepts and sequence of the EDF-specific hazard assessment methodology are described in ENG 2-9L [56], and the main points are summarised in the following sections. The Hazard Vulnerability Analysis is a key part of the deterministic assessment and is summarised below.

HVA Step 1 – Review of Hazard Sources and Safety Volumes: identifies the set of HISs and HIEs in each HSV, as described in Section II-2.1.1.2.

HVA Step 2 – Definition of Bounding and Representative Hazards Scenarios: derives the bounding DBIHs for the HSV, as described in Section II-2.1.1.2.

HVA Step 3 – Identification of potential induced DBIF: identifies the DBIFs that are potentially induced by the bounding DBIH.

HVA Step 4 – Functional Analysis at Architectural Level: assesses the ability to manage the induced DBIFs from Step 3, predominantly based on the two principles of separation (separation between trains and separation between SSCs that prevent a DBIF and the SSCs claimed as protection or mitigation against the same DBIF).

Steps 3 and 4 are closely linked and are described in the licensee's self-assessment [49].

HVA Step 5 – Detailed Analysis of the Hazard Effects: uses phenomenological modelling to assess the consequences of a DBIH inside a HSV for the HSV/DBIH combinations which were concluded not to be adequately managed at Step 4. The methodologies are described in more detail in the licensee's self-assessment [49].

HVA Step 6 – HSV Boundaries Integrity: verifies and substantiates that the HSV boundaries are resilient to the hazard loads. This assessment uses EPRESSI modelling for most HSVs, or the alternative methodology for large volumes in the reactor building. The assessment methodology is described in Section II-2.1.2.1.3 and has links to design substantiation evidence.

HVA step 7 – ALARP Assessment: confirms that the risk is ALARP and that all reasonably practicable measures have been included in the design.

HVA Step 8 – Decision to implement a Design Change or confirmation of Design Stability based on ALARP arguments: finalises and concludes the assessment.

The deterministic assessments were not all complete when the licensee's submission [49] was compiled in April 2023. Further detail on the HVA Steps 3 to 6 is provided in the licensee's self-assessment [49].

II-2.1.2.2. Fire propagation assessment

NNB GenCo uses the EPRESSI methodology to demonstrate the fire resistance performance of fire safety volumes and justify the absence of fire propagation outside the fire safety volume, including propagation to adjacent buildings. The methodology is described in [57] and was developed in France. Section 4 of the EPRESSI UK companion document [52] presents the UK context interpretation, including the following key changes from the original French EPRESSI methodology.

- The original French methodology allows fixed automatic fire extinguishing systems to be claimed to justify all the fire partitioning elements in the room without having to perform modelling calculations. However, this approach was challenged by the ONR during the Generic Design Assessment (GDA) process, so all rooms presenting a fire risk are modelled regardless of whether they have a fixed firefighting system.
- Margins have been included for fire load inventory input data to allow for potential late modifications or temporary storage during the life of the plant without potentially invalidating the assessment.
- Small electrical cabinets and cubicles identified as presenting a possibility of a localised fire (PFL) do not need to be modelled if the cabinet has no propagation risk to other nearby cabinets and if there are no mobilizable fire loads above the cabinet or in the plume from the burning cabinet. Generic arguments are made that the fire loading from such cabinets smaller than 0.34 m³ have a lower fire load than other types of PFL and the associated fire power according to NUREG 2178 is quite low.
- Motors with voltage of 10 kV or higher are considered as PFL.
- Fire is considered to spread between two opened adjacent cabinets and the PFL takes account of the fire load from all opened adjacent cabinets.
- The maximum power of pyrolysis (HRR) value of an electrical equipment fire has been updated and is based on values from NUREG CR 6850 for motors greater than 10 kV and NUREG 2178 for cabinets and cubicles.

II-2.1.2.3. Identification of safety functions and SSCs to be protected against fire

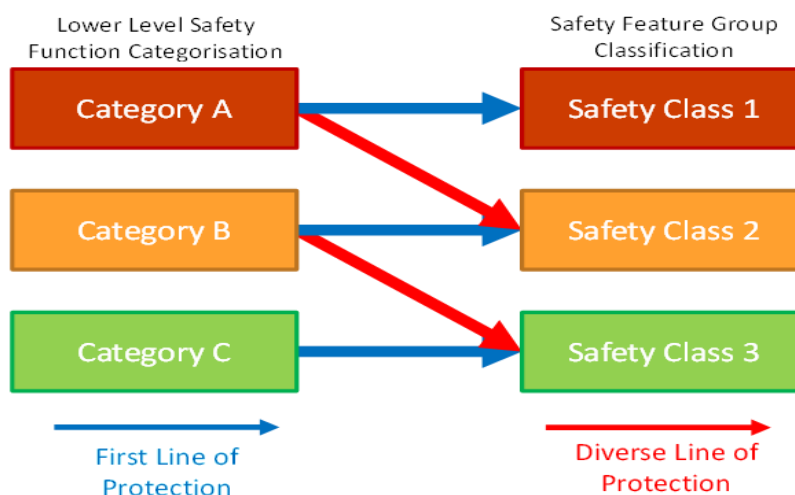
The overall process for deriving SFs from the MSFs is described in Section II-2.1.1.1 and the licensee's self-assessment for TPR2 [49].

NNB GenCo categorises LLSFs based on their importance to safety as follows:

- **Category A:** any function that plays a principal role in ensuring nuclear safety;
- **Category B:** any function that makes a significant contribution to nuclear safety; and
- **Category C:** any other Safety Function (SFn).

Safety Features (SFs), which are the means of providing SFns, are classified as class 1, class 2 or class 3 based on the highest category of SFn they support and their role in providing the function. This allows the SFs providing the SFns to be designed, substantiated and maintained in a manner proportionate to their importance to safety. The Safety Feature Groups (SFG) are classified as follows, and the criteria are shown in Figure 4 (from SCM [47]).

Figure 3: Relationship between categorisation of LLSFs and classification of associated SFGs



- **Class 1:** Safety Feature Group provides a **principal** means of fulfilling a Category A LLSF;
- **Class 2:** Safety Feature Group provides a **principal** means of fulfilling a Category B LLSF, or provides a **diverse** means of fulfilling a Category A LLSF; and
- **Class 3:** Safety Feature Group provides a **principal** means of fulfilling a Category C LLSF, or provides a diverse means of fulfilling a Category B LLSF.

Further detail on the categorisation of the LLSF-H and the factors considered, such as the frequency and dose band of the set of consequences is provided in the licensee's self-assessment for TPR2 [49].

II-2.1.2.4. Assessment of fire loading

NNB GenCo's method to quantify the fire load inventory is given in the 'Guidance for fire load inventory' [58]. A short summary of some of the key assumptions is given below.

- An assessment has been made of a broad range of cables qualified for use on the EPR and the assumed fire load is 18.8 MJ/kg of total cable mass (including both combustible and non-combustible parts). This is not an average value but a conservative value (few individual cable types exceed that value). Cable trays are assumed to be filled to 80% capacity (there is a design requirement to maintain 20% spare capacity).
- Electrical cabinets are assumed to have a fire loading equivalent to 850 MJ/m³ of cabinet volume. Combustible liquids are assumed to have a fire loading of 46.4 MJ/kg.

Different values are assigned to electric motors depending on the power rating of the motor.

- The main input data is the 3D model, TAGs database and equipment supplier data. If the fire loading associated with suppliers' equipment is not known, then bounding conservative assumptions are made for the initial analysis. The analysis will then be rechecked once the suppliers have confirmed the fire loading for their equipment to ensure that the actual loading remains bounded by the initial assumptions.

HPC is still under construction, so routine surveillance of actual fire loading is not currently being carried out. Procedures being developed for the operational phase of the station are anticipated to include a requirement for fire load surveillance.

II-2.1.2.5. Characterisation and control of transient combustibles

NNB GenCo has not counted transient combustible materials in the inventory of fire loads, but included margins for fire load inventory input data to allow for potential late modifications or temporary storage during the life of the plant without invalidating the assessment. Details of the procedural controls for fire loading are currently still under development by NNB GenCo, who acknowledge that they may need to include limits on transient combustibles in particular areas. NNB GenCo confirmed that any subsequent changes to transient combustibles would be assessed as part of the modification control process to check whether they challenge the fire loading on which the analysis and safety case are based.

II-2.1.2.6. Fire service intervention

NNB GenCo does not claim fire service intervention as a deterministic safety measure for nuclear safety, because the preventive and protective measures described in Section A-II-3.1, A-II-3.2 and A-II-3.3 are claimed instead. Intervention is however included as a safety measure for life safety, taking account of other relevant hazards such as radiation, contamination, criticality and spent fuel water chemistry. The HPC design includes features such as firefighting stairs, corridors and lobbies, dry risers and communication facilities. Intervention is also important for business continuity.

II-2.1.2.7. Fire PSA

NNB GenCo is currently developing the fire PSA to support the current HPC design, which will be reported on timescales commensurate with the HPC Pre-Commissioning Safety Report (PCmSR) report. As such, NNB GenCo considers that it would be premature to provide any indication of risk at this time. Currently the work is undergoing phase 3 (as presented in Section II-2.1.1.4) and is being applied to the whole HPC plant for all reactor states – initially for the level 1 PSA, with it being extended to the level 2 and level 3 PSA on PCmSR timescales.

II-2.1.2.8. Change management

NNB GenCo states that the top-level safety report is updated at set points during initial phases of the plant lifecycle (design, construction and typically inactive commissioning).

The safety report at each of these points is linked to a design Reference Configuration (RC), which is in turn linked to milestones or hold points. However, NNB GenCo acknowledges that changes will occur during the evolution of the design and the construction process, between each RC and hence between safety report updates.

The NNB Licence Condition (LC) 20 process for compliance with ONR LC 20 aims to ensure that significant changes to the plant design or procedures between each RC are understood and justified from a safety case perspective. NNB GenCo considers that each change to the safety case is categorised and appropriate justification is recorded, pending update to the wider safety case documentation and issuing of the subsequent top-level safety report.

NNB GenCo assesses modifications according to their significance to the safety case and follows different review and acceptance routes depending on their significance. The review process includes consultation of safety case practitioners and fire SQEPs where fire safety may be affected to ensure that implications for the fire analysis are adequately captured in any proposed changes. NNB GenCo considers that once the initial project phases are complete, the plant will be operated with the potential for direct radiation risk, and therefore it will be necessary to ensure the plant operating rules and instructions (LC23 and LC24) are consistent with the wider safety case at all times.

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

II-2.1.3.1. Consequences within an HSV

NNB GenCo's approach is that a hazard occurring in a HSV is initially conservatively assumed to lead to the loss of all equipment housed in the HSV, and Hazard Functional Safety Analysis (HFSA) is carried out to determine whether loss of this equipment leads to a DBIF and whether sufficient mitigation remains available to reach the SSS. NNB GenCo then carries out further phenomenological studies if the initial assessment concludes that loss of all the equipment in the HSV is not tolerable.

II-2.1.3.2. Consequences outside an HSV

NNB GenCo undertakes modelling to determine whether the fire remains inside a HSV by comparing the modelled consequences of a fire with the robustness of the HSV boundaries.

NNB GenCo then reviews the overall margin in the modelling and makes engineering judgements including sensitivity to the relative position of targets (e.g., plume areas and flow zones at openings). NNB GenCo considers the margin between measured values and success criteria, particularly for scenarios where there is a long thermal exposure of targets such as cable fires, and when modelling tools are used outside their validation domain [59] section 7.

II-2.1.3.3. Radiological release and dispersion

NNB GenCo's radiological release and dispersion dose calculation methods and assumptions are described in [60]. The consequences of all DBIFs, including those triggered by fire, use release fractions and decontamination factors based on parameters

such as primary circuit activity, fuel clad, system and building integrity. These are common to all potential initiators of the faults and fire is not treated as a special case.

NNB GenCo's methodology and assumptions for fire leading directly to radiological release or dispersion are in [61] and consider both whether the fire burns solid waste, fuel assemblies or containers, and whether radioactive fluids have lost one confinement barrier.

II-2.1.4 Main results/dominant events (licensee's experience)

The deterministic assessments were in progress and not yet complete when the licensee's submission [49] was compiled in March 2023, so it is too early to report which are the dominant events.

II-2.1.5 Periodic review and management of changes

II-2.1.5.1. Overview of actions

The main actions that NNB GenCo is carrying forward for HPC include:

- Development of a specific methodology for the reactor building where the volumes of rooms and enclosures are too large for EPRESSI to be valid; and
- Use of non-fibrous materials where cable tray wrapping is required in the reactor building.

II-2.1.5.2. Implementation status of modifications/changes

HPC is still under construction; however, NNB GenCo has adopted several design change modifications, including changes to meet additional UK regulatory expectations. They are recorded as License Summary Statements (LSS). A selection of the most significant design changes is summarised in Table 3 below and are considered examples of good practices in the context of TPR2.

Table 3: Design Changes to meet UK expectations and OPEX summary

Reference	Title	ORIGIN	Comments
T2DDS-UK-08062 A [62]	Fire strategy modifications	British Standards and ONR	<p>Various modifications to align with British Standards and in response to ONR comments, including:</p> <ul style="list-style-type: none"> • Addition of secondary power supplies to firefighting shaft lighting; • Addition of fixed firefighting to areas with significant risk; • Changes to fire sectorisation and openings for personnel evacuation;

			<ul style="list-style-type: none"> • Upgrade Safeguard Building lifts to firefighting lifts; and • Additional dry riser outlet in radwaste building to improve coverage.
T1DDM-UK-08067 A [63]	Additional Fire Compartmentation (linked to CIG5041UK B)	Licensing, GDA or UK regulations	Additional fire compartmentation to Nuclear Island buildings following discussions with NNB, ONR meetings, and development of Fire Strategy documents.
T2EIB-UK-11455 [64]	Set Down Area Fire Segregation	Design non-conformance	Addition of fire dampers for redundancy and after re-routing of a HVAC duct.
T1EIB-UK-14823 A [65]	Implementation of 80mm Fire Wrapping for Protection of Ducts and Supports – Phase 1	Post CS2 – NNB (Civil or MEH) supplier late feedback	40mm thickness was assumed in the 3D model during early stages of the design where 1 hour fire resistance, but no commercially available product was found with the required fire resistance, so model was modified to assume 80mm thickness.

II-2.1.6 Licensee's experience of fire safety analyses

II-2.1.6.1. Overview of strengths and weaknesses identified

NNB GenCo's considers that the fire safety analysis in development for HPC broadly complies with WENRA SV 6.1 and WENRA E6.1. Specifically, NNB GenCo highlights the following as strengths:

The fire safety analysis has been developed using standards that are more recent than those that were in place during the design and construction of other stations within the UK fleet, and close collaborative working between the UK and France has allowed benefits to be shared. The analysis has also had the benefit of development of modelling techniques and use of 3D computer models of the buildings and structures that were not available during the design of other stations in the UK fleet.

NNB GenCo acknowledges the following weaknesses in their fire safety analysis:

- **Reactor building:** the assessment techniques used for most of the fire HSVs were found not to be directly applicable to the reactor building because the large volumes were beyond the range of applicability of the models used for other buildings. A separate assessment methodology was therefore developed for the reactor building.
- **Fires outside buildings:** the assessment methodology can be applied rigorously to fires initiated within a building or structure. Although the methodology covers fire spread through penetrations in a wall that is common to two buildings, it does not cover fire or smoke spread through external openings, fire from an outside source such as stored

materials or vehicle fire, or a large fire on the site. A gap analysis has been carried out and specific assessments are being carried out as required.

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

HPC is currently undergoing construction and is not yet operational. NNB GenCo acknowledges that, although events are recorded and reviewed so that lessons can be learned, many of the events to date are from transient hazards associated with the construction environment and have limited applicability to the operational plant.

NNB GenCo maintains an ongoing OPEX register for the project since 2012 and a summary report is issued at regular intervals [66]. The list below is a sample from the most recent version report. The OPEX has been taken into account in the HPC design where appropriate and included:

- Post-cooling of hot batteries and manoeuvrability of Nuclear Auxiliary Building ventilation isolation registers (NME0808);
- Operational issue when testing switchover of Remote Shutdown Station ventilation in the event of a fire (NME0939);
- Inability to install cable wrapping as required by the design in some areas due to congestion (NME0797); and
- Spurious fire detection system operating on ventilation system caused fans to run at zero flow (NME940).

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

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

Guidance

NNB GenCo's fire hazard analysis guidance as applied at HPC is summarised in Section II-2.1.1. Section II-2.1.2 shows how NNB GenCo's safety assessment principles and guidance take account of national and international standards, which have been incorporated into the HPC Safety Case Manual, ETC-F EPR Technical Code Fire Protection and NNB GenCo's Nuclear Safety Design Assessment Principles (NSDAPs).

ONR's assessment confirms that the NNB submission reflects the higher-level nuclear fire requirements set in ONR SAPs and TAGs, which form the basis for ONR assessment of licensee safety cases, and are benchmarked against international standards. NNB GenCo has identified these as an input its NSDAPs and has demonstrated consistency with the principles set out in these documents.

Fire loading and data sources

Consistent with SAP AV.3 and the ONR internal hazards TAG, the licensee self-assessment describes how both fixed and transient loads are considered, how change management considers the impact on fire safety, and how underpinning data is based on experimentation and relevant validation testing. It also details how this information feeds into both hazard analysis and operational limits placed on facilities as appropriate. As a result, ONR is content that NNB GenCo meets regulatory expectations in this area.

Deterministic analysis approach

Consistent with the ONR internal hazards TAG, SAPs EHA.1, EHA.5, EHA.6, IAEA SSR 2/1 [31], IAEA SSG-64 [17] and WENRA SRLs, NNB GenCo has set out how tools are selected for analysis of fire behaviour and provided a description of the factors applied in these decisions. This includes zone models and, where appropriate, CFD. NNB GenCo has described a proportionate, graded approach to tool selection that is generally in line with ONR expectations. However, the choice of fire model for the reactor building may not be the most appropriate and NNB was asked to confirm whether it has considered the use of alternative fire zone modelling NNB GenCo has confirmed [67] that it has modelled fires in the reactor building using suitable fire zone models, within their limits of use, i.e. MAGIC and CFD modelling. ONR is assessing the use of these models through routine engagement with NNB GenCo and will be subject to ONR's permissioning assessment of Summary Safety Case Document #3 prior to release of the Hold Point for delivery of fuel to the HPC site.

NNB GenCo notes in Appendix B that that its current fire risk assessment methodology does not consider fires which occur on the site but outside of buildings or fire spread between buildings. ONR will assess the development of these methodologies through routine engagement with NNB GenCo and will be subject to ONR's permissioning assessment of Summary Safety Case Document #3 prior to release of the Hold Point for delivery of fuel to the HPC site. NNB also notes in section II-2.1.2.1.2 that fire zoning opening elements that are safety classified and meet the fire resistance criteria are claimed in the analysis and assumed to be closed. Fire zoning elements which cannot be claimed are treated as either open or closed depending on which is more conservative. NNB has clarified that boundaries are assumed to be closed but all other openings within the hazard safety volume HSV are assumed to be open to allow adequate levels of oxygen to feed a fire. ONR will assess the conservatism of these assumptions.

ONR considers NNB GenCo's use of site-specific data and building layout information from HPC's 3D model as an area of good practice against SAPs AV.1.

As described in Sections II-2.1.1.2 and II-2.1.2.1, NNB GenCo's hazard assessment methodology includes principles for the identification of fire hazard initiating sources and events, fire initiation of design basis initiating faults, fire impacts on consequences and a deterministic approach based on an adequate level of passive fire protection to contain the worst foreseeable fire. Consistent with ONR SAPs EKP.3 and para 155 and the expectations of IAEA SSG.64, NNB GenCo has described how it considers fire service intervention, noting that it is not claimed in the analysis, and how contributions to defence in depth are considered within the safety assessment process and as part of building design.

ONR's assessment concludes that in general this approach aligns with key principles for deterministic fire hazard analysis as set out in IAEA SSG-2, SSG-64, and ONR SAPs and TAGs. ONR has identified gaps in the methodologies (i.e. the assumption that zoning opening elements are closed and internal fire outside buildings not being addressed by the methodology and the zone modelling of the reactor building), is following them up to resolution through routine regulatory engagement with NNB GenCo, and will be subject to ONR's permissioning assessment of Summary Safety Case Document #3 prior to release of the Hold Point for delivery of fuel to the HPC site.

Combined and consequential hazards

In section II-1.2.2, NNB GenCo states that the UK EPR fire design principles presented in ETC-F were compared and shown to generally comply with the fire safety principles in IAEA NS-G-1.7 [68], which has now been superseded by SSG-64 [17].

Consistent with WENRA SRL E 6.1 [33], IAEA SSR-2/2 [69], NNB GenCo's self-assessment summarised in Section II-2.1.1.3 shows that a systematic process to identifying hazard combinations is applied, and that hazard combinations which are not screened out will be considered within the safety assessment process. ONR's assessment has identified that NNB GenCo's self-assessment does not show the potential effects of combined hazards on the selection, design and performance expectations for active fire protective systems, the potential for combined hazards to affect the capacity for firefighting or how the firefighting system may contribute to combined hazards. NNB GenCo has acknowledged [67] that it has not carried out a review of the potential impact of combined and consequential hazards to the JDT system and it considers that an initiating hazard which impacts the JDT system and then results in a fire could be considered potentially feasible. However, NNB GenCo concludes that as the JDT is qualified to external hazards as per the buildings it is contained within it judges that such an event would be an accumulation of low frequency events. ONR is following the gap to resolution through routine regulatory engagement with NNB GenCo, and will be subject to ONR's permissioning assessment prior to release of Hold Point for SSCD#3 – the safety case for bringing fuel to the HPC site.

Probabilistic safety analysis

NNB GenCo has reported in Sections II-2.1.1.4, II-2.1.2.6 and II-2.1.4 how it uses probabilistic arguments in support of fire hazard analyses. ONR considers that the sections adequately describe work being carried out to develop a Fire PSA for HPC which is consistent with WENRA SRL SV 6.1 and SAP EHA.18 (on the use of a probabilistic approach).

Periodic safety review

NNB GenCo reported its plans to apply a programme of periodic safety reviews throughout the life of the plan and is progressing the development of the process in line with the safety case development and HPC construction timeline. The detail of the process was not expected to be available at this stage and will be subject to regulatory oversight as part of future regulatory hold points.

Learning from experience

In Section II-2.1.6.2, NNB GenCo described its approach to recording events on the HPC construction site and the development and management of an OPEX register. NNB GenCo also provided examples of how OPEX has influenced the HPC design. ONR considers this as evidence of NNB GenCo's commitment to identifying fire-relevant events at the site, in line with ONR expectations in SAPs MS.4 and IAEA SSG-64 [17].

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

ONR assessed the internal hazards aspects of the EPR design for HPC at key stages during the design and the ongoing construction project. This includes assessment through the UK's Generic Design Assessment (GDA) process. As part of the internal hazards assessment [70] in GDA, ONR raised an assessment finding requiring the future licensee to demonstrate how the requirements from analyses associated with common mode failure in the event of fire would be captured within future revisions of the safety case. NNB GenCo explained the planned Hazard Vulnerability Analysis process (as detailed in Section II-2.1.2.1) which ONR assessed, allowing it to close the finding.

ONR carried out an assessment of the internal hazards safety case at PCSR3 (Pre-Construction Safety Report 3) focusing on the basic design hazard protection schedules for key hazards including fire. ONR's assessment requested that the relevant Flamanville verification and validation studies, and substantiation available for a selection of faults from the BDHPS should be made available to ONR. NNB GenCo provided dedicated workshops for ONR to sample the evidence at source thus addressing the finding.

HPC has been subject to a number of licence condition compliance inspections, none of which raised any issues relating to fire safety from a nuclear safety perspective. The findings of life fire/conventional site safety inspections undertaken during the construction phases to-date, identifying life fire related issues, are reported in Section A-II-3.2.4.2.

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

For NNB GenCo, ONR is content that the licensee is implementing processes for developing nuclear fire hazard analysis in close alignment with national and international standards. Nevertheless, ONR considers that improvements to fire safety analysis on the HPC site would be beneficial in one area: NNB GenCo should identify the potential effects of combined hazards on the types, main characteristics and performance expectations for active fire protective systems, the potential for combined hazards to affect the capacity for firefighting and how the firefighting system may contribute to combined hazards. ONR is monitoring NNB GenCo's progress towards closing this gap through routine regulatory engagement and therefore no additional TPR-specific action is raised.

2.2. Research reactors

In line with Section 1.1.2, the UK has no operational research reactors or research reactors under decommissioning that merit inclusion in the list of UK candidate installations for TPR2 on fire-related radiological risk grounds. This section is consequently left blank.

2.3. Fuel cycle facilities

The text in the sections below has been prepared by Urenco UK Ltd (UUK) and Springfields Fuels Ltd Background information on the sites and the range of installations considered in the scope of the assessment is provided in Sections 1.1.2 and 1.1.3.

I Enrichment facilities – URENCO Capenhurst

I-2.3.1 Types and scope of the fire safety analyses

UUK requires Nuclear Fire Assessments to cover:

- a) The direct impact of fire on radiological and hazardous material inventories; and
- b) The impact of Design Basis Safety Measures (DBSM) and associated SSCs in place to address other hazards and faults.

UUK Nuclear Fire Assessments identify SSCs in line with the following principles:

- Primary measures against fire propagation or to limit explosion damage;
- Risk reduction measures; and
- Personnel escape routes, detection and alarms.

Where UUK identifies safety measures as having a significant or principal role in nuclear fire safety, it expects safety designation in accordance with their Safety Functional Category, as discussed in UUK Safety Assessment Handbook (SAH) 410 (please see Section I-2.3.2).

UUK's primary technique for identification of nuclear fire hazards is the Hazard Identification (HAZID) process. HAZID studies are a systematic critical examination of facilities to identify any potential hazards and the consequential effects, addressing both nuclear and non-nuclear hazards based upon a generic proforma.

UUK states that HAZID processes consider all relevant process steps and operational states to ensure full coverage of hazards is presented, for example, where fire loading hazards may fluctuate. For nuclear fire, UUK uses Hazard and Operability (HAZOP) studies. HAZOP is a systematic qualitative technique to identify process hazards and potential operating problems using a series of guide words to study process deviations. UUK uses the HAZOP model to challenge each part of a process to discover what deviations from the intention of the design can occur and what their causes and

consequences may be. UUK applies this technique to new and existing processes to identify hazards.

UUK also uses Fire Walkdowns to determine the relevant hazards when reviewing existing facilities, to validate previous assessments and control measures such as likely combustible inventories, potential ignition sources and means of fire progression. It also uses Fire Walkdowns to identify nuclear or hazardous material inventories that may be vulnerable to direct or indirect effects of fire and firefighting.

UUK states that it carries forward all identified nuclear fire hazards from the HAZID studies to a Nuclear Fire Assessment. The latter provides the detailed assessment of the hazards. The level of detail in the hazard assessment is cognisant of the radiological hazard presented by the fire, with more significant hazards subject to suitable safety case assessment techniques such as:

- **Layers of Protection Analysis (LOPA):** a semi-quantitative risk assessment method for analysing risks of scenarios with higher consequence potential. This is used by UUK to identify the required independent protection layers to reduce the frequency of an initiating event to within a defined level of risk appetite.
- **Design Basis Accident Analysis (DBAA):** a deterministic analysis used by UUK to establish many of the conditions that are considered when designing or modifying a facility.
- **Probabilistic Safety Analysis (PSA):** a more detailed modelling of failure modes for the whole or parts of a plant, which can be used to assist in identifying the importance of any dependencies, and identify if there is disproportionate reliance on particular systems or components. This analysis may lead to the identification of additional safety measures to further reduce risk.
- **As Low As Reasonably Practicable (ALARP) Reviews:** the approach applied by UUK to demonstrate risks are reduced to ALARP. It involves evaluating risks and the options for reducing them further, to determine whether existing safety measures should be enhanced. UUK considers that the risk will be ALARP when the cost of making the next incremental risk reduction is grossly disproportionate to the value of the benefits gained.

UUK states that mitigative measures such as incident fire response are not typically claimed for nuclear safety but are discussed in the ALARP demonstration.

UUK describe the following steps for nuclear fire assessments:

- a) Determine if a fire could lead to a nuclear release (using fire calculations, CFAST modelling, or fire assessor judgement).
- d) Then determine the associated consequence context of the release (which consequence region is in line with the SAH e.g. DBAA, PSA, LCM, ALARP).
- e) Then the fire assessor made a judgment on whether there were suitable and sufficient safeguards in place (using a 'multi-barriered' approach akin to LOPA).

- f) If insufficient measures were identified a qualitative judgement was made on the residual PSA risk (no numbers beyond a calculated IEF in some instances, PSA just qualitatively judged to be intolerable, tolerable or broadly acceptable).

I-2.3.2 Key assumptions and methodologies

UUK maintains internal nuclear fire assessment guidance within its Safety Case Manual (SCM) and Safety Assessment Handbook (SAH) which, in addition to fire, address hazardous material-radiological interaction, safety function categorisation and classification of safety measures, radiological fault sentencing and simplification of fault assessment, and environmental assessment. These company guidance notes have been informed by a range of wider guidance including ONR SAPs, ONR TAGs, IAEA and WENRA guidance documents.

UUK Nuclear Fire Assessments identify SSCs in line with the following principles:

- Primary measures against fire propagation or to limit explosion damage;
- Risk reduction measures; and
- Personnel escape routes, detection and alarms.

Where UUK identifies safety measures as having a significant or principal role in nuclear fire safety, it designates according to their Safety Functional Category as discussed in the UUK SAH for 'Designation, Recording and Standards for Safety Measures'.

UUK determines fire loadings by generating lists of items that are manufactured from or contain combustible or flammable materials, recording the number, mass or volume. UUK then uses this information to calculate a combustible load (in MJ). UUK then defines the fire load density (MJ/m^2) as the total fire load in the room divided by the floor area, to provide an indication on the potential severity of a fire initiating in the room.

UUK reports that the fire load inventory is maintained during safety case development, and Room Data Sheets aid in the identification of changes in fire loading that may impact the fire assessment for nuclear or significant non-nuclear materials, or where SSCs may be affected. The fire load may vary for different plant phases, including construction, commissioning, operations and maintenance/outages (e.g., additional 'transient' fire loads such as cleaning solvents and hot working equipment may be required). Administrative controls are established to define the fire loading for all plant phases.

UUK states that the Nuclear Fire Assessment is subject to review, at sufficient detail, across the planned safety case review phases covering Short Term, Interim and Long-Term Periodic Review. Examples of administrative controls to underpin assumptions related to fire loading where routine inspections, which are used to ensure good housekeeping is maintained, and restricted vehicle access. The UUK nuclear fire Hazard Analysis (HAZAN) modelling section lists three potential methodologies: algebraic models (empirical correlations), zone model (CFAST) and CFD models. It then states that only the first two have been used, supported by SQEP judgement if no modelling is undertaken.

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

UUK states that deterministic fire analysis is undertaken in accordance with its SAH guidance for 'Fire, Explosion and Internal Hazards Assessment'. UUK also states that during the assessment, a number of different effects must be considered and dealt with, in particular the potential for more than one system to be affected, and the focus is primarily on the damage to nuclear and hazardous material inventory that could result from a fire or explosion.

UUK considers that as part of its deterministic assessment, fire modelling is likely to be employed to understand the fault progression. It also states that fire modelling tools can vary across assessments but are likely to involve algebraic models (empirical correlations), zone models or Computational Fluid Dynamics (CFD). UUK states that the tool selected and the depth of modelling employed takes cognisance of the hazard potential of the relevant fault and its consequences.

UUK recognises that the material data typically utilised in fire modelling would be generic unless there are specific conditions or considerations which require specific site-based data to be used. Although all data used must be supported as deterministic, assessments are intended to be conservative and bounding. UUK states that, where appropriate, sensitivity analysis may be used to examine any specific key criteria or conclusions.

Finally, UUK notes that, once the fire model has been developed, fire assessors work in conjunction with radiological assessors to determine the resultant radiological and hazardous material consequences using various hazard assessment consequence models such as constant concentration, time-varying concentrations or gaussian plume models, taking due account of the potential for inventories to be pressurised or changing state due to the impact of fire.

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

UUK reports that it qualitatively applied probabilistic safety analysis to the recent updates to safety cases. For the most significant hazard this involved reviewing the suitability and sufficiency of the lines of protection available against the hazard and a qualitative estimate of the residual risk position.

UUK predominantly identified fire sources of a conventional nature, with the potential for nuclear fire risk subsequently generated from key plant or equipment threatened by radiative and conductive heat transfer. The dominant fire hazards within UUK occur where there is significant combustible load in proximity to nuclear inventories. UUK reports that this does not typically relate to transient combustible loads or presence of combustible waste material, but rather permanent combustible loads within the facility such as potentially combustible insulated core panels both internal and external to building structures (learning from the outcome of the UK Grenfell Fire Inquiry and subsequent investigation reports).

UUK considers that the residual risk from nuclear fire scenarios does not dominate the risk profile of facilities at the Capenhurst site. However, it states that where required

improvements had been recommended to ensure sufficient lines of protection were available and residual risks were maintained at ALARP levels.

I-2.3.5 Periodic review and management of changes

I-2.3.5.1. Overview of actions

The Capenhurst site has been engaged in enrichment activities for approximately fifty years and has facilities and infrastructure of varying age within that period. This results in stages of development and renewal to support business growth and reflect the changing needs, including changes to infrastructure as well as operational activities with the potential to alter the fire safety profile.

I-2.3.5.2. Implementation status of modifications/changes

UUK manages modifications to plant, equipment and controls via the Change Management Process Company Instruction. The process requires documented hazard assessment of the change and its impact (if any) on the safety case. UUK considers fire hazards as part of the baseline hazards considered within safety cases and this is therefore part of UUK's periodic review stages of safety cases: Short-Term, Interim and Long-Term Periodic Review. The level of review within these phases is cognisant of the level of detail each review stage involves. Beyond the specific safety case requirements, UUK manages fire hazards through the conventional fire risk assessment reviews. These also support safety case reviews.

I-2.3.6 Licensee's experience of fire safety analyses

I-2.3.6.1. Overview of strengths and weaknesses identified

UUK considers that nuclear safety cases are not significantly impacted by fire, and therefore the predominant focus is on conventional fire safety hazard identification and associated control measures which, in turn, provide additional nuclear fire risk assurance. UUK states that it has on-site SQEP resource to maintain a detailed programme of inspection and review and that this provides a dynamic model for compliance and support to operational activities. UUK acknowledges that the routine focus on conventional fire hazards carries potential for cumulative change to develop in areas that may present an increase in nuclear fire risk, which could go undiscovered until periodic review of safety case assessments. To minimise this, UUK states that all change management proposals involve a Safety Case Manager to identify where challenge to safety measures may be incurred.

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

UUK records fire events alongside all other safety related events in an electronic event reporting and investigation system, supported by a linked action recording and tracking module. UUK uses the system to ensure visibility of all events and suitable response for action and learning.

UUK states that the above is supplemented by learning gained external to the organisation from both within the nuclear sector and beyond, and that during periodic reviews of safety cases, a formal review of learning from experience is undertaken.

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

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

Strengths

UUK's self-assessment concludes that a low nuclear fire risk exists due to the inherent properties of the nuclear material handled and its treatment during operational processes. The licensee therefore considers that the predominant focus is on conventional fire safety hazards and associated control measures.

UUK's self-assessment describes how a HAZID process is used to identify fire hazards which then go forward for nuclear fire assessment with the level of detail applied by the assessment being cognisant of the significance of the radiological hazard presented by the fire.

UUK describes a programme of conventional fire safety management, inspection and risk assessments, which references appropriate guidance (BS9999 Fire Safety in the Design, Management and Use of Buildings Code of Practice [71] and BS9997 Fire Risk Management Systems 2019 [72]– defining requirements with guidance for use)

UUK reports that fire events are recorded in an electronic event reporting and investigation system, supported by a linked action recording and tracking module. Several examples of fire safety improvement projects are referenced involving emergency lighting, compartmentation and fire alarm and detection systems and further projects, not referenced in the submission include improvements to the emergency control centre and fire hydrant main system. These are referred to in Chapter 3.

UUK self-assessment describes fire sources as being predominantly conventional, with the potential for nuclear fire risk subsequently generated from key plant or equipment threatened by radiative and conductive heat transfer and that, where required, improvements had been recommended to ensure sufficient lines of protection are available and residual risks are maintained at ALARP levels. UUK describes that the dominant fire hazards arise in areas where there is significant combustible load in proximity to nuclear inventory. It states that these relate to permanent combustible loads within the facility, such as potentially combustible insulated core panels both internal and external to building structures. UUK's self-assessment acknowledges the importance of adequately addressing the risks presented by insulated core panels and understanding of this risk was demonstrated following a recent ONR fire inspection.

Weaknesses

In consideration of the risk presented by insulated core panels, UUK acknowledged in the UUK External Wall Cladding Register document, that there are examples where this risk is

not considered in the extant safety case, but that an assessment of the findings concluded that the nuclear fire safety risk from all buildings was acceptable and that the nuclear fire safety risk from building cladding did not require any acceleration of the planned Long Term Periodic Review of the safety cases. UUK should ensure that the nuclear fire risk presented by fire sources, such as insulated core panels and other sources, is identified and analysed within future review of safety cases.

It was identified by ONR during the 2023 fire safety intervention at UUK, that a UUK safety case originally produced in 2003 was being updated to modern standards and that a Nuclear Fire & Explosion Hazard Analysis document was being developed as part of this process and this process is encouraged by ONR.

UUK referenced the Urenco Safety Case Manual (SCM) and Safety Assessment Handbook (SAH) in its self-assessment and these generically reference a range of guidance including ONR SAPs and TAGs, IAEA and WENRA guidance. ONR recommends that UUK maintains focus on the development of safety case standards and takes the opportunity to ensure explicitly reference and implementation of relevant good practice guidance for fuel cycle facilities.

UUK's self-assessment acknowledged that the transfer of fire safety-related actions to project management functions may result in undue deferrals or closure which emphasises the importance of cooperation, coordination and prioritisation in fire safety management.

The UUK submission does not describe combined or consequential hazards assessment as part of the current site safety case. This does not explicitly align with WENRA Safety Reference Level E 6.1 [1] or IAEA SSG 64 [17]; however, it should be noted that these apply to reactor facilities and therefore a graded approach should be considered in the context of the UUK site and low nuclear safety hazards and risks. Nevertheless, ONR Safety Assessment Principles [15] and Technical Assessment Guide on Internal Hazards [16] take due account of WENRA SRLs, and IAEA standards are applicable to fuel cycle facilities as well as reactor facilities.

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

ONR provides oversight of licensee operations through inspection and assessment and has a nominated site inspector assigned to UUK's Capenhurst site to monitor emerging site issues and advise project and specialist inspectors on areas of regulatory interest, including significant construction, modification or decommissioning projects.

ONR's fire safety inspection in 2023 sampled a safety case, originally produced in 2003, and confirmed that it is being updated to modern standards and that a Nuclear Fire & Explosion Hazard Analysis document was being developed as part of this process. ONR continues to monitor progress to ensure fire hazards at the facility, and other buildings on site, are fully considered and that guidance used by UUK reflects current RGP.

A recent ONR fire safety inspection checked UUK's use of potentially combustible insulated core panel construction on site. ONR's inspection found that the use of such panels had been surveyed with resultant findings considered for nuclear and conventional fire safety

implications. Furthermore, a conventional fire safety inspection identified shortfalls in the provision and management of the automatic fire detection and alarm system in a building on site detail of which may be found on the ONR website which UUK is addressing through an improvement project across site.

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

UUK's self-assessment submission considered that a low nuclear fire risk exists, due to the inherent properties of the nuclear material handled and its treatment during operational processes. It also considered that safety case conclusions are not significantly impacted by fire events and that focus is therefore on an adequate programme of conventional fire safety. UUK's self-assessment described a dominant fire hazard in terms of structural building fire loading, which had been sampled in a recent ONR intervention and confirmed as being adequately assessed.

UUK recognised a need to update its safety case arrangements and guidance for consideration of nuclear fire safety in light of IAEA e.g. SSG-64 in so far they are transferable to fuel cycle facilities, applying a graded approach. Through this review and ONR inspections UUK recognised an opportunity to make secondary improvements to documents to fire safety action and follow up, closure and link with safety cases. ONR has raised a recommendation that UUK reviews and makes any necessary improvements to its safety case arrangements and guidance in relation to the consideration of fire and of its combinations with other hazards including traceability of fire-related action follow up and closure in safety cases. A combined nuclear fire safety and life fire safety inspection is planned at the Capenhurst site for early 2024 which will examine the linkage between the nuclear fire safety case and implementation of fire safety measures, including any identified hazard combinations. Any outstanding actions required to address TPR2 findings will be tracked through regulatory issues.

II Fuel fabrication facilities – Springfields Fuels Ltd

II-2.3.1 Types and scope of the fire safety analyses

Springfields Fuels Ltd's overarching requirements for the production and management of safety cases are set out in Springfields' 'Arrangements for compliance with licence Condition 14 – Safety Documentation' (primarily SSI350). These are underpinned by a range of further Site Safety Instructions, including SSI 917 [73], which govern the process of substantiating all systems structures and components with a safety-related role.

Springfields Fuels Ltd undertakes nuclear and chemotoxic fire hazard analysis in support of the Continued Operations Safety Report (COSR) process. It also considers the potential for fire as an initiator for faults elsewhere in the analysis, for example, fault sequences in the Radiological and Criticality HAZANs. Where Springfields Fuels Ltd considers that there is a significant potential consequence either to workers or the public, it assesses the effects of fire on engineered safety measures such as Safety Mechanisms (SMs) or Safety Features (SFs), to demonstrate that they are robust to fire and the contribution to risk is low.

Springfields Fuels Ltd does not assume the effects of severe natural phenomena, such as flooding and seismic events, to occur concurrent with a fire. In addition, Springfields Fuels Ltd does not consider seismically-induced fire specifically although it recognises that such hazards could occur in combination. The Springfields site is in a low seismic activity area and no specific seismic qualification is deemed necessary for general building structural elements, safety mechanisms, safety features or safety-related instrumentation and equipment. The drum store racking for enriched material is seismically qualified.

Internal Fire Hazards

Springfields Fuels Ltd defines internal fire hazards as those that originate both within a building or facility and within the Springfields site boundary external to the building or facility and include:

- Fire spread from buildings;
- Fires originating from vehicles operating on the site;
- Fire involving vegetation on site; and
- Normal process and maintenance activities.

The design of a building or an area within the Springfields site storing radiological or chemotoxic material typically includes structures, systems or components (SSCs) which perform safety functions. Some of these SSCs are essentially passive SFs such as shielding offered by concrete walls and bunds. Other SSCs are engineering measures which, in the event of a malfunction of the plant, intervene to mitigate or terminate the risk of radiation exposure to plant operators or the general public.

In certain circumstances, a malfunction of an SSC important to safety or the inability to implement a plant operating requirement (ORQ) may be the precursor to an off-site

radiological release above normal conditions. Such an event could cause failure of a deterministic safety feature or the simultaneous malfunction of multiple protection systems and potentially lead to a radiological release or radiation exposure. Fire or explosion can be one internal hazard, which could either directly or indirectly lead to such an event and prevent the safety/protection system from performing its safety function.

Springfields Fuels Ltd states that SSCs important to safety are where practicable designed and located to minimise the likelihood and effects of internal fires and explosions caused by internal events. It also states that, when assessing existing buildings, fire protection measures may need to be implemented retrospectively to protect these measures.

Springfields Fuels Ltd states that fire requirements are met by achieving an appropriate level of defence in depth, which is maintained throughout the lifetime of the plant by the suitable incorporation of redundant parts, diverse systems, physical separation, independence and/or design for failsafe operation, such that the following objectives are achieved:

- The probability of a fire starting is minimised by management controls of ignition sources and the use of non-flammable materials, and by minimising as far as practicable the quantity of combustible materials;
- Early detection of fires by means of an appropriate fire detection and alarm system allows early manual fire suppression using portable equipment or intervention by the site fire service;
- Structural stability of any buildings containing radiological materials in the event of fire is ensured by either inherent or applied fire resistance capable of withstanding the worst credible fire;
- Special fire risks (if any) are protected by appropriate localised fire suppression systems; and
- Those SSCs required to perform critical safety functions are protected such that fires will not prevent the safety function of the SSC from being carried out.

External fire hazards

Springfields Fuels Ltd states that external hazards are addressed in accordance with Westinghouse Safety Assessment Guidance [74]. External fire hazards include aircraft impact, lightning and fires originating off site.

Springfields Fuels Ltd does not assess external fire hazards as part of the nuclear fire hazard assessment but includes it in the external hazards assessment. Specific hazards associated with the Springfields site, which were assessed by Springfields Fuels Ltd as part of the external hazards assessment, include natural gas pipeline failure, ethylene pipe failure, hazards arising from the use of hydrogen tankers and hazards arising from aircraft movements around the Springfields site.

II-2.3.2 Key assumptions and methodologies

Springfields Fuels Ltd states that its fire hazard analyses are based on IAEA guidance [19] and [75] checked against ONR SAPs [15] and TAGs [16] and NFPA 801 [76]. It also states that no formal probabilistic fire hazard analysis is undertaken, although it notes that fire frequencies for electrical equipment (e.g., electrical cabinets) can be used in support of arguments in fire safety cases. Springfields Fuels Ltd uses frequency data derived from EPRI/NUREG documented sources [77] and states that no tools or models other than NUREG spreadsheets [78] and hand calculations are undertaken.

Springfields Fuels Ltd has no licensee-specific fire analysis guidance and confirmed that, for COSR reviews, F1.10 guidance produced by Sellafield Ltd. was initially used for the assessments. Springfields Fuels Ltd states that it has superseded this practice and it currently undertakes the reviews using IAEA guidance, ONR SAPs and TAGs.

Springfields Fuels Ltd states that SSCs/targets are identified through review of the relevant Radiological/Chemotoxic and Criticality HAZANs produced as part of the safety case. It also states that these assessments consider the radiological and criticality risks associated with faults which could result in a significant risk to the public or workforce when compared to company targets.

Springfields Fuels Ltd's practice is to compare each Fault Sequence Group in the assessments against company criteria and Design Basis Accident (DBA) analysis criteria. Springfields Fuels Ltd states that any fault with an Initiating Event frequency in excess of 10^{-5} per year and an unmitigated consequence in excess of 20mSv (on site) or 0.1mSv (aerial/off site) is subject to DBA. Where consequences of the fault sequence exceed company criteria, Springfields Fuels Ltd specifies Operating Rules and each would be supported by two suitable Safety Measures meeting company criteria. Where it identifies two safety measures, Springfields Fuels Ltd gives consideration to the potential for common cause failure due to fire. Where it identifies a single safety measure only, Springfields Fuels Ltd assumes that loss of the measure could be caused by initiators other than fire, such as mechanical damage or loss of power. Springfields Fuels Ltd applies an exception for chemotoxic consequences that could result in serious harm to workers or the public and where only one safety measure has been identified that requires a high degree of reliability. In those cases, Springfields Fuels Ltd considers the effects of failure of the single safety measure due to fire.

In general, Springfields Fuels Ltd assumes that SFs such as concrete, walls and bunds are robust items that are inherently reliable and that are not likely to be threatened by fire. It nevertheless states that such SFs are assessed during COSR reviews to confirm that they will still perform their safety function, for example, fire loads do not exceed the designated fire resistance and there are no penetrations that could be a route for fire or smoke spread.

Springfields Fuels Ltd states that damage or failure of safety measures such as safety mechanisms that comprise electrical cabling is assessed using NRC fire assessment guidance [79] for nuclear power stations, which provides vulnerability criteria for cables of both thermoplastic and thermosetting insulation type. Springfields Fuels Ltd determines other thresholds using publications such as an EPRI publication [80], which provides simplified fire hazard analysis methods developed as part of the risk-based fire-induced

vulnerability evaluation (FIVE) methodology for nuclear power plants. Springfields Fuels Ltd considers that these fire hazard analyses allow a conservative evaluation of the potential for credible exposure fires to cause critical damage to essential safe-shutdown equipment and thereby screen from further analysis spaces where a significant fire hazard does not exist.

Springfields Fuels Ltd has not used CFD models or zone models at the site, and takes a deterministic approach based on an adequate level of passive fire protection to contain the worst foreseeable fire. NUREG spreadsheets and hand calculations such as those in the SFPE handbook, 'Introduction to Fire Dynamics or Structural Eurocodes' are examples of methods used to calculate hazards such as pool fires and the effect of radiant heat flux on exposed equipment, building structures or inventories such as uranium hexafluoride (hex) cylinders.

Key sources of data are site-specific flammable inventories for pool fires and fire loading calculations for assessing structural fire resistance (e.g., structural steel and fire compartment boundaries).

Springfields Fuels Ltd does not generally quantify consequences from fires specifically. Instead, the potential for fire as an initiator for faults is considered elsewhere in the analysis to demonstrate the contribution to risk is low. Typically, worst case scenarios are considered, for example, tanks and vessels are assumed to contain 100% inventory. Calculations concerning hex cylinders and time to rupture assume a full cylinder.

Within the safety cases, Springfields Fuels Ltd uses a bespoke dispersion modelling model called ASTRA to determine doses to the most exposed individuals. This was originally developed for BNFL, but Springfields Fuels Ltd has a version specifically designed and underpinned with Springfields' site-specific meteorological data. It uses a methodology referred to as the R91 model. When scaling for specific releases rather than generic baselines, Springfields Fuels Ltd uses Release Fractions and Decontamination Factors from a database currently managed by Sellafield on behalf of the NDA.

Fire loading

Springfields Fuels Ltd carries out fire load quantification using the principles in BS EN 1991-1-2 Eurocode [81] and PD 6688-1-2: 2007 [82], which is the background paper to the UK National Annex to this standard.

The fire load represents the energy (measured in MJ) that can be released in a compartment as a result of a fire. The total fire load in a compartment is calculated by adding up the products of each combustible component mass and their calorific value. Typically, Springfields Fuels Ltd uses the Ingberg relationship for general area fire loads based on the standard time/temperature curve. Distributed and localised fire loads are calculated in accordance with NFPA 557 [83]. Springfields Fuels Ltd then establishes a fire load density (FLD) as the total fire load per square metre of the floor area (MJ/m^2).

Springfields Fuels Ltd determines the minimum periods of fire resistance for industrial buildings on the Springfields site in accordance with Table A1 of the AD(B) [84]. These requirements are based on post-war fire studies which refer to the fire grading of buildings according to the hazard and fire loading of the premises. This fire grading report

recommends a buildings fire loading be graded into low, moderate and high with fire resistances of <60 minutes, 60–120 minutes and 120–240 minutes, respectively.

The above figures produce a linear relationship between fire loading and fire resistance requirements. Springfields Fuels Ltd uses the figures to determine an equivalent fire duration in minutes for each area or room of a building and records them in a fire loading table.

Springfields Fuels Ltd uses engineering judgment to calculate the cable loading on trays and ladders based on the measured width of the ladder or tray, and a judgement is made on the percentage fill of the tray or ladder. Springfields Fuels Ltd also uses engineering judgement to estimate the fire loading in offices, as described below.

Springfields Fuels Ltd uses fire test data derived from a study by VTT of Finland [85] to calculate fire loading in electrical cubicles. In rooms with highly varied fire loads, a conservative addition of 10% may be used to account for potential inaccuracies in the calculations. If the figures obtained by this approach exceed structural fire resistance (e.g., that of main structural members or fire compartment boundaries), Springfields Fuels Ltd may undertake more detailed analysis to revisit some of the conservative assumptions and determine the approach to be taken. Such an approach may involve a reduction in fire loading or enhancements to passive protection or provision of fire suppression.

Springfields Fuels Ltd calculates fire loads in accordance with NFPA 557 [83]. Clause 5.4.1 as both localised and distributed fire loads, and then uses this information to assess local vulnerabilities. As an example, localised fire loads were considered as part of a study of cable risers and trays where they were near structural members. The original fire safety case for the building had not designated structural protection based on an assessment of low fire loading. In these areas it would have been impracticable to retrofit passive fire protection to the structural members. As a result of this study, cabling in areas where the steelwork was calculated to be vulnerable was coated with ablative paint to prevent fire spread.

Surveys of common combustible materials

Springfields Fuels Ltd states that a wide range of inventory items are commonly encountered in Springfields buildings. It states that many of such items were weighed and a specific combustible contribution in MJ was calculated for each item. For other ad hoc items, Springfields Fuels Ltd calculates the combustible load based on the material involved and a calculation of the weight of the specific item. Where it cannot calculate weight accurately (e.g., the item is too heavy to weigh or is fixed), Springfields Fuels Ltd makes a conservative estimate. Springfields Fuels Ltd uses data sources for common materials from references [29], [86], [87], [88], [89], [90], [91], and [83], as well as documented sources for weights of items such as manufacturers' information and published research.

Descriptions of specific methodologies for quantifying electrical cables, electrical cubicles and protected fire loads and office fire loads are provided in the Springfields self-assessment submission to the NAR [9].

Frequency of assessment

Springfields Fuels Ltd typically reviews the fire loading studies as part of the ten-year COSR review process. It states that a detailed study is only undertaken once as there tend to be few major building changes. However, if changes have occurred during the ten-year period, Springfields Fuels Ltd amends the fire loading studies. In general, once the quantitative assessment has been undertaken, Springfields Fuels Ltd's subsequent reviews are qualitative, to confirm that the assumptions remain valid.

Transient combustibles

Springfields Fuels Ltd typically assesses transient combustibles qualitatively through daily walk downs by fire nominated persons and plant management. Plant areas should be generally free from transient combustibles and any significant accumulations (assessed qualitatively) are required to be removed. Office/plant based walkdowns (SSI 638 [92] C and D) are completed within defined periods and fire risk assessments undertaken. Issues identified within the assessment are tracked via a fire actions database. Fire risk assessments are undertaken on a three yearly basis. Springfields Fuels Ltd states that there are limited laydown areas for timber scaffolding within plant areas and there is an expectation on site for the use of Euroclass C rated scaffold boards. Springfields Fuels Ltd assesses areas of high fire load identified during a COSR review or fire risk assessment and makes recommendations for removal of combustibles, uprating the fire resistance of the storage area and/or passive fire protection measures. It also states that, in some areas, measures are augmented by signage prohibiting combustible materials. Typically, Springfields Fuels Ltd allows a factor of 10% for uncertainty during the calculation of fire loads in areas with a wide range of materials, which accounts for the presence of transient combustibles. No derived limits on transient combustibles are calculated. Plant areas should be generally free from transient combustibles and any significant accumulations (assessed qualitatively) are required to be removed. Limits are typically communicated for nuclear fire safety in the first instance through Operating Requirements in the facility HAZANs, an example of which is given below.

Operating Requirement: The accumulation and use of combustible materials (paper, polythene, cardboard etc.) MUST be minimised, consistent with operational requirements.

Springfields Fuels Ltd states that there are regular management safety walkdowns which include housekeeping to ensure the Operating Requirement is met. It also notes that a global Corrective Action Programme (CAP) is raised to the appropriate building owner or business unit head where improvements to premises keeping is required, based on the subjective judgement of those undertaking the safety walkdowns.

CAP is Springfields Fuels Ltd's integrated process for identifying and prioritising issues that impact on compliance, customer confidence, product quality and cost-effective production. It allows each business to see the most important issues and ensures that practical and efficient corrective and preventive actions are implemented. CAP also supports improvement processes by promoting suggestions for improvement and sharing best practice. Springfields' internal, extrinsic and supplier audits, together with associated

findings, are also managed through CAP. Near misses, including those that could have led to a fire event, are also recorded using the CAP.

Limits are communicated to workers on a day-to-day basis by signage in certain areas prohibiting storage of combustible materials, toolbox talks and the CAP process.

Fire service intervention

Springfields Fuels Ltd does not claim intervention by site personnel such as operators in the analyses. On-site fire service intervention is claimed in nuclear fire safety assessments as part of defence in depth.

Springfields Fuels Ltd states that it requires use of non-hydrogenous firefighting agents in buildings where there is the potential for a criticality event. It provides 50 kg dry powder trolley units for site fire service use and does not expect the local authority fire service to be familiar with firefighting in criticality areas. Springfields Fuels Ltd provided the following example:

In the case of the OFC Building there is no structural fire protection of steelwork and the partitions used for fire compartmentation provide only 12 minutes insulation. The inherent fire resistance of unprotected steel is typically in the region of 10-15 minutes. Fire loading studies in OFC have quantified the fire loads and where these cannot be reduced e.g., on cable ladders ablative paint has been applied. Elsewhere there are restrictions on transient combustibles. Together with measures to protect steelwork and limit accumulation of transient combustibles, site fire service attendance is claimed in the safety case to extinguish fires, as part of defence in depth.

Off-site response

Springfields Fuels Ltd states that the Springfields Off-Site Emergency Plan was prepared by the Lancashire County Council (LCC) Emergency Planning Department in liaison with the Springfields Emergency Planning Team, further detailing that:

- The off-site plan covers the responses of all the organisations involved in mitigatory actions in the event of an on-site event or an event that has the potential to escalate, thereby threatening the general public and/or the environment in the vicinity of the site.
- No specific credit is taken in the nuclear fire safety cases for off-site response.
- Response times are not specifically quantified as all plant can be made safe by the plant operators or safety systems. There is no specific period over which any plant on the Springfields site would fail to an unsafe condition. Loss of ventilation, including as a result of fire, may result in a loss of containment; however, once restored and following confirmation by Health Physics, a building would typically be safe to re-enter.

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

A description of the site approach to modelling and fire hazard data is provided in Section II-2.3.2.

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

As stated within Section II-2.3.2, Springfields Fuels Ltd does not undertake formal probabilistic fire hazard analysis characterising the dominant hazards in a quantitative way. Assessments consider the radiological and criticality risks associated with faults that could result in a significant risk to the public or workforce when compared to company targets.

II-2.3.5 Periodic review and management of changes

Springfields Fuels Ltd states that all designs and modifications of nuclear plant are subjected to detailed safety reviews of the engineered systems and operating and maintenance procedures. When relevant, this extends to reviewing changes to organisational structures and resources. Springfields Fuels Ltd uses independent expertise to check major changes within a plant. A Nuclear Safety Committee (NSC) advises the Managing Director of SFL on all aspects of safety operations. At Springfields the NSC is known as the Springfields Environment Health and Safety Committee (SEHSC) and contains independent members, including a representative from another nuclear licensed site.

Springfields Fuels Ltd reviews conventional, nuclear and chemotoxic fire safety as part of the COSR process on a ten-yearly basis with recommendations delivered to plant management via the Management Safety Committee (MSC).

SSI 668A states that apart from conventional fire safety, there may be additional fire safety precautions identified (in the plant safety case) to ensure nuclear and chemotoxic safety in the event of fire. SSI 668A states that it is therefore important that modification proposals should consider nuclear and chemotoxic fire safety as well as conventional fire safety. In the same way, any fire risk assessments should consider any requirements for nuclear and chemotoxic fire safety identified in the safety case. Where necessary a check should be made against the safety case.

Springfields Fuels Ltd details the arrangements for plant modifications in a Springfield Site Instruction (Plant Modification Procedure – PMP). The main aims of the PMP are described in Springfields 'self-assessment submission for the NAR' [9]. The following are Springfields Fuels Ltd's expectations as provided in the self-assessment:

- There is a standard PMP form to be completed before any modification is implemented, which contains a checklist to prompt any possible effects on safety and safety case documentation. The modification proposal must be categorised in accordance with its potential effect on safety. This categorisation then determines the level of authorisation required for implementation, which ranges from the Site Managing Director down to the Plant Manager, and for higher category proposals some degree of regulator involvement. The latter are also reviewed for approval by the SEHSC. All proposals

except the most minor are put before the relevant Management Safety Committee for endorsement.

- SSI 668A states that apart from conventional fire safety, there may be additional fire safety precautions identified (in the plant safety case) to ensure nuclear and chemotoxic safety in the event of fire. SSI 668A states that it is therefore important that modification proposals should consider nuclear and chemotoxic fire safety as well as conventional fire safety. In the same way, any fire risk assessments should consider any requirements for nuclear and chemotoxic fire safety identified in the safety case. Where necessary a check should be made against the safety case.
- Plant modification proposals which affect fire safety in an existing building, temporary accommodation or decommissioning area must be reviewed by the Core Fire Nominated Person/Building Fire Nominated Person and must be submitted to the Fire Safety Manager for vetting and approval prior to implementation. Such modifications could include changes to building structures, internal layouts, fire separating and compartment boundaries and surface finishes (cladding, penetrations, etc.), fire notices, emergency lighting, fire exits, fire assembly areas, firefighting equipment, fire alarm systems, temporary accommodation (including contractors' accommodation), significant changes in occupancy (i.e., manning levels or in silent hours), and introduction of or significant increase in the use of flammable materials.

Springfields Fuels Ltd has a ten-year rolling programme for the Periodic Review of all safety cases across the Springfields site, which is owned by the Springfields Safety Case Manager, monitored by the SEHSC (the Springfields arrangement for LC 13, Nuclear Safety Committee) and shared with ONR. Every ten years, a facility with a nuclear or chemotoxic safety case undertakes a review of nuclear and chemotoxic safety and presents that review in the form of a Continued Operations Safety Case (COSC), which may be shared with ONR on request. The purpose of the review is to provide ongoing confidence that operations will continue to be adequately safe and risks are managed to be ALARP in order to justify continued operations for a timescale that is appropriate for that facility.

Springfields Fuels Ltd states that fire hazard calculations, if appropriate, are reviewed at the time of the ten-yearly COSR review. It also states that HAZANs are reviewed for changes affecting the consequences of fault sequences and, if consequences to workers or the public have increased or additional fault sequence groups have been added, further analysis of the potential for fire is undertaken.

Springfields Fuels Ltd states that, further to the ten-yearly Long Term Periodic Review cycle, all safety cases are also reviewed during their period of validity at a frequency appropriate to the complexity of the safety case and the magnitude of the associated hazard. These interim reviews include specific consideration of the cumulative impact of plant modifications and operating experience upon the underpinning safety assessments (including those for fire safety), so any emerging issues of concern may be identified and addressed as early as practicable.

The formal review processes are in addition to the routine monitoring of individual plant modifications for fire safety implications. Should a modification that would materially affect

the nuclear fire safety analysis be proposed, actions to update that analysis would be specified and require completion before the modification is implemented.

Springfields Fuels Ltd undertakes separate fire hazard analysis of the plant for significant changes, for example, as part of the EURRP Reconfiguration Project, for which a separate Nuclear and Chemotoxic Fire Safety Assessment addendum report was produced. Springfields Fuels Ltd incorporated this separate analysis into the continued operation safety case as part of the COSR process at the time of the periodic COSR review. Springfields Fuels Ltd states that all changes to plant are considered as part of the PMP process and, if not significantly major to warrant a separate standalone report, they are recorded and reviewed as part of the COSR process.

II-2.3.5.1. Overview of actions

A description of the site Fire Actions Database and examples of typical actions is provided within Section C-II-3.1.2.

II-2.3.5.2. Implementation status of modifications/changes

Springfields Fuels Ltd did not identify specific current modifications relevant to nuclear fire safety. Examples of modifications made by Springfields as a result of fire events are provided in Section I-2.3.6.2.

II-2.3.6 Licensee's experience of fire safety analyses

II-2.3.6.1. Overview of strengths and weaknesses identified

Springfields Fuels Ltd did not identify specific strengths and weaknesses. However, examples of weaknesses identified following fire events or other missions and associated corrective actions are provided in Section I-2.3.6.2.

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

Springfields Fuels Ltd states that, in accordance with SSI 212 [93], all accidents, near misses or abnormal occurrences must be reported to a line manager, supervisor, visit host or Superintending Officer, who will onward report to the Shift Plant Manager. It also states that all accidents must be recorded using the Accident Report Form 5155C, as per SSI 234 [94].

The Shift Plant Manager will provisionally decide whether the occurrence constitutes an event. The Shift Plant will record the event in the Shift Plant Manager's Logbook and in the EH&S Event file. The Shift Plant Manager will determine a provisional severity based on Appendix 1 of SSI 212. Fire or explosion would be a Category A2 as follows:

...any explosion or outbreak of fire on a licensed site, being an explosion or outbreak affecting or likely to affect the safe working or safe condition of a nuclear installation.

Appendix 1 requires external reporting for fire and explosion events.

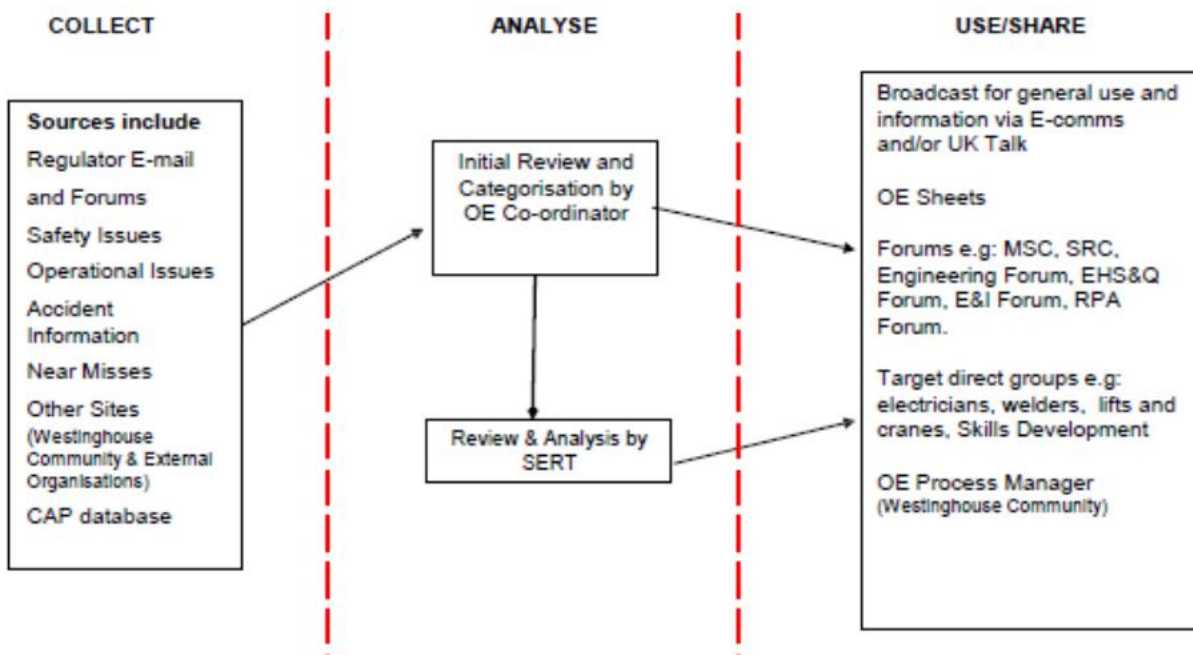
The Environmental Health Safety & Quality (EHS&Q) Director (or nominated Deputy) will determine whether an event is reportable to any of the regulatory authorities based on the following guidance: [95], [96], [97] and [98].

Springfields Fuels Ltd states that there is a daily EHS&Q review meeting where all events are discussed along with whether a Corrective Action Programme (CAP) should be raised. It also noted that all events raised on CAPs are reviewed by the appropriate Issue Review Committee. They are assigned a significance level with any required analysis and managed in accordance with the requirements of SSI 696 (which is a signpost to W2-5.1-101, 'Westinghouse Corrective Action Program Procedure', and associated procedures).

Operational experience

Operational experience (OE) is covered in SSI 212C [93]. Springfields Fuels Ltd provided the flow chart in Figure 4 below, taken from SSI 212C, to give an overview of the process.

Figure 4: Overview of Springfields Fuels Ltd OE Process



Springfields Fuels Ltd reports that there have been no significant recent fire events and provided information on some historical fire events which are reproduced in turn below.

Fume cupboard fire

In 2000 a fire occurred in a laboratory fume cupboard during a material fusion process (not involving nuclear material) carried out using a standalone burner supplied with propane and compressed air. The fusion process was undertaken in a crucible held in tongs over a flame by an operator.

As a result of the incident, Springfields Fuels Ltd undertook a fire risk assessment of all fume cupboards where fusion processes took place and made a recommendation that the duct leading from one of the cupboards was cleaned of oil residues and that future work be

carried out in a fume cupboard with the scrubber operational. Other recommendations made included improvements to the control of transient combustibles, the method of igniting the burner and fitting of ventilation low flow alarms. This process is no longer undertaken on the Springfields site.

Vibrating table powder feeder fire

In February 2000 a fire occurred involving a vibrating table powder feeder. Following examination of the remaining components of the powder feeder and tests, Springfields Fuels Ltd concluded that the fire was the result of an electrical defect affecting the incoming electrical supply cable.

As the unit had been designed to operate under a nitrogen inert atmosphere, Springfields Fuels Ltd concluded that sufficient oxygen must have been present to allow the fire to develop to the extent that it breached the containment of an acrylic sight glass. Springfields Fuels Ltd established that an air atmosphere could have been possible within the confines of the neoprene seal where the electrical supply cable was connected to a solenoid vibrator. There was no monitoring of the nitrogen environment within the transfer system this equipment was a part of.

Springfields Fuels Ltd made the following recommendations following the fire:

- Residual Current Device (RCD) protection to be provided;
- Consideration to be given to using components within the powder feeder that will not support fire propagation;
- A suitable gland to be fitted to the cable where it passed through the table base to prevent damage to the cable caused by vibration;
- Consideration to be given to continual oxygen monitoring; and
- The design of the powder feeder to be modified to allow nitrogen into the inner area containing the solenoid.

Electrical cubicle fire

In July 2000 a fire occurred in an electrical cubicle in a switch room of a building. The fire occurred in a tier of cubicles. The bottom cubicle in which the fire originated served the general building input ventilation fan. The fire was detected by the fire detection system in the switch room. The point of origin was at a connection into a contactor. The cause was a slack connection that resulted in resistive heating and ultimately led to arcing and combustible cable insulation in the cubicle igniting.

Springfields Fuels Ltd listed the following recommendations:

- Connections to be periodically checked to confirm that they are tight;
- Consideration be given to firestopping open cable penetrations between cubicles and at the top of cubicles to prevent fire spread in the event of fire; and

- Procedures for fighting electrical cubicle fires to be reviewed in the knowledge of the significant number of carbon dioxide extinguishers required to control the fire and their availability within the building.

Shredder fire

In April 2006 a fire occurred due to ignition of oil mist in a shredder ignited by sparks due to rapid oxidation of depleted uranium (DU) swarf during shredding. Springfields Fuels Ltd reports that the swarf had been exposed to atmospheric oxygen due to failure or reduced flow of coolant oil. The Risk Analysis Process (PMPs and Risk Assessments) did not identify the fire hazard. Springfields Fuels Ltd recognises that it was possible that other equipment on the Springfields site may be generating oil mists and undertook a review. Springfields Fuels Ltd's reported learning included the acknowledgement that safety cases needed to consider the possibility of oil mists, in the same way as explosion hazards are considered. It raised an action so that, prior to processing operations, a search should be performed of all possible information to identify details and hazards, in particular for historic residues which may have fire risks associated with them that are poorly recorded.

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

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

Strengths

Fire safety analysis methodology

The licensee has identified recognised and relevant standards as the basis of its fire safety analysis. This includes IAEA SSR-4 [19] which contains specific requirements for fire hazard assessment in fuel cycle facilities. This IAEA standard is aligned with ONR's Technical Assessment Guide on Internal Hazards [16]. The licensee's consideration of fire frequencies, utilising guidance from the United States Nuclear Regulatory Commission (US NRC) and the Electric Power Research Institute (EPRI) [78] [77] [80], provides confidence that input data used to derive fire hazard consequences is adequately verified and validated.

The licensee also reported that it completes fire loading surveys on a compartment-by-compartment basis and that it uses the collected data to determine the required integrity rating of compartment lines. The licensee also reported that there are established requirements for the surveying and quantification of different types of combustible loads to ensure that compartmentation is adequately implemented. The approach is in line with the expectations of the ONR Technical Assessment Guide on Internal Hazards [16].

Weaknesses

Combined and consequential hazards

The licensee identified that it does not undertake combined or consequential hazards assessment as part of the current site safety case. This does not explicitly align with WENRA Safety Reference Level E 6.1 [1] or IAEA SSG 64 [17]; however, it should be

noted that these apply to reactor facilities and therefore a graded approach should be considered in the context of the Springfields site and low nuclear safety hazards and risks. Nevertheless, ONR Safety Assessment Principles [15] and Technical Assessment Guide on Internal Hazards [16] take due account of WENRA SRLs, and IAEA standards are applicable to fuel fabrication facilities as well as reactor facilities. ONR therefore concluded that it would be appropriate for Springfields Fuels Ltd to develop and apply a suitable methodology for considering combined and consequential hazard analysis proportionate to the site's hazards and risks. ONR raised this finding with the licensee, which provided further information:

Combined hazards such as fire combined with flooding or fire post seismic event are considered as part of the safety case process. The nuclear fire hazard analysis assesses each fault sequence group in the Criticality, Radiological and Chemotoxic HAZANs, including internal and external hazards, to determine whether the fault sequence could result in a consequential fire or if fire could increase the associated risk. Such nuclear fire analysis has been conducted for all legacy plant and no further improvements to the design are required. This position is reviewed at each Long-Term Periodic Review (conducted to meet the requirements of LC15) and whenever a substantive modification is made to a plant or facility.

There are no water-based suppression systems that could result in flooding. The site is not prone to flooding. All processes on site can be shut down and do not require ongoing power supplies, cooling, or other services to maintain nuclear safety. For new builds, cognisance is taken of guidance given in the ONR TAGs and SAPs. In the event that the site embarks on a significant programme of new facilities consideration will be given to developing a specific methodology for fire hazard analysis of combined events taking into consideration guidance given in IAEA Safety Standards Series no. SSG-64 [17].

The existing on-site hazards are such that there is no requirement for seismic qualification of fire suppression systems. No suppression systems are required to ensure nuclear or chemotoxic safety. There are no suppression systems that if operated due to planned or inadvertent discharge would result in a radiological release. The only automatic systems are total flooding carbon dioxide suppression systems for protection of turbine enclosures in the CHP plant. The operation of these would be in response to a fire within the turbine enclosure and is for conventional fire safety/business continuity purposes only.

ONR welcomes that the licensee recognises the need to consider combined hazards as part of its suite of fire safety analysis and formalising the approach. ONR therefore recommends that Springfields Fuels Ltd reviews and makes any necessary improvements to its treatment of combined hazards, for example, by formalising a suitable methodology for assessment of combined hazards including fire proportionate to the site's hazards and risks.

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

ONR's regulatory approach as described in Section II-2.3.6.5 applies to Springfields Fuels Ltd. ONR has undertaken multiple fire safety inspections at the site (2021, 2019, 2017 and 2016), focused on life fire safety due to the site's risk profiles. These inspections resulted in three regulatory issues at level 4 (lowest level) which have all since been adequately addressed and closed out. These issues related to housekeeping, the implementation of suitable fire alarm and detection for life safety purposes and fire safety management with respect to FRA findings. A combined nuclear fire safety/life fire safety inspection is planned for 2023.

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

ONR concluded that Springfields Fuels Ltd developed and applies an adequate fire safety analysis process which implements relevant standards and guidance. The fire safety analysis relies on engineering judgement and hand calculations, but also assesses fire loadings quantitatively. ONR judges that this is proportionate to the facilities' radiological hazards and risks and aligned with ONR expectations in the SAPs and TAGs. ONR has nevertheless identified an area of improvement for Springfields Fuels Ltd relating to the assessment of combined and consequential hazards: the development, formalisation and application of a suitable methodology for assessment of combined hazards, including fire, proportionate to the site's hazards and risks. The licensee has recognised the gap and ONR will monitor progress to completion. A combined nuclear fire safety and life fire safety inspection is planned at the Springfields site for early 2024 which will examine the linkage between the nuclear fire safety case and implementation of fire safety measures, including any identified hazard combinations. Any outstanding actions required to address TPR2 findings will be tracked through regulatory issues.

2.4. Dedicated spent fuel storage facilities

Dedicated spent fuel facilities on reactor sites are reported in Section 2.1. Spent fuel management facilities at Sellafield are reported in Section 2.5.

2.5. Waste storage facilities

I Sellafield facilities

The text in this section of the report has been prepared by Sellafield Ltd, with minor changes for conciseness and clarity made by ONR. To avoid duplication, all Sellafield Ltd. facilities, including waste processing and decommissioning facilities, are reported in this section.

I-2.5.1 Types and scope of the fire safety analyses

I-2.5.1.1. Principles

Sellafield Ltd. states that a Nuclear Fire Safety Analysis (NFSA) applies to all facilities that require a nuclear safety case and to all phases of the plant/facility life cycle, from design through to decommissioning and returning the site back to the land's original state as required by UK legislation and the Nuclear Site License.

Sellafield Ltd. reports that the Safety Case Process and Methods Technical Guidance on NFSA [99] is proportionate to the radiological risks within the plant being assessed and offers a variety of methods and approaches for undertaking such assessments. The guide requires that an assessment of all fault sequences identified in supporting documentation, such as Radiological Safety Assessments (and Criticality Assessments if applicable), is carried out in an NFSA to ascertain whether fire could credibly impact upon them. The main points considered by Sellafield Ltd. are:

- Can a fire event prevent the identified Safety Measures from completing their Safety Function?
- Could a fire event initiate the fault sequence and if so, are there any common failures, i.e., can the fire initiate the fault sequence whilst disabling the associated Safety Measures?
- If the fault sequence exceeds Design Basis Accident Analysis (DBAA) threshold bands, could a fire event increase the Initiating Event Frequency (IEF) of the fault sequence, such that a DBAA threshold band is exceeded?
- If the fault sequence does not exceed DBAA threshold bands, could a fire event increase the radiological consequences of the fault sequence, such that it moves the fault sequence into a higher DBA region, i.e. DB1 to DB2?

The Nuclear Fire Safety Analyses assess the potential for fire as an initiator for faults considered elsewhere in the Nuclear Safety Case, for example, fault sequences in the Radiological and Criticality HAZANs. Where there is a significant consequence either to workers or the public, the effects of fire on safety measures such as Safety Mechanisms (SM) or Safety Features (SF) is assessed, and control measures provided where necessary to demonstrate they are robust to fire and the contribution to risk is tolerable.

The guide requires an assessment of Safety Function Classes (SFC) offering a normal operational safety function. Sellafield Ltd. states that the implementation of provisions for conventional fire safety purposes helps reduce the risk of fire leading to an unsafe radiological condition by offering a level of defence in depth between ignition of a fire and an unacceptable radiological consequence. Within this context, and for Sellafield Ltd, conventional fire safety relates to life safety, loss prevention for property and business continuity protection, and the general reduction of fire hazards.

Sellafield Ltd.'s key fire protection principles include:

- Reducing the potential for ignition through control of the types of materials used in the construction of the building (selection of non-combustible materials where reasonably practicable, or fire-resisting/flame-retardant alternatives), and, where possible, appropriate selection of services and equipment;
- Appropriate control of transient combustible material and ignition sources;
- Preventing fire spread or structural failure, which may threaten radiological materials, with the use of fire compartmentation and/or passive fire protection of primary structural steelwork (this also allows any multi-channel safety systems to be segregated by fire resistant barriers or fire compartments);
- Provisions for means of escape to allow people in the building to evacuate as early as possible (primarily for conventional fire safety, but also supports nuclear fire safety), especially when coupled with an automatic fire detection and alarm system and automatic link to the fire station and therefore earliest intervention by the Sellafield Ltd. Fire and Rescue Service (SF&RS); and
- Facilities provided for SF&RS, such as firefighting shafts, dry risers and private fire hydrants for firefighting water supplies.

I-2.5.1.2. Plant specific example – BEPPS-DIF

The BEPPS-DIF plant is a recent example where the Nuclear Fire Safety Analysis process detailed above was followed. Sellafield Ltd. conducted a Nuclear Fire Collaborative Review (NFCR), the purpose of which is for the various disciplines involved in the project to assess the impact of a fire on the main plant items and systems that may be relied on in the building design to maintain the radiological safety of the plant. The review uses keywords related to nuclear fire and its effects to prompt discussion of the design features and determine whether there are any issues arising from the impact of fire, smoke, hot gases, heat or firefighting extinguishants. The review identifies fire requirements such as nuclear fire compartments/barriers and passive fire protection of SSCs.

Sellafield Ltd. reports that the NFCR was carried out based on the fault sequence groups for the BEPPS-DIF project, but other fire scenarios and various fire effects considered appropriate by competent fire engineers were included. The discussions within the review included potential impact on SSC, and any conclusions relating to the potential nuclear consequences of failure of those SSCs or the impact of fire on them have been used as the basis of the nuclear fire analysis.

Sellafield Ltd. performed a hazard identification and familiarisation exercise of the plant and processes as part of the NFCR and this allows an appreciation of the Baseline Nuclear Safety Case to be made, such that further nuclear fire assessment of the vulnerability of significant elements to fire can be completed and recorded.

The NFSA for BEPPS-DIF includes a review of conventional fire engineering provisions both passive, active and managerial controls, assessment of potentially high consequence faults determined from the hazard identification process within the HAZANs for example, Radiological and Criticality Safety HAZANs, and a review of process description and normal SSCs considered important to the Radiological Safety of the building, which are taken from the Engineering Schedule (ES). From the review of the Radiological HAZANs for BEPPS-DIF and from the discussions held in the NFCR, Sellafield Ltd. established an understanding of the basis of safety for these operations and the consequences of various faults. This then allowed the Nuclear Fire Safety Analysis to be completed for fire scenarios that may impact upon the measures and SSCs that are deemed important to the radiological safety associated with BEPPS-DIF.

I-2.5.1.3. Combined hazards

Internal and external hazard definitions

Sellafield Ltd. defines an internal hazard as “a hazard generated within a facility outside of the facility’s process that could affect either its SSCs or its operational measures and that is within the control of the facility, including (but not limited to) flooding, missiles”. Sellafield Ltd. considers that this includes hazards identified in IAEA SSR-4 [19].

Sellafield Ltd. considers fire as an internal hazard with bespoke assessment arrangements as detailed in Nuclear Safety Case Process and Methods Technical Guidance [99]. The Nuclear Fire Safety Analysis considers fire hazards arising within the boundary (or battery) limits of a facility that have the potential to harm the facility or to jeopardise normal safe conditions.

External hazards are considered by Sellafield Ltd. to be natural or man-made hazards (fires and explosions) originating externally to the site and its processes whereby Sellafield Ltd. has very little or no control over the initiating event. Examples of external hazards considered by Sellafield Ltd. are in line with IAEA SSR-4 (Requirement 16) and include (but are not limited to) aircraft crashes, fires originating off site, seismic events and flooding [19].

In addition to the above definition of an external hazard, all hazards external to the boundary limits are to be considered as an external hazard (e.g., vehicle fires external to the boundary limits), with the exception of those safety measures or fault SSCs that fall within the boundary limits of a different plant (located either upstream or downstream) upon which a claim has been made.

Sellafield Ltd. has Nuclear Safety Case Process and Methods Technical Guidance on how to undertake an external hazard analysis. Individual plant nuclear safety cases contain an external hazard analysis and there is also a holistic site wide external hazard analysis.

Fault Combinations and Consequential Hazards

To ensure fault combinations and consequential hazards are understood and protected against, Sellafield Ltd. states that it undertakes robust hazard identification (ID) using a number of different techniques as appropriate and proportionate to the risk, particularly Hazard and Operability Studies (HAZOP) and internal hazards walkdowns which prompt the consideration of 'domino' and coincident events [100].

An internal hazards walkdown (or desktop study if a walkdown is not possible) is defined by Sellafield Ltd. as a systematic hazard ID study of potential hazards in a facility, but outside of the facilities process, which can challenge the SSCs providing nuclear safety in that facility. However, Sellafield Ltd. carries out detailed analysis of the significance and magnitude of the consequences that may be derived from these faults as a separate exercise. This analysis is presented in the HAZANs, which consider the range of faults applicable to new or modified operations and where the safeguards applicable to the faults are identified. Where Sellafield Ltd. considers that a combination of faults and conditions is required for a significant radiological release, it highlights this in the HAZAN and then takes it into account in the fault sequence frequency and risk assessment.

Sellafield Ltd.'s process for assessing identified hazards and faults is in a Nuclear Safety Case Process and Methods Technical Guidance. The guidance requires a consideration of the level of independence and defence in depth of the safety measures, ensuring they are not overly susceptible to common cause failures and coincident failure modes and identifying where this may be the case. For example, loss of power may prompt the requirement for a non-interruptible power supply.

Specific specialist nuclear safety assessments are used where coincident failures or domino effects may be more likely, for example, Construction Crane Assessments or Loss of Service Assessments (either a bespoke assessment or incorporated into existing assessments). Sellafield Ltd. considers leaks from process water damaging power supply leading to fire, nuclear fire (for example seismically induced fires) and external hazards combinations (for example aircraft crash resulting in fires, adverse weather e.g. flooding resulting in fires, among others). The detailed specific analyses provide further confidence that the Hazard Management Strategies (HMS) identified in the safety case are robust to other hazards, or combinations of hazards, which originate outside of the primary process of a particular facility.

The assessment reviews possible effects of fire on safety equipment. This includes confirming that the fire loading in each room is as previously documented and remains valid when taking into account factors such as housekeeping, modifications and changes of use. This also confirms that all hazards identified have been addressed in the NFSA. The NFSA also assesses the effect of fire on nuclear safety.

Sellafield Ltd. is currently updating the NFSA Safety Case Process and Methods Technical Guidance methodology (financial year 2023-24). The newly updated NFSA methodology (awaiting internal approval) provides improved specific guidance to ensure appropriate advice is given for the systematic identification and screening of combined and consequential hazards.

I-2.5.1.4. Probabilistic analysis

The NFSA Nuclear Safety Case Process and Methods Technical Guidance provides direction on the application of Probabilistic Safety Assessment (PSA) tools. Probabilistic, risk-based arguments articulate the level of fire risk, which is integral for the NFSA, and where required form part of a holistic ALARP argument.

Sellafield Ltd. establishes the consequences of a fire using fire engineering calculations, fire modelling or through the application of fire engineering judgement and presents them qualitatively, quantitatively or through a combination of the two.

Sellafield Ltd. states that the likelihood of the consequences being realised can be demonstrated both quantitatively (probabilistic study), qualitatively and semi-qualitatively. Probabilistic assessment is a fundamental tool for radiological safety assessment; however, due to a lack of validated statistical data it has not been used extensively for NFSA of Sellafield Ltd. facilities. If the NFSA identifies probabilistic assessment as the most appropriate methodology, Sellafield Ltd. judges that the decision falls under the remit of High-Level Engineering Judgement and should therefore be subject to the rigorous levels of peer review. Sellafield Ltd. states that it is more common for it to express the likelihood qualitatively and that it applies a number of techniques, for example:

- Barrier analysis;
- Defence in depth arguments; and
- Fault analysis.

Sellafield Ltd. considers that the techniques present a means to demonstrate what needs to occur for the consequence to be realised and can ultimately support qualitative risk techniques such as a Qualitative Risk Matrix.

Sellafield Ltd. has used probabilistic techniques to assess the impact of potential vehicle fires on nuclear inventory and SSCs. A method is described in Sellafield Ltd.'s Safety Case and Process Methods Technical Guidance on Transporters Fire Generic Risk Profile [101]. The risk associated with vehicle fires is a common consideration within nuclear fire safety assessment and there is internal guidance detailing the fire risk profile of transporters. The document does not place this risk within the context of nuclear safety (i.e., account for the impact on and consequence associated with any nuclear material being transported). However, it does provide a referenceable baseline from which further, context-specific detailed nuclear fire hazard analysis can be undertaken.

In addition, the Sellafield Ltd. NFSA process also utilises data on the probability of electrical fire risks to provide guidance to assessors on how to evaluate electrical fire risks that could affect nuclear safety, and this is presented in Nuclear Safety Case Process and Methods Technical Manual as Nuclear Fire Guidance for the Assessment of Electrical Items [102].

This provides guidance on the undertaking of qualitative nuclear fire safety assessment of electrical items (cables, electrical panels, switchgear and transformers). Sellafield Ltd. considers that it also provides evidence to support removal of non-credible electrical faults

for a proportionate, streamlined NFSA and to improve consistency between assessments, demonstrating mitigation of electrical fire risks through existing engineering safety management system arrangements. Sellafield Ltd. has a supporting document to the above guidance, covering the risk and probability of ignition and propagation for common electrical equipment, to support the undertaking of risk-based analysis. Sellafield Ltd. states that this level of consideration will not necessarily be required if the safety measures are proven to be deterministically safe. The technical guidance has been shared within the UK Nuclear Industry through the Nuclear Industry Fire Safety Co-ordinating Committee (NIFSCC) to promote learning and to share relevant good practice within the industry.

I-2.5.2 Key assumptions and methodologies

I-2.5.2.1. Guidance, relevant good practice and legislation

Sellafield Ltd. produces Mandatory Standards for various topic areas such as Fire Protection, which identify obligations placed on Sellafield with respect to Fire Protection and specifically nuclear fire hazard analyses. The Nuclear Safety Cases mandatory standard outlines what Sellafield are obliged to do, in relation to the requirement to develop and implement Nuclear Safety Cases in support of Sellafield Ltd. endeavours, and what we will do to meet their obligations. These standards refer to (not exclusively):

- Legislation, e.g., Nuclear Installations Act 1964 [103], Regulatory Reform (Fire Safety) Order 2005 [20], Building Regulations;
- Nuclear Site Licence Conditions;
- IAEA Standards, e.g., Specific Safety Requirements No. SSR-4 [19];
- WANO Performance Objectives & Criteria [104]; and
- Industry standards and relevant Good Practice such as WENRA Safety Reference levels.

Nuclear fire safety analyses are based on UK legislative requirements and codes of practice, International Atomic Energy Authority (IAEA)/World Association of Nuclear Operators (WANO) standards and guidance, and associated British and European Standards and relevant good practice (RGP).

Requirements linking back to obligations outlined in the Mandatory Standards are detailed in the Nuclear Safety Case suite of documents within the SLMS (Nuclear Safety Cases Manual and Sellafield Ltd. Practices).

In addition, there is an extensive suite of supporting 'how to' guidance, including those for assessing nuclear fire risks. These guides cover topics such as risk profiles of transporters and a relevant good practice note on roofing system fire requirements.

Fire analyses specifically are undertaken by Sellafield Ltd. through application of the supporting Nuclear Safety Case Process and Methods suite of Nuclear Fire Analysis Technical Guidance.

The Sellafield Ltd. Technical Guides are applied by Sellafield Ltd.'s nuclear fire engineers, deemed SQEP to undertake such analyses for all nuclear facilities where applicable. Sellafield Ltd. expects application of relevant good practice as part of the process.

Sellafield Ltd. reports that it continues to update internal standards and processes in line with updates to relevant good practice, changes to national and international standards and UK legislation.

As part of the assessment process Sellafield Ltd. expects its Fire Engineer to apply relevant good practice to support production of the Safety Case Fire Analyses. In addition to the IAEA Standards and WANO Performance Objectives and Criteria (PO&Cs), Sellafield Ltd. NFSAs utilise British Standards, British Standard European Norms, trade association and regulator guidance including ONR SAPs [15] and ONR TAGs. Sellafield Ltd. also has established practices for engineering design to promote the delivery of safe design solutions, and it reports that these are based on ONR SAPs [15]. Sellafield Ltd. also reports that it applies mandatory Engineering Design Safety Principles (EDSPs) that include nuclear fire requirements.

I-2.5.2.2. Fire loading assessment

Approach

Sellafield Ltd. assesses fire loads (fixed and transient) according to the building lifecycle stage, for example, at design stage, operational stage, decommissioning stage or care and maintenance stage. Where there are threats to fire compartments, SSCs for nuclear safety, or nuclear inventory, Sellafield Ltd. assesses the fire loads qualitatively and/or quantitatively in the conventional fire analysis and fire safety strategy (for a new building design), and as part of the fire analyses (for the safety case of all types of nuclear facilities, as per the safety case manual previously described).

Sellafield Ltd. reports that fire load data is updated periodically in line with the safety case periodic review programme required by the Nuclear Site Licence. When there are plant modifications or changes, depending on the significance, this can be either quantitative or qualitative. Fire loads are also considered qualitatively as part of the fire risk assessment process for compliance with Regulatory Reform (Fire Safety) Order 2005 for life fire safety.

Sellafield Ltd. has a Nuclear Safety Case Process and Methods Manual and a programme for the production of new technical guides. Sellafield Ltd. reports that a technical guide on the process of how to undertake a fire load assessment is planned for development in Financial Year 2023/2024. This is to include a suite of tools to enable relevant stakeholders to undertake fire load assessments to manage and control the risks site-wide.

Sellafield Ltd. reports that fire load assessments are generally carried out in accordance with the principles in BS EN 1991-1-2 Eurocode 1 [81] and PD 6688-1-2: 2007 [105]. Sellafield Ltd. uses "Fire loads applicable to new builds on Sellafield Site" [106], a report by BNFL Engineering, as a standard reference point based on published data and fire load studies carried out on Sellafield new build projects. The requirements are based on early post war fire studies which refer to the fire grading of buildings according to the hazard and

fire loading of the premises. The report recommends that buildings should be graded into three categories of fire load:

1. **Low fire loads**, where the combustible contents do not exceed on average 1100 MJ/m² (equivalent to approximately 60 kg/m² of wood) of net floor area. This equates to a fire resistance period of up to one hour in the standard fire test in BS EN 1991-1-2 [81];
2. **Moderate fire loads**, where the combustible content lies between 1100 MJ/m² and 2200 MJ/m² (i.e. between one and two hours fire resistance); and
3. **High fire loads**, where the combustible content lies between 2200 MJ/m² and 4400 MJ/m² (i.e. between two and four hours fire resistance).

Sellafield Ltd. derives the total fire load in MJ/m² for each room and area by dividing the total fire load by the area of the room. Sellafield Ltd. states that the figures produce a linear relationship between fire loading and fire resistance requirements, and using the Ingberg correlation, it provides the fire resistance equivalence. Sellafield Ltd. uses the figure to determine an equivalent fire duration in minutes for each area and room of a building and records it in a fire loading table, which is referenced in the safety case.

Data sources

Sellafield Ltd. reports that a supply chain fire engineering company (RPS) [107] with Sellafield Ltd. has developed a fire loading calculation tool, and that the tool includes a methodology and data sources for calculating fire loadings arising from electrical cabinets, cable trays and other common items.

Sellafield Ltd. states that several data sources are utilised to quantify fire loading, in addition to the RPS fire loading calculation tool. These include fire data in terms of calorific values and heat release rates. Sources of fire science data for materials used in nuclear facilities also include publications such as An Introduction to Fire Dynamics, The Society of Fire Protection Engineers (SFPE) Handbook [28], The Ignition Handbook [87] and National Fire Protection Association (NFPA) 557 [83].

Electrical Cabinet and Cable Tray Example

Methodology (Electrical Cabinet)

Sellafield Ltd. takes the information for calculating the fire load density of an electrical cabinet from 'Full scale fire experiments on electrical cabinets II' [108]. This reference reports tests conducted on electrical cabinets, with two of the tests leading to a complete burn. Sellafield Ltd. reports that it takes the results from experiment one, as this provides a higher fire load density value, allowing a 'worst case' approach. To calculate the fire load density, two values are required: the volume of the cabinet and the total energy released in combustion.

Sellafield Ltd. states that, in many cases, the figures used for electrical cabinets are conservative as many cubicles will contain less combustible fire loading than the figures used in the VTT Technical Research Centre of Finland Ltd fire tests [108] for electrical panels.

Methodology (Cable Tray)

Sellafield Ltd. reports that a few assumptions are needed to calculate the fire load of a cable tray unless specific cable data is available (as may be the case in new build facilities). From Sellafield Ltd.'s experience, detailed cable data is typically not available for older facilities; the following section presents the methodology followed to determine a generic fire load value for cable trays.

Sellafield Ltd. states that the first assumption is the cable material, assumed to be XLPE (cross-linked polyethylene) as this is a common insulation type giving a pessimistic fire load. The value for the energy density of XLPE cable was taken from 'ESBWR Design Control Document', section 9B.5.3 [109] and the energy per unit volume calculated from the energy density and the mass density values. Sellafield Ltd. then multiplies by a factor of 0.8 to take into account the cross section of the cable inside the cable tray as a circle instead of a square or rectangle. The true reduction factor is 0.785, but 0.8 is used to give a slightly pessimistic approximation. Sellafield Ltd. then considers that the metal core of the cable occupies 5% of the cable volume and that portion will not contribute to the fire load. This conservative assumption is based on project experience, assuming a room features power or mixed cable types, as some cable core occupies a much greater volume, upwards of 50%. In legacy buildings, Sellafield Ltd. applies engineering judgment to calculate the cable loading on trays and ladders based on the measured width of the ladder or tray and makes a judgement on the percentage fill of the tray or ladder, unless design information is available (e.g., as per new build facilities).

Common items fire load

Sellafield Ltd. reports that items encountered in the nuclear facilities are either weighed, measured, or average values used to calculate the specific combustible contribution in MJ. It also notes that where weights cannot be accurately estimated, such as when the item is too heavy or fixed in place, it makes a conservative estimate that is documented in the RPS fire loading tool.

Fire loading surveys

Sellafield Ltd. reports that fire loading studies are typically undertaken quantitatively during the design process for new build and documented in (or referenced out) of the Conventional Fire Hazard Analysis/Fire Safety Strategy. It also states that qualitative fire load assessments are undertaken for legacy buildings where design information may not be available. Sellafield Ltd. reviews fire loads as part of the ten-year Periodic Safety Review. Quantitative studies are undertaken once, prior to the facilities becoming active, as there tend to be few major building changes. Sellafield reports that the fire loading studies are changed to reflect the as-built status if changes have occurred during the ten-year period, and that these are also assessed as part of PMP procedures. Sellafield Ltd. notes that, in general, reviews undertaken after the quantitative assessment will be qualitative to confirm that the assumptions made remain valid. Finally, Sellafield Ltd. undertakes qualitative fire load reviews as part of compliance with life safety requirements of the Regulatory Reform (Fire Safety) Order and as part of the Internal Hazard Assessment process.

Transient combustibles

Sellafield Ltd. refers to fire safety requirements, including preventing fires from starting and maintaining appropriate levels of defence in depth as per ONR SAPs [15] IAEA standards. It also refers to the principles of fire prevention in Article 10, Part 3 of Schedule 1 of The Regulatory Reform (Fire Safety) Order [20], which sets out the hierarchy for combustible management through avoiding risks, evaluating the risks that cannot be avoided, combating at source, adapting to technical progress, replacing dangerous with non- or less dangerous, giving appropriate instruction to employees and developing policy to cover technology, organisation of the work and the influence of factors relating to the working environment. Sellafield Ltd. states that it follows a hierarchy of control aiming to minimise combustibles at source and, where necessary, appropriate controls are in place to minimise the risk of fire. It also states that references and signposting are available as self-assessment tools for combustible management, enabling Sellafield Ltd. plants to implement fit-for-purpose solutions.

Sellafield Ltd. typically considers transient combustible inventories through regular inspections carried out by Building Managers, or others in the facility with a duty to minimise combustible fire loading. Sellafield Ltd. also reports that a team of Fire Protection Advisors assesses combustible loads qualitatively as part of the Fire Risk Assessment process and provides training to employees on fire load management techniques.

Sellafield Ltd. estimates transient combustible inventories quantitatively during the fire design assessment process, which is part of the safety case assessment process to provide physical and managerial controls. Sellafield Ltd. reports that operational plants utilise a combination of design data and internal standards to control and manage combustibles throughout the nuclear facilities lifecycle. Fire Risk Assessments consider transient fire loading qualitatively and, where a fire risk is identified, control measures and actions are raised, documented, and tracked to address fire load problems. Fire Risk Assessments consider transient fire loading qualitatively and, where a fire risk is identified, control measures and actions are raised, documented and tracked to address fire load problems.

Sellafield Ltd. has a supporting practice document on Combustible Management Principles and Guidance [110]. The document sets out the scope and references other relevant standards and requirements, assumptions, and management principles.

Sellafield Ltd. has produced methods and tools for quantification of fire loading to enable plants to undertake high-level assessments of permanent and temporary laydown and storage areas. These are undertaken by non-specialist personnel and therefore incorporate conservatism. Sellafield Ltd. states that, where challenges arise, more detailed risk-based assessment are undertaken by SQEP in consultation with the Sellafield Ltd. Fire Engineering Team. Sellafield Ltd. has shared these with the NIFSCC and WANO as examples of good practice. The approach is as follows.

For laydown area, five questions are answered to produce an accumulative score. This is then compared to defined scoring criteria to produce an upper limit for combustible load in the laydown area. Once the combustible limit for the laydown area is identified, a comparison is made with the items and materials to be stored within the area using the values presented within the Sellafield guidance. If the cumulative score of all items to be

stored is less than the Combustible Limit for the area, the risk associated with the storage of the combustible material is deemed to be tolerable.

Sellafield Ltd. states that, where there is a nuclear safety consequence associated with combustibles management, Radiological Safety Assessment HAZANs will detail Operating Assumptions (OAs) and required Operating Instructions (rOIs) to control and limit combustibles. It also states that it communicates the limits through operational fire risk assessments, local rules (i.e., the OAs and rOI in the HAZANs and Safety Cases), safety procedures and plant specific toolbox talks. Sellafield Ltd. reports that laydown areas may then be demarcated within the facility, requiring that any materials must be stored within it temporarily.

Finally, Sellafield Ltd. reports that, where there is a nuclear safety consequence associated with combustibles management, Radiological Safety Assessment HAZANs will detail OAs and rOI to control and limit combustibles.

FRAs for legislative compliance for life safety are produced and reviewed internally. The FRA details fuel sources and combustible management recommendations and control measures required to minimise fire loads across the whole of the Sellafield site, since high standards of life fire safety contribute to the overall fire risk reduction methods to ensure high levels of nuclear fire safety.

Candidate facilities examples

Waste Vitrification Plants, Magnox Reprocessing and Encapsulation Plants

Sellafield Ltd. reports that quantitative fire loads were assessed and detailed in the Continued Operations Safety Case (COSC) Conventional Fire Hazard Analysis for Waste Vitrification Plants, Magnox Reprocessing and Encapsulation Plants. Sellafield Ltd. states that this was subsequently updated in the Continued Operations Safety Report (COSR) Conventional Fire Hazard Analysis and that an explicit quantitative fire loading study was not carried out for the COSR. It instead carried out a semi-quantitative assessment, assessing the fire loading in each area and assigning values based upon observations. Sellafield Ltd. states that some areas identified during the plant walkdowns of the facility where the fire loading could potentially threaten fire compartmentation were subject to quantitative fire loading assessment. It used the information to generate recommendations to control and manage the fire loads within expected design parameters.

BEPPS-DIF and SPRS

Sellafield Ltd. states that BEPPS-DIF and SPRS are relatively new build facilities. It reports that fire loading was quantitatively assessed as part of the conventional fire analyses detailed in the design Nuclear Safety Case production. The Operational Safety Case Conventional Fire and Internal Hazard Analyses assessed the fire loads qualitatively and took into account transient and fixed fire loads. Sellafield reports that the information was used to generate recommendations to manage fire loads within expected design parameters.

Pile 1

Sellafield Ltd. considers Pile 1 as a low hazard facility that is in a quiescent state under a regime of care and maintenance. It reports that the radiological and non-radiological fire loads were quantified within the HAZANs and that it used the information to manage them within expected design parameters.

I-2.5.2.3. Fire service intervention

Sellafield Ltd. reports that fire service intervention is considered a defence in depth mitigation measure, but not claimed, designated or substantiated in its safety cases. Sellafield Ltd. also reports that firefighting access and facilities are assessed and provided in accordance with the Building Regulations and Sellafield EDSPs commensurate with the worst-case fire scenarios.

The service provided by Sellafield Fire & Rescue Service (SF&RS) is a 24/7 first strike, rapid response capability for the containment and extinguishment of fires. Following prompt activation of the fire alarm and detection system and subsequent notification to SF&RS, Sellafield Ltd. considers it reasonable to assume that SF&RS will respond to the alarm promptly. Sellafield Ltd. has assessed and quantified on-site SF&RS response times. However, this data is not used in fire analysis. The main aim of deterministic fire analysis is to ensure fires are addressed and designed out and, where this is not possible, appropriate control measures are put in place. The fire service is required if all other measures have failed and a fire occurs. Should a fire propagate and become unmanageable by the onsite fire service, Sellafield Ltd. states that off-site support would be summoned to control and extinguish the fire.

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

Sellafield Ltd. reports that a deterministic approach is undertaken based on an adequate level of passive fire protection to contain the worst foreseeable fire. Sellafield Ltd. fire engineering utilises various techniques such as US Nuclear Regulatory Commission Regulation (NRC) Nuclear Regulatory Report (NUREG) spreadsheets [78] and fire engineering calculations contained in the Society of Fire Protection Engineers (SFPE) Handbook [28], Introduction to Fire Dynamics [29] or Structural Eurocodes [81]. Sellafield Ltd. uses calculation tools to assess pool fires and the effect of radiant heat flux on structures, systems, components and nuclear inventory. Key sources of data are site-specific flammable inventories for pool fires and fire loading calculations for assessing structural fire resistance, for example, fire resistance of structural steel and whether fire compartment boundaries are adequate for the type of fire load.

I-2.5.3.1. Analysis tool selection

Sellafield Ltd. reports that it applies a wide variety of models for the prediction of a various fire behaviours. These range from simple algebraic correlations through to zone models and Computational Fluid Dynamics (CFD) models. Sellafield Ltd. reports that it frequently uses algebraic models in deterministic NFSA, including equations that consider flame height, heat release rate, plume and ceiling jet velocities, gas layer temperatures and depth, thermal radiation, and other descriptors of fire phenomena. Sellafield Ltd. also states that it applies zone models, such as CFAST, more often than CFD models, such as Fire

Dynamics Simulator (FDS). Sellafield Ltd. states that the selection of the appropriate fire analysis technique depends upon numerous factors, including:

- Whether or not the equations and assumptions in the model are appropriate for the problem under review;
- Required level of accuracy;
- Time limitations; and
- Availability of appropriate computational resources.

I-2.5.3.2. Analysis data

Sellafield Ltd. states that, in the majority of cases, fire engineering analysis will be based upon site-specific information. This includes existing buildings through building inspection of fire loads, building dimensions and ventilation characteristics, and where there is sufficient background information readily available. Similarly, Sellafield Ltd. considers that, during building design, worst case design fires are established with the use of fire loads, location, building layouts and reviews of the Building Information Models (BIM).

Sellafield Ltd. reports that generic data may be used occasionally, but only where there is an absence of supporting information on the specific nature of the fire load. When applied, the approach will be conservative and bounding. An example of where Sellafield Ltd. may apply this is during concept design, when detailed information on combustible inventories and fire load is not available for analysis. Sellafield Ltd. lists the key types of data as follows:

- Characteristics of the fire load for the design fire;
- Construction of the room, compartment or building;
- Materials of construction of targets, radiological boundaries, etc.;
- Location of the fire loads;
- Layout of the room, compartment or building;
- Ventilation characteristics;
- Ambient temperature;
- Location of targets, radiological boundaries, etc.;
- Available fire protection in the room, compartment or building; and
- Occupancy.

The first three bullets are associated with the establishment of the design fire and how it can impact upon the room, compartment of building. Sellafield Ltd. reports that the design

fire is generally established by first understanding the combustible constituents of the fire and then using data from reference material to establish the design fire heat release rate curve or the peak heat release rate. Sellafield Ltd. reports that it uses a plethora of Fire Engineering reference material to establish this, including the Society of Fire Protection Engineering Handbook of Fire Protection Engineering [28], the Introduction to Fire Dynamics [29], Published Document 7974-6 Fire Safety Engineering [111], and various National Fire Protection Association and NUREG guidance documents. Sellafield notes that the list is not meant to be exhaustive and that some of the references listed above also provide good information on the characteristics of building materials that may need to be input into a specific fire engineering analysis approach. Specific information relating to building characteristics, layout, ventilation, etc. would be ascertained either by building inspection or by review of design information.

Sellafield Ltd. reports that if there are uncertainties in the data used in the fire engineering analysis technique, a conservative and bounding input is selected based upon the available information. A sensitivity analysis may also be applied to understand the potential impact of varying the values of the uncertain input. If there are intolerable uncertainties in the output from the analysis, ultimately the output will not be used. A more sophisticated modelling technique might instead be applied to achieve a greater level of certainty.

I-2.5.3.3. Fire consequence analysis

Sellafield Ltd. reports that it applies numerous methods, some of which are listed below.

Fire loading assessment and time equivalence

Sellafield Ltd. reports that it completes a fire loading assessment for all buildings. This involves a calculation of the fire load density per room or fire compartment in the building. It then applies the fire load density to calculate the time equivalence, which in turn allows it to review the fire resistance requirements for fire compartmentation.

Sellafield Ltd. reports that the fire loading assessment includes all combustible inventories in a room or fire compartment. It also states that the fire loading assessment and time equivalence techniques applied use standard approaches such as the Published Document (PD) 7974 suite of standards [111]. Depending on the arrangement in question, it then follows a time equivalence calculation technique using the ventilation characteristics of the room or compartment, or a more linear equation comparing fire load density to time equivalence. Sellafield Ltd. also states that the propensity of the applied technique to over- or underestimate the time equivalence is reviewed through sensitivity analysis as appropriate.

Sellafield Ltd. also reports that fire load assessments are completed for all plants to provide evidence that the fire compartments and fire barriers have suitable and sufficient fire resistance.

Heat release rate establishment and thermal radiation

Sellafield Ltd. establishes the heat release rate of a design fire as a start point for further Fire Engineering Analyses. The Fire Engineering techniques subsequently drive how it

establishes the heat release rate. Where it applies algebraic models, the peak heat release rate might be established through the application of the combustion characteristics of the fire load from reference data (area, mass loss rate and heat of combustion). Should more complex algebraic calculations or a zone or CFD model be the next step, a heat release rate curve might be calculated using the principles of t^2 growth, steady state phase and decay (as defined in references such as PD 7974-1 [111]).

Sellafield Ltd. reports that thermal radiation received from a fire can be calculated using simple algebraic models, such as the point source model, or by applying more complex software tools. Sellafield Ltd. utilises both approaches, but concludes that simple algebraic approaches are utilised more often. NUREG 1805 Quantitative Fire Hazard Analysis Methods from the U.S. Nuclear Regulatory Commission Fire Protection Inspection Program – NUREG Calculation Spreadsheets [78] were recently used on the BEPPS-DIF Project. These hand-based fire engineering calculations were used by Sellafield Ltd. to show that a fire involving crane components would not have detrimental effects on the nuclear packages transported.

Consolidated model of Fire And Smoke Transport (CFAST) zone modelling

Sellafield Ltd. states that it uses zone models where appropriate. It reports that the limitations of these models are well understood, with one of the primary limitations being that the output is an average temperature for each of two zones, so care should be taken if localised temperatures are an expected output. Sellafield Ltd. reports that it uses this software within the bounds of applicability reported in reference material and that the output is reviewed against defined failure criteria. If the safety margin was not considered to be sufficiently large, further modelling would be completed to validate results.

Sellafield Ltd. reports that CFAST zone modelling was recently utilised in the BEPPS-DIF Nuclear Fire Hazard Analysis, to understand the impact of a transporter fire within the plant. The first step in the fire modelling process was to define the parameters of the fire. This was achieved by using transporter cab and trailer specifications and associated fire loads. The information was then used to develop a heat release rate curve for all the materials to ascertain how a full transporter fire would grow. The output was shown graphically as the fire growth rate and average peak temperature achieved. Sellafield Ltd. also showed the Upper Gas Layer Temperature in the particular area of the plant. Sellafield Ltd. states that all the structural steel members in the particular area were provided with a two-hour load bearing fire resistance capability to BS 476 Part 20-21 [112] [113], concluding that this protection met the withstand requirement calculated with CFAST (the burn duration was significantly shorter than the fire resistance rating of the steelwork's passive fire protection).

Sellafield Ltd. acknowledge that the modelling output is an average value over the volume of the particular area, and that the value will be significantly higher in the locality of the fire, with the potential to challenge the integrity of the structural steel beams if they were not protected, as is the case for BEPPS-DIF.

Dispersion modelling

Sellafield Ltd. has methodologies for modelling release and dispersion of radioactive material. The Release Fraction Database (RFDB) contains a repository of release fractions relevant to fires for different material types and scenarios.

Sellafield Ltd. also has methodologies for calculating dispersion of material off site following a release of activity. Although the cause of the release is not specified in this methodology, Sellafield Ltd. considers that it would be equally valid for a fire as for any other form of release (although a fire may be more energetic than other causes of release, this will already be factored into the Release Fraction applied).

Sellafield Ltd. estimates activity releases using the software tool called HAZCALC, which takes into account Dose Release Ratios (DRRs) for different isotopes. This is underpinned by the National Radiological Protection Board R91 Model for dispersion of radionuclides in the atmosphere for public doses [114] and also International Commission Radiological Protection (ICRP) Publication 68 [115] for worker doses. Further detail is provided in Safety Case Process and Methods Technical Guidance and supporting documents:

- Assessment of Consequences from Releases of Activity;
- Dose Release Ratios; and
- Calculation of Worker and Public Doses from an Aerial Release.

Sellafield Ltd. notes that the Release Fraction Database contains Release Fractions and Decontamination Factors, some of which are specific to releases from fires. The values on the RFDB are provided on the Nuclear Decommissioning Authority (NDA) hub for all personnel to access.

I-2.5.4 Main results/dominant events (licensee's experience)

Sellafield Ltd. reports that probabilistic fire hazard analysis is undertaken for nuclear facilities. The techniques and tools applied to fire scenarios are covered in methodologies such as the transporter fire risk profile methodology for assessing the impact of a vehicle fire and Sellafield Ltd. guidance for assessing electrical items in the nuclear fire context. Sellafield Ltd. reports that worst case scenarios in nuclear facilities are considered, for example, the BEPPS-DIF worst case fire scenario is associated with a vehicle fire in a particular area of the facility.

I-2.5.5 Periodic review and management of changes

In accordance with Nuclear Site Licence Condition 15 (Periodic Review) and Sellafield Ltd.'s internal arrangements, a ten-year rolling Periodic Safety Review (PSR) programme is owned by the Head of Safety Cases and monitored by ONR. That is, every ten years, a facility (which has a nuclear safety case) undertakes a review of nuclear safety and submits that review to ONR. The purpose of the review is to provide ongoing confidence that operations continue to be adequately safe, and risks are managed to be ALARP. The overriding principle of the PSR arrangements is that the PSR is not an assurance activity and instead should seek to confirm (or otherwise) that the organisation operates diagnostically and the implemented arrangements are applied effectively. By evidencing

this, (e.g. issues are being identified at the time and being corrected promptly, learning is proactively sought and shared, changes to standards etc are communicated at the time rather than being 'stored up' for ten years etc.), the risk of the organisation of operating with potential threats to safety for a long period of time is minimised. This programme is significant in terms of the number of facilities on the Sellafield Site and involves a lot of planning and preparation work. Sellafield Ltd. considers that it manages this large portfolio of reviews of nuclear safety cases well, and that it sets an example of good practice.

Sellafield Ltd. states that its arrangements for maintaining a nuclear safety case help ensure that it is kept live, presenting a clear and visible safety argument that reflects the operational status and the configuration of the plant, processes or equipment. Sellafield Ltd. concludes that it sets expectations on the currency of the nuclear safety case (including supporting evidence and analyses) as well as decision points for escalation if changes are expected, which would be managed through its process for maintaining safety cases.

I-2.5.5.1. Overview of actions

Waste Vitrification Plant

Sellafield Ltd. reports that there are no physical modifications planned that would affect nuclear fire safety but, as there is a programme in place to implement revised nuclear fire safety assessments (prompted by a finding from the 2022 periodic safety case review), emergent work may arise.

Magnox Reprocessing

Sellafield Ltd. reports that there are no plant modifications planned that would impact nuclear fire safety and that there have been no significant modifications historically that claimed to impact nuclear fire safety.

Encapsulation Plants

Sellafield Ltd. reports that Encapsulation Plants have had no major structural modifications since the buildings were constructed. It states that there have been modifications to installed equipment and modifications to allow different flasks to be encapsulated but nothing that impacted nuclear fire safety or required changes to the nuclear or conventional fire safety analyses.

SPRS

Sellafield Ltd. reports that since operations commenced in SPRS, there have been no PMPs which have significantly had an impact on either nuclear or conventional fire safety. The SPRS Modifications Project, which is necessary to install new SSCs within SPRS to allow transfer of packages between SPRS and a new facility on Sellafield Site, will require the Nuclear and Conventional Fire Safety Case to be reviewed. The new SPRS Control Systems upgrade may also introduce changes, so fire safety will be given adequate consideration during production of the PMP(s) for this upgrade.

BEPPS-DIF

BEPPS-DIF is a relatively new facility and has not had any nuclear fire risk significant modifications since it was built in 2016. Sellafield Ltd. reports that nuclear fire safety consideration was designed into the building.

Pile 1

Sellafield Ltd. reports that Pile 1 is a low hazard facility in a quiescent state of operation under a regime of care and maintenance. The scope of operations routinely carried out in Pile 1 and associated buildings is limited and has not changed significantly since the last review. The operations are all associated with maintaining Pile 1 and associated buildings in a safe and stable state, and include routine surveys, tests and maintenance as well as the continued operation of the Pile 1 ventilation system.

I-2.5.5.2. Implementation status of modifications/changes

Sellafield Ltd. recognises they have obligations in terms of implementing modifications or changes to plant. These obligations are in reference to:

- Legislation e.g. Control of Major Accident Hazards (COMAH) Regulations 2015 [23];
- Nuclear Site Licence Conditions;
- WANO Performance Objectives and Criteria; and
- Environmental Permits.

To comply with these requirements, Sellafield Ltd. has established arrangements to assess and mitigate risks associated with the modification of existing plants or processes which may affect safety (nuclear, environmental and COMAH). Sellafield Ltd. has also established governance and scrutiny via various committees to ensure those involved in the review, approval and implementation of PMPs are competent. Sellafield Ltd. reports that PMP arrangements are applied to:

- All modifications or experiments on existing plant or processes on the Sellafield Nuclear Licensed Site that could have an effect on radiological or nuclear safety, environmental performance or COMAH safety; and
- All modifications on existing plant or processes that are required to mitigate hazards associated with adjacent plant.

Sellafield Ltd. assigns a radiological, environmental and COMAH classification to each proposal to ensure that they are subject to adequate scrutiny. Sellafield Ltd. considers that the classification system for safety significance is consistent with that used for Nuclear Site Licence Condition 22. Finally, Sellafield states that, where appropriate, it divides the modification or experiment into stages laid out in a hold point control plan if associated with a permissioning activity which is used as an engagement tool with ONR. Provision of adequate documentation to justify the safety of the proposed modification or experiment

and where appropriate, submission of the documentation to ONR and/or the Environment Agency is also required as part of the proposal.

Sellafield Ltd. has a process to control any modification or experiment, carried out on any part of an existing plant or process, which may affect safety, environmental or COMAH performance as part of its arrangements under Nuclear Site Licence Condition 22.

Sellafield Ltd. states that application of the PMP process ensures that:

- The full extent of what is or could be affected by the modification, both during and following its implementation, is identified and adequately considered;
- All new and increased risks to safety, the environment and nuclear fire measures are identified, assessed and adequately controlled;
- Safety, environmental and COMAH classifications are assigned to the modification to reflect its safety significance and ensure it is the subject of adequate scrutiny;
- The correct standards and procedures are applied to any engineering or operational changes;
- The correct standards and procedures are applied to any design changes;
- All requirements to update any records associated with the modification are identified; and
- All training and communication requirements associated with the modification are identified.

Sellafield reports that a PMP form is produced to categorise and assess the modifications to identify any nuclear fire requirements to be completed before the modification is instigated. As part of that process and form, the PMP author in conjunction with the Fire Prevention Advisor and Fire Engineer identifies the requirement to undertake nuclear fire analysis and, if necessary, the nuclear fire assessment is appended to the PMP for approval at the PMP committee and subsequent implementation.

In addition, Sellafield Ltd. undertakes a fire risk assessment of the life safety, property protection, business continuity and environmental fire issues to ensure compliance with fire safety legislation and relevant good practice with respect to assessing, controlling, and managing fire issues holistically. Sellafield Ltd. considers that this ultimately provides a defence in depth approach to nuclear fire since well-controlled and -managed conventional fire safety issues help reduce the potential for fire to initiate, develop and affect nuclear safety SSCs and inventory where reasonably practicable.

I-2.5.6 Licensee's experience of fire safety analyses

I-2.5.6.1. Overview of strengths and weaknesses identified

Sellafield Ltd. states that it takes a proactive lead in sharing internal Safety Case Process, Methods and Standards internationally with WANO and, within the UK, with NIFSCC

members and that this demonstrates a healthy appetite for learning and sharing good practice and benchmarking with the nuclear industry. This includes (but is not limited to) the Nuclear Fire Hazard Analysis Techniques, combustible fire load management quantification methods and the classification of fire events.

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

Fire event recording

Sellafield Ltd. reports that, following a fire event on the Sellafield Site and depending on the scale of the fire, an investigation may be convened. Sellafield Ltd. reports varying levels of investigation: Basic Cause Investigations, Management Investigations and a Board of Inquiry. It also states that contractors working on the site convene their own independent investigation. These investigations identify recommendations which are assimilated and addressed in the relevant parts of the company safety management systems. Sitewide and individual project bulletins and/or videos are also posted such as toolbox talks, which share the learning from events and identify the root causes so repeat events can be prevented. This is supplemented by regular fire safety shares at beginning of meetings, for example, within the Safety Case or Fire Professions and on plant.

Sellafield Ltd.'s Fire Engineering provides regular updates on fire events to the Safety Case Profession and Programme Project Partners (PPP) to ensure learning is shared and enable improvements to be addressed and embedded in new projects, designs, modifications and existing legacy plants, thus reducing the potential of a reoccurrence of the fire event.

Sellafield Ltd. has access through ONR to the Organisation for Economic Co-operation and Development (OECD) fire event database from nuclear facilities internationally, which is utilised as a source of learning to prevent similar fires on the Sellafield Site. In addition, Sellafield Ltd. is a member of NIFSCC. Learning is briefed out at site and project levels to embed any learning within new projects or existing facilities as appropriate.

Sellafield Ltd. records fire events on the ATLAS (Analysing, Trending, Learning And Safety) system where the plant raise a condition report to capture the fire event. If SF&RS respond to the fire, they also raise a condition report. The condition report is coded by the Performance Improvement team using guidance provided by Fire Protection in terms of fire classification. The classification of fires has been produced and shared with the NIFSCC where other nuclear licensees adopt the same classifications of Major, Notable, Minor and Smouldering fires. The classification has been shared with WANO. Sellafield Ltd. reports that condition reports with a Fire Protection code are reviewed periodically by the Fire Protection team to identify potential trends. Prior to this classification system, fire events were recorded on the Firecall database which was managed by SF&RS.

Sellafield Ltd. fire categorisation criteria are as follows:

- **Major Fire:** Anything in the below categories plus fatality, significant loss of production/plant shutdown or property loss of over £2.5m;

- **Notable Fire:** Extinguishment from two or more handheld extinguishers, portable foam system, fixed fire suppression system or hoses ran from fire hydrant system; and, fire spread beyond first item of ignition, caused long-term unavailability of plant and equipment, triggered a Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) Dangerous Occurrence or reportable injury, caused significant distraction to safe operation or caused spread of contamination and/or nuclear fire;
- **Minor Fire:** Sustained flame where one extinguisher is used, or power isolated manually or undetected fire which has spread beyond first item of ignition but has self-extinguished; and
- **Smouldering Fire:** No sustained flames where action has been taken, items overheating or smoking, fire has not spread beyond first point of ignition and has self-extinguished, manual call points or fire alarm and detection systems have been triggered.

Fire events

Since Sellafield Ltd. adopted the above classification criteria in 2018, there have been no recordable fires in Waste Vitrification Plants, Encapsulation Plants, Sellafield Product and Residue Store or BEPPS-DIF nuclear facilities.

Sellafield reports that Magnox Reprocessing had a notable fire in one of the adjacent facilities within a higher contaminated area in 2021. The fire did not have any significant nuclear or radiological consequences and no personnel were injured. The fire began in an electrical light fitting which ignited some combustible scaffolding boards and sheeting in the local area. It was extinguished by the SF&RS. Sellafield Ltd. undertook an investigation and learning was implemented across site, resulting in changes to fire policy for use of combustible scaffolding boards and a programme of work to replace fluorescent tube lighting across site in line with the European Directive [116]. Magnox Reprocessing also had a small fire in 2022 where a computer screen was found to have small flames and smoke emissions; this was locally extinguished. In both cases, the fire did not have any consequences beyond the immediate damage, and there was no nuclear or radiological consequence.

Sellafield Ltd. reports that there have been several small fires in the facilities over the years that have been attributed to Uninterruptible Power Supplies (UPS) panels burning out, minor fires from hot work and overheating equipment. If using the classification retrospectively, Sellafield Ltd. considered that most would be smouldering fires as they were found to have burned out and did not require extinguishing. Finally, Sellafield Ltd. concludes that regular analysis of condition reports allows common cause fact finding to determine any potential trends, and that in recent years there had been no adverse trends to suggest any issues in particular facilities or processes.

Learning from fire events

Sellafield Ltd. reports that there was a fire within a breakdown cell in Waste Vitrification Plants in 2000, which occurred when sparks from grinding operations ignited some combustible waste. Sellafield Ltd. states that, following the fire, additional fire extinguishing

measures were fitted in the cell and an extent of condition was carried out to ensure there was no combustible waste in any other cells in the building.

Since Sellafield Ltd. adopted the new fire event classification, it reports that there had been changes following fire events in areas of the Sellafield Site. This included adopting the hierarchical approach to choosing scaffold boards (non-combustible) and increased oversight of contractors' fire safety arrangements.

Finally, Sellafield Ltd. reports that most of the recordable fires on the Sellafield site have been due to electrical failures such as light fittings failing. Visibility of obsolescence and maintenance is a priority for Sellafield currently, to manage all electrical assets and prevent any failures.

I-2.5.7 Regulator's assessment and conclusions on fire safety analyses

I-2.5.7.1. Overview of strengths and weaknesses identified by the regulator

Guidance

Sellafield Ltd. details the guidance it applies for fire hazard analysis across its facilities in Section I-2.5.1. In this section Sellafield Ltd. describes how national standards and legislation flow down into company guidance. In addition, the licensee claims that their fire analysis guidance aligns with and incorporates IAEA standards and WENRA reference levels into:

- Sellafield Ltd. Management System (SLMS);
- The suite of supporting Nuclear Safety Case Process and Methods Technical Guidance for all aspects of the nuclear safety case including nuclear fire safety; and
- Engineering Design Safety Principles (EDSPs).

ONR's assessment confirms that these documents reflect the higher-level nuclear fire requirements set in the international standards. The ONR SAPs and TAGs, benchmarked against international RGP, form the basis for ONR assessment of licensee safety cases. Sellafield Ltd. has identified these as an input to the licensee's own EDSPs and has demonstrated consistency with the principles set out in the documents in line with ONR expectations.

Fire loading and data sources

ONR assesses the adequacy of licensee' fire load analyses against the Internal Hazards TAG [16] and this expects the safety case to provide reference to surveys or studies of combustible substances, which should be systematic and demonstrably complete. This should include consideration of solids, gases, liquids, vapours and transient loads. ONR SAPs AV.3 also expects that the data used in the analysis of plant with safety significance should be valid for the circumstances by reference to established physical data, experiment or other appropriate means.

The licensee self-assessment describes how both fixed and transient loads are considered. This includes confirmation that load data is periodically reviewed and underpinning data is based on experimentation and relevant validation testing. It also details how the information feeds into both hazard analysis and operational limits placed on facilities as appropriate. As a result, ONR judges that Sellafield Ltd. has shown understanding of regulatory expectations in this area.

Deterministic analysis approach

ONR's expectations for fire hazard analysis are set out in the internal hazards TAG [16] and the SAPs [15] [16]. Consistent with the relevant IAEA and WENRA documentation, ONR expects suitable fire consequence analysis methods and models to be applied in the estimation of fire severity (SAPs EHA.1, EHA.5, EHA.6 [15]) and that the outputs from fire and ignition source identification are taken forward for analysis. Consequences to SSCs and performance requirements for fire safety measures should then be determined.

Sellafield Ltd. sets out how tools are selected for analysis of fire behaviour and provides description of the factors applied in these decisions. This includes hand calculations, zone models, and where appropriate, CFD. Sellafield Ltd. describes a proportionate, graded approach to tool selection that is in line with ONR expectations. Furthermore, the use of site-specific data utilising building layout and review of the Building Information Models (BIM) is seen as a specific area of good practice against SAPs AV.1 by ONR [15].

As described in Section I-2.5.1, Sellafield Ltd. considers, via application of its Safety Case Process and Methods Technical Guidance on Nuclear Fire Safety Analysis, key principles including fire effects on safety functions, fire initiation of fault sequences, fire impacts on consequences and initiation frequencies and a deterministic approach based on an adequate level of passive fire protection to contain the worst foreseeable fire. ONR judges that this approach is aligned with key principles for deterministic fire hazard analysis as set out in IAEA SSG-2 [34], SSG-64 [17] and ONR SAPs and TAGs [15] [16].

Sellafield's reporting of the BEPPS-DIF fire analysis shows some of the breadth of fire hazard analysis applied at Sellafield and how a deterministic approach is generally taken, based on an adequate level of passive fire protection to contain the worst foreseeable fire in line with ONR's expectations. Sellafield Ltd. provides evidence that the approach is generically applied across its estate as appropriate and supported by well-established and benchmarked arrangements.

Sellafield Ltd. describes how fire service intervention is considered but not claimed within the analysis and how contributions to defence in depth are defined as part of building design. This approach is in line with ONR SAPs EKP.3 and para. 155 [15], and meets the expectations of IAEA SSG.64 [17] (the extent of reliance on on-site and off-site fire services should be established at the design stage).

Combined and consequential hazards

WENRA E 6.1 expects that credible combinations of individual events that could lead to anticipated operational occurrences or design basis accidents, including internal and external hazards, shall be considered in the design [33]. It is noted that WENRA SRL E 6.1,

developed to specifically correspond to the consideration of event combinations for nuclear power plants, might be considered as appropriate also for fuel cycle facilities, subject to a graded approach [33].

In Section I-2.5.1.3, Sellafield Ltd. states that its hazard definitions include hazards identified in IAEA guidance SSR-4 [19]. SSR-4 Requirement 15 sets out expectations in paragraphs 6.44-6.47 that all foreseeable hazards and correlated events shall be examined systematically and in combination with facility conditions and that the interrelation or interaction of external events with internal hazards shall also be considered in the design where appropriate. Requirement 19 also sets out expectations that the impact of multiple correlated events on a single facility shall be considered in the safety analysis and that the set of identified postulated initiating events shall be confirmed to be comprehensive.

ONR adopts these requirements in the internal hazards TAG [16] and SAPs [15]. This ONR guidance also expects that hazard analysis should take into account hazard combinations, simultaneous effects, common cause failures, defence in depth and consequential effects. ONR expects that a systematic identification and screening process is applied to develop a combinations list that represents a credible and reasonable set of plant challenges. The TAG identifies that this often takes the form of a hazard combination matrix, developed from a consolidated list of all internal and external hazards. Furthermore, it is expected that safety cases record any assumptions made to dismiss hazard combinations or their effects.

Sellafield Ltd.'s self-assessment recognises that combinations such as seismically-induced fires are credible, and that these would be considered within safety assessment processes. However, the Sellafield Ltd. submission does not indicate that a full systematic combined hazards identification and screening process is undertaken. Sellafield Ltd. recognised this gap and identified changes to the NFSA Safety Case Process to address the gap. Sellafield Ltd. states that the revised guidance would specially consider the systematic identification and screening of combined and consequential hazards in its hazards safety cases, and is currently awaiting internal approval.

Probabilistic safety analysis

While WENRA SRLs have not yet been specifically developed regarding fire safety analyses for fuel cycle facilities, the TPR specification outlines how the WENRA SRLs for other installations – for example, SV 3.1, SV 3.2 and SV 3.3 – should be considered proportionately in the NAR according to the graded approach. WENRA SRL SV 3.1 expects that probabilistic methods are applied as far as practicable for internal hazards. Similarly, ONR expects licensees to place greater emphasis on deterministic means of demonstrating safety. However, probabilistic arguments may be of some use when assessing proportionality and on optimising the effectiveness of measures, consistent with ALARP principles. In Section I-2.5.1.4, Sellafield Ltd. reports how specific probabilistic arguments are used in support of fire hazard analyses. This meets ONR expectations.

Periodic safety review

ONR requires PSR under license condition 15. PSR provides a ten-yearly review of safety at the plants. ONR can confirm that fire as an internal hazard is included in the licensee's PSR process as set out in the IAEA's Safety Guide SSG-25.

The most recently reviewed PSR submission for a candidate facility was for WVP in 2023. No significant issues were identified in ONR's assessment of the top-level suite of PSR documentation for WVP.

Learning from experience

Sellafield Ltd. sets out in Section I-2.5.6.2 a systematic approach to recording and categorising fires at the site. This method was shared with WANO as an example of good practice. Sellafield Ltd. demonstrates how fires at site have led to specific improvements in arrangements. ONR assesses this as a strength of the licensee's arrangements, in accordance with SAPs MS.4 [117] and IAEA SSG-77 [18].

Summary

In summary, ONR concludes that the licensee has adequate arrangements for undertaking nuclear fire hazard analysis, with one area for potential improvement identified: the systematic consideration of combined hazards.

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

ONR provides regulatory oversight of licensees' activities through its inspection and assessment functions. Sellafield has a nominated site inspector for the whole licensed site, in addition to several site inspectors for specific facility groups. Project inspectors are assigned to significant modification, construction or demolition activities. Specialist inspectors support in all these areas.

ONR assessed the internal hazards aspects of BEPPS-DIF at the pre-inactive commissioning report stage in 2021 [118]. This assessment concluded that Sellafield had demonstrated that relevant good practice has been met with regards to the Internal Hazards and Nuclear Fire Safety aspects of the safety case to support inactive commissioning of BEPPS-DIF. Some shortfalls relating to vehicle fire suppression and passive fire protection in the roadbay were identified. ONR assessed the licensee's response to these shortfalls at the pre-active commissioning report stage in 2023, finding that the shortfalls had been adequately closed [119] by providing automatic fire suppression within all transporters in use on the site.

As part of the pre-active commissioning report assessment ONR specifically sampled the roadbay fire modelling in BEPPS-DIF, finding that Sellafield Ltd. had met the expectations of SAPs AV.1, AV.2, AV.3 and AV.6 in the modelling undertaken, EHA.1 and EHA.14 in characterisation and analysis of the fire and EKP.4 and EKP.5 in the safety measures identified.

In 2022 ONR conducted fire focused system-based inspections at Sellafield's Magnox East River (MER) and Thermal Oxide Reprocessing Plant (THORP). While outside of the candidate facility list, these inspections allowed ONR to form a view on general nuclear fire safety at the site. Both inspections were rated as green (no formal action) across all licence conditions. Regulatory advice was provided on laydown area control and fire damper requirements assessment at MER. The holistic fire strategy approach employed by MER

was raised as a point of good practice and ONR has highlighted this as a practice that should be adopted across the Sellafield facility groups.

Within the candidate facilities, Magnox Reprocessing was the subject of a fire protection SBI in 2017. This was rated green against LCs 10, 23, 24, 28 and 34. LC27, was rated as amber with a regulatory issue relating to condition of suppression system components. This has since been addressed by Sellafield Ltd.

In July 2021, ONR undertook a Licence Condition 23 (Operating Rules) Nuclear Fire Safety inspection at SPRS. ONR observed that the licensee had a good understanding of the LC 23 arrangements from a nuclear fire safety perspective. On a sample basis, evidence was seen that the dutyholder had adequately implemented required Operating Instructions (rOIs) associated with the Nuclear Fire Safety Assessments and compliance checklists were adequately completed and updated in accordance with the plant status. An inspection rating of green (no formal action) was assigned for compliance against this LC.

ONR also inspects the Sellafield Ltd. facilities under its Nuclear Site Health and Safety purpose in the area of life fire safety. This comprises regular inspections against the requirements of the Regulatory Reform Fire Safety Order 2005 [20], and/or the Construction Design and Management Regulations 2015 [120]. The findings of these inspections and incident investigations relate primarily to fire protection and so are reported in Section 3.5.

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

For Sellafield Ltd, ONR concludes that the licensee has adequate processes and guidance for developing nuclear fire hazard analysis such as the Nuclear Safety Case Process and Methods Technical Guidance and EDSPs. ONR is content that the arrangements are consistent with good practice. ONR nevertheless judges that there is one area where secondary improvements to fire safety analysis on the Sellafield Ltd. site would be beneficial. There is a need for Sellafield Ltd. to review the guidance for fire hazard analysis to ensure appropriate advice is given for the systematic identification and screening of combined and consequential hazards. ONR is content that this task is being progressed by Sellafield Ltd. and will monitor it to completion. Several nuclear fire safety inspections are planned at the Sellafield site for 2024/25 which will give specific opportunities for ONR to assess progress. Any outstanding actions required to address TPR2 findings will be tracked through regulatory issues.

2.6. Facilities under decommissioning

Pile 1 at Sellafield is a facility under decommissioning. To reduce repetition, all Sellafield Ltd. facilities are reported within Section 2.5. The text in the Sections below has been prepared by Dounreay Site Restoration Ltd Background information on the site and the range of installations considered in the scope of the assessment is provided in Sections 1.1.2 and 1.1.3.

I Dounreay

Dounreay reports that it ensures adequate provision of fire safety and prevention measures through adherence with the Fire (Scotland) Act 2005 (FSA) [21] and associated legislation including the Fire Safety (Scotland) Regulations 2006 [121]. Dounreay considers that compliance ensures that the likelihood of fire development and spread is minimised, people and the environment are protected from the effects of fire, a fire risk assessment is completed, and lessons are learned from previous events and good practice. Dounreay considers that this aligns with WENRA SRL S-30.

Dounreay states that the fire risk assessment reflects the potentially increased risk for facilities built prior to 2005 that cannot fully comply with the FSA [21], and the requirement for additional fire control measures. Dounreay carries out Fire Risk Assessments at least annually to continually monitor compliance with current legislation and reports that any modifications to any part of a building must not take place without approval from the Fire Safety Advisor.

The Dangerous Substances and Explosive Atmosphere Regulations 2002 (DSEAR) [122] are concerned with the protection against risk from fire, explosion and similar events arising from dangerous substances used or present in the workplace. Dounreay requires a DSEAR assessment for areas where materials are likely to constitute a dangerous substance.

Dounreay reports that each of the facilities at Dounreay were constructed mindful of the fire standards of the day. These may vary considerably from the construction of the FCA in the 1950s through PFR in the 1960s and the Dounreay Cementation Plant (DCP) Store Extension 2 in 2020.

Dounreay also reports that all facilities at Dounreay are subject to a Deterministic Fire Risk Assessment (DFRA), which primarily assesses fire and explosion hazards that have the potential for radiological consequences. It also states that the methodology for the DFRA applied at PFR is the same as elsewhere on the site and that it considers it representative of the process. Dounreay states that its DFRA considers the potential sources of ignition, the probability of ignition resulting in a sustained fire or explosion, the probability and rate of fire spread and the radiological and fire containment barriers. The assessor walks down the facility to identify combustible inventories and ignition sources in order to qualitatively identify credible fire scenarios that could result in a radiological release. Credible scenarios require radiological hazard assessment.

Dounreay reviews safety cases periodically, including the DFRA, under Licence Condition 15 (a defined period of usually 10 years). Dounreay states that, as the extant DFRA would

be provided to the fire assessor for information, the periodic review is likely to require a walkdown by the new fire assessor to ensure that all credible ignition sources and fire scenarios are freshly identified. For existing facilities where it may not be possible to eliminate fire hazards, Dounreay applies the hierarchy of controls and considers any fire related improvements at ALARP review alongside any other safety case recommendations.

I-2.6.1 Types and scope of the fire analyses

The work undertaken at PFR is outlined in Section 1.1.3.6 and this was the scope of the PFR LC15 Review DFRA.

Dounreay identifies faults including those pertaining to fire through a hazard identification process and captures them in a Fault Schedule. For the DFRA, the due process considers the identification and assessment of fire hazards. Dounreay considers this as a specialist task carried out by SQEPs, such as a practicing fire engineer, with the following steps:

- The Fault Schedule is provided to the fire engineer responsible for the completion of the DFRA.
- Each area of the building is considered in turn to identify the ways in which a radiological release or loss of an SSSC could occur due to fire in that area and then describes potential fire scenarios which may initiate there.
- Each fire scenario is considered qualitatively, as to whether development to the point of causing the radiological consequences is clearly incredible therefore able to be dismissed, or not. This consideration takes into account passive features (e.g. walls, fire doors), and also qualitative assessments of the likelihood of a fire and its potential severity. Active measures (e.g. firefighting by operators or the on-site fire service, activation of fire dampers) are not taken into account in the qualitative assessment.

Dounreay considers that the approach is aligned with WENRA SRL SV 6.1

The DFRA provides a qualitative assessment of fire scenarios involving significant combustible inventories and ignition sources within PFR and associated buildings. Dounreay subjected the scenarios to a detailed quantitative assessment to determine whether radiological releases were possible, and if so, the radiological inventories involved and a bounding frequency for the fire affecting that inventory. In the case of PFR, Dounreay found the fire scenarios identified within the DFRA as requiring further assessment to have been considered or to be bounded by existing assessments. One scenario, an external vehicle fire adjacent to hydrogen cylinders, required additional measures to prevent the fault from being realised.

Dounreay reports that there are a number of fire loads located at PFR, generally defined as electrical switchgear, storage of combustible waste, electrical equipment and panels, vehicles, hydraulics associated with tools and alkali metal contaminated components.

Dounreay's Liquid Metal Fires HAZAN for PFR considered liquid metal fires, noting that the External Events HAZAN considered fires as a consequence of external events separately as discussed below. The Liquid Metal Fires HAZANs considered the consequences of small NaK fires arising because of intrusive maintenance and bagging operations on alkali metal

contaminated components. The assessment considered a large liquid metal fire as a consequence of a dropped load resulting in loss of containment of bulk alkali metal. All faults considered in the Liquid metal HAZAN were assessed to fall below the threshold for risk assessment (2 mSv low consequence methodology).

Dounreay considers that a seismic event at Dounreay would affect all PFR facilities simultaneously. The External Events HAZAN considers scenarios such as a collapse of the Secondary Containment Building with cracking of the reactor roof which could lead to fire involving the residual sodium and release of radioactivity. Similarly, Dounreay assessed aircraft crash onto the PFR facilities. The total public risk arising from radiological events and accidents associated with PFR is 1.3×10^{-12} per year, this is dominated by aircraft crash causing severe damage to the structural containment resulting in a loss of containment and fire. This risk is less than the ONR Safety Assessment Principles [15] Target 7 of 1×10^{-6} per year.

Dounreay is a decommissioning site and therefore in accordance with WENRA SRLs for decommissioning facilities does not require the completion of a full Probabilistic Fire Hazard Analysis.

I-2.6.2 Key assumptions and methodologies

Dounreay reports that the DFRA for PFR was completed in accordance with the site due process and that British Standards were considered throughout as follows:

- In accordance with Safety Case due processes, hazards and operability issues are identified, and the consequences assessed.
- The preventative and mitigatory controls are then assigned a class based on the assessments. Safety functions and performance requirements are identified against each SSSC including any pertaining to fire protection in an Engineering Schedule.
- The SSSCs are substantiated to consider if they can meet the cited functions and performance requirements. The only SSSC that was identified to protect against the consequences of fire was the PFR Fire Detection and Alarm System.
- The fire loading was recorded throughout all areas of the buildings in the PFR complex. It was quantified by considering the mass against the Heat of Combustion (SFPE Handbook of Fire Protection Engineering) [123].

As the buildings are largely open plan in the areas where SSSCs are located, the number of fire barriers in the building is low and the distribution of fire loading is widespread and in accumulations, Dounreay considers that there was no benefit from completing a global fire load density assessment for individual rooms. Dounreay placed emphasis on calculating the fire load in discrete areas in the building and on assessing the potential local impact of a fire involving these combustibles. However, where it considers it credible for the total fire load in a room to be involved in a fire and there was a potential impact upon nuclear safety, Dounreay assesses the fire load explicitly.

Dounreay reports that it identified transient combustible inventories as part of the facility walkdowns completed in support of the DFRA. The Fire Safety Engineer considers quantities, origin, etc. of the combustibles. Dounreay recognises that such a plant inspection can only provide a “snapshot”, but states that the provision of local expertise enabled the surveyor to determine how typical the plant status on the day of the survey is, and how conditions may vary during normal operations. Dounreay also states that project-specific fire risk assessments consider the generation of combustibles as a result of specific tasks. The regular planned general inspections of the facility and project areas also consider combustibles within the facility.

PFR was recently subject to a periodic review, and Dounreay reports that all faults and associated HAZANs were reviewed and that a new DFRA was issued. Dounreay concluded that modifications consider any implications to the fire risk assessment through consultation with a fire advisor.

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

Dounreay reports that the DFRA considered each area of PFR, identified the ways in which a radiological release or loss of an SSSC could occur due to fire in that area and then described the potential fire scenarios which may initiate. Each fire scenario was considered qualitatively as to whether development to the point of causing the radiological consequences was credible or could be dismissed. Dounreay’s assessment considered passive features and qualitative assessments of the likelihood of a fire and its potential severity. Dounreay reports that active measures were not considered in the qualitative assessment.

The DFRA identified the faults which required quantitative assessment, and it then groups them into fire scenarios on the basis of similarities of consequences or initiation, namely fires impinging on structural steelwork, office fires, combustible liquid fires, cable fires, vehicle fires etc. Dounreay reports that it quantitatively assessed each of the fire loads to ascertain whether they could lead to structural failure should they be involved in a fire. It states that a variety of analysis tools and data [123] [78] [124] [125] [126] [111] were used.

Dounreay incorporated no claims for Decontamination Factors (DF) in the Liquid Metals Fire HAZAN e.g. the DF provided by either the site or structure of the vessel in which the incident takes place or by the operators using Respiratory Protective Equipment (RPE). Dounreay reported that its approach was to create bounding assessments that assumed all the alkali metals are involved; even with adopting this pessimistic approach the analyses determined that such an event would give rise to very low radiological consequences and chemotoxic implications that are below Dangerous Dose thresholds. Dounreay concluded that the DFs for the structures were incorporated and applied in the External Events HAZAN.

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

N/A – Dounreay reported it had no requirement for probabilistic fire hazard analysis to be undertaken.

I-2.6.5 Periodic review and management of changes

Dounreay considers fire analyses as part of the periodic review of the safety case as per the site due process. Plant modifications consider if there are implications to the fire analyses. The Periodic Review considers changes to the facility, processes, activities and any life limiting factors and the resultant impact onto the Safe Operating Envelope. The periodic review considers changes to due process requirements.

The key changes identified by Dounreay during the periodic review of PFR were:

- The removal of the bulk sodium was complete and, more recently, the heel pool of sodium had been removed from the base of the Reactor Vessel (RV).
- All of the Irradiated Oxide Fuel (IOF) had been removed from the pond within the IFBS, but the pond remains full of water. The IOF was transferred to the IFC where it will be stored until the Intermediate Level Waste Size Reduction Facility is operational.

The DFRA was prepared as a new document with the previous assessment used as a reference only. Dounreay reports that all new walkdowns were undertaken and engineering judgement was based on the status of the plant at the time the assessment was prepared.

I-2.6.5.1. Overview of actions

Dounreay's DFRA identified a small number of recommendations pertaining to location and storage of combustibles.

I-2.6.5.2. Implementation status of modifications/change

Dounreay reports that all the recommendations identified in the DFRA had been resolved.

I-2.6.6 Licensee's experience of fire safety analysis

The PFR DSC was subject to a periodic review in 2019. Dounreay engaged contractors to produce and peer review the DFRA.

I-2.6.6.1. Overview of strengths and weaknesses identified

Dounreay reports as strengths that it has an on-site Fire Safety Advisor who is familiar with the on-site hazards and can provide advice on optioneering, modification and design. It considers that, given the on-site capability of DFARS, a prompt response to fire is assured. It also reports that all site personnel receive mandatory fire safety training which is periodically refreshed.

Dounreay reports as a weakness that it does not have in-house fire engineers to complete DFRA's and is reliant upon the expertise of contracting organisations. Dounreay nevertheless notes that contract frameworks are in place to assure that personnel are available to support.

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

Dounreay reports that fires are recorded as Unusual Occurrence Reports (UNORs). Dounreay uses UNORs to record deviations from the norm, defects, situations which have or could have caused injury to people, damage to plant or equipment, harm to the environment or pose a quality non-conformance. Dounreay reports that the UNOR database is monitored to identify and analyse trends and provide reports. There have been two fires in the PFR facility in the last decade, one in 2014 and one in 2022:

- A sodium fire was discovered during sodium dig out in the Sodium Tank Farm (STF) in 2014. Dounreay checked each aspect of the work and identified procedural non-compliances and behavioural practices as factors in the incident.
- A second fire occurred in 2022 during treatment (enhanced weathering of sodium residues whereby a flow of humidified air is generated and is then passed through a tank) of sodium in the STF. Dounreay concluded that this was the result of blocked drainage.

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

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

Strengths

Low Baseline Risk

The licensee has identified that the baseline hazards and risks within the PFR facility with respect to nuclear safety are low. This is based on the PFR DSC. The worst-case unmitigated dose and total public risk from the facility are already low and the risk-dominant scenario is an external hazard (aircraft impact). This is primarily due to the fact that the majority of the bulk radioactive sodium coolant has been removed from the facility and residual sodium is held up in pipes/vessels as residues or films. The DSC which covers care and maintenance operations, routine operations, support to decommissioning activities and limited decommissioning tasks has been reviewed recently (2022) as part of Dounreay's LC15 (Periodic Review) compliance arrangements. ONR has recently (2023) assessed the Deterministic Fire Risk Assessment (DFRA) associated with the DSC LC15 review and confirmed that actions identified have been closed out. ONR also confirmed that the analysis undertaken is appropriate for the hazards and risks within PFR.

Modification Safety Case Process

Significant activities or modifications to plant not covered by the DSC are subject to the licensee's modification safety case process. This forms part of the licensee's arrangements for compliance with LC22 (modification or experiment on existing plant). Modification safety cases are subject to the licensee's arrangements, hold point control plan and ONR's permissioning process [127].

The licensee provided relevant examples including the PFR Reactor Vessel Treatment and Reactor Dismantling Projects. The licensee also highlighted that its processes required any modifications to any part of a building to be consulted with the fire safety advisor. This is aligned with the expectations of IAEA SSG-77 I.14 [18] which identifies the need to review implications for nuclear fire safety due to plant modifications. ONR has assessed modification safety case hazard analysis (including fire) for the Reactor Vessel Water Vapour Nitrogen (RWVN) Project and found the analysis to be adequate and broadly aligned with ONR SAPs and TAGs.

Weaknesses

Resourcing of Fire Engineering Support

Dounreay self-identified a potential weakness in that it does not currently have in-house fire specialist engineers who would be able to complete new DFRA's. This places a reliance on contracting organisations and potentially creates a lag between site changes and a complete understanding of any new fire risks. Large changes would be captured by the site modification safety case process (see above) however, smaller changes such as the relocation of combustibles or the introduction of new ignition sources (such as for hot works) would not. As part of a recent intervention, ONR sampled the fire safety analysis for PFR prepared by external contractors [128] and found that the expectations of the ONR TAG on internal hazards [16] had been met. This included the use of recognised fire hazard characterisation and calculation techniques.

Fire Loading and Data Sources

ONR TAG 14 [16] on Internal Hazards provides guidance to inspectors on the adequacy of data related to fire loading including specific examples of loading categories. This guidance builds on ONR SAP EHA.14 – sources of harm [15]. TAG 14 [16] states that “the safety case should provide reference to surveys or studies of combustible substances, which should be systematic and demonstrably complete”. This is aligned with the expectations of IAEA SSG-77 Appendix I-25 [18] to establish and record maximum permissible fire loadings.

The licensee acknowledged that a global (room-by-room) fire load assessment had not been carried out for PFR and limits on fire loading were not derived from the DSC. It should be noted that PFR is in advanced stages of decommissioning with a low baseline nuclear safety risk. Additionally, the licensee stated that fire loading is largely contained in discrete accumulations. This is reflective of the largely open plan nature of the facility with limited barriers to bound a fire loading survey.

ONR inspected Dounreay's control of fire loading at PFR as part of a recent intervention and judged it to be adequate, see Section I-2.6.7.2. ONR nevertheless considers that decommissioning work being undertaken could introduce significant transient combustibles into PFR, particularly low level or non-classified waste and scaffold board used to reach areas in the reactor hall. ONR concludes that Dounreay should develop and implement a methodology for characterising fire loading in a proportionate way, considering the range of projects/facilities which are present at Dounreay and therefore raises it as a recommendation for improvement. The methodology would enable Dounreay to clearly

demonstrate the link between the nuclear safety case and its day-to-day management of fire loading across PFR, and the site more generally.

Combined and Consequential Hazards

ONR expectations on the analysis of combined hazards is captured within TAG 14 [16] and ONR SAP EHA.6 [15]. These are in turn aligned with WENRA SRL E 6.1 [1] and IAEA SSG-64 [17]. As described in Section I-2.6.1, Dounreay's DSC considers the effects of secondary fires due to seismic events or aircraft impact as well as discrete scenarios such as dropped loads leading to fire. The seismic hazard analysis assumes the complete inventory of radioactive sodium is released due to collapse of the secondary containment building. ONR has assessed Dounreay's consideration of combined hazards within specific processes in modification safety cases and concluded that, for example, fire and hydrogen deflagration from the same source are considered within RVWVN hazard analysis.

ONR judges that Dounreay's DSC for PFR does not include a systematic identification of combined hazard scenarios, and these are not systematically reported in the DFRA. Whilst Dounreay has shown that assessment of potential fire hazard combinations is undertaken within PFR, its analysis does not demonstrate that all potential combinations are considered. PFR benefits from a low baseline nuclear safety risk and contains few SSCs which have a hazard withstand claim attached (including from fire). ONR has assessed both the PFR DSC and associated modification safety cases and found that the assessment of hazard combinations is commensurate with the facility type and residual risk. Nevertheless, ONR considers that Dounreay should develop and implement a methodology for combined and consequential hazard analysis (proportionate to the hazards and risks associated with the decommissioning site) and therefore raises it as a recommendation for improvement.

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

ONR provides oversight of licensee's operations through its inspection and assessment functions. Dounreay has two nominated site inspectors who are present onsite approximately one week per month to monitor emerging site issues and advise specialist inspectors on areas of regulatory interest. Significant construction, modification or decommissioning projects which are planned or undertaken by site are assigned a project inspector, supported by specialist inspectors as required.

ONR undertook a nuclear fire safety themed inspection at PFR in February 2023. The inspection focussed on LCs associated with Operating Rules (LC23), Operating Instructions (LC24), Safety Mechanisms, Devices and Circuits (LC27) and EMIT (LC28) in the context of nuclear fire safety. A particular focus was placed on the control of combustibles and actions identified in the DFRA. The inspection found that generally PFRs arrangements were adequate and an inspection rating of green – no formal action was awarded. A level 4 regulatory issue (lowest significance) was assigned to PFR. This related to record keeping of fire alarm maintenance work. Whilst the licensee was able to demonstrate that all alarm addresses were working on the fire alarm panel, the documented trail of repairs was not fully traceable to closure. This action has now been closed as Dounreay has provided adequate evidence of improvements to record keeping and confirmed that any residual

defects on the PFR fire alarm and detection system have been resolved or a suitable work order is in place.

ONR also inspected the PFR facility as part of a life fire safety intervention in July 2022. Whilst this inspection focussed on the requirements of the Fire Scotland Act [21], which is not nuclear site-specific legislation, aspects relevant to nuclear fire safety were examined including ageing and obsolescence of fire systems, staff training and general fire safety management. The inspection concluded that Dounreay's was in compliance with the Act and an inspection rating of 'green' was given. ONR also sampled Dounreay's maintenance and replacement of fire alarm systems and advised Dounreay to take a proactive approach to manage system obsolescence. Dounreay have adopted this approach to manage the condition of assets across site and ensure availability of critical spares.

I-2.6.7.3. Conclusions drawn on the adequacy of the licensee's fire safety analysis

For Dounreay, ONR concludes that a fire safety analysis process is in place and that it is based on recognised sources of relevant good practice. Dounreay's fire safety analysis is completed largely by external contractors and primarily utilises hand calculation techniques and engineering judgement. Dounreay assesses fire loading quantitatively for defined fire scenarios and not globally. ONR has assessed examples of Dounreay's fire safety analysis and raised two recommendations, for Dounreay to develop and implement proportionate approaches to systematic assessment of combined hazards and the characterisation of fire loadings. Dounreay have recognised the gaps in the safety case methodology and committed to address them. A life fire safety based inspection is planned at the Dounreay site for January 2024. This will include consideration of TPR2 findings and the approach taken to suitably close these out. It is intended that a representative from Magnox's central fire team will also attend to provide clarity on Dounreay's ongoing resource profile for fire safety. Any outstanding actions required to address TPR2 findings will be tracked through regulatory issues.

3. Fire protection concept and its implementation

3.1 Fire prevention

This section contains the elements of the fire protection concepts applied for the installations in the scope of the TPR covering the three levels of defence in depth with regard to fire safety and their implementation in the installations, commencing with the first level of defence in depth, namely prevention of fire.

A Nuclear power plants

The text in the sections below has been prepared by EDF NGL and NNB GenCo (HPC) Ltd with minimal editing by ONR.

A-I Operating Facilities – EDF NGL

A-I-3.1.1 Design considerations and prevention means

General: EDF NGL reports that hot works are only considered when all alternative cold work methods, technology and approaches have been considered and discounted as unsuitable. EDF NGL considers this through individual task risk assessment when the need for hot work is identified.

EDF NGL states that persons producing hot work task risk assessments are 'Selected Persons' and trained in hot work methodologies and associated risks, as well as the impact of any hot work in the affected plant areas and any plant fire protection systems in the area. It states that individuals receive formal authorisation to perform the role of 'Hot Work Selected Person' on completion of the necessary training and an authorisation interview demonstrating competence.

EDF NGL's Hot Work Controller assesses the status of work instructions, affected work area and the training of the work party to ensure it is safe for hot work to commence. The Hot Work Controller approves start permission for hot work when satisfied that all controls are in place. EDF NGL requires further Independent Verification (IV) of hot work controls and work area set up prior to receiving work start permission in areas classed as high fire risk. Other high fire risk hot work activities, such as plasma cutting, require IV before start permission is received.

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

General - EDF NGL reports that laydown and storage areas are registered, clearly identified and controlled in accordance with the laydown and storage approval process.

EDF NGL completes fixed fire loading assessments as part of Periodic Safety Reviews (PSR) to ensure the fire loadings remain within the limits afforded by the fire barriers. It

reports that any change to fixed fire loading is subject to the Engineering Change process and respective fire protection specialist assessment. EDF NGL applies limits on the basis that a 1-hour fire barrier will withstand energy from fire loading up to 900MJ/m².

The laydown/storage process for managing transient fire loads (as discussed in I-2.1.2.4 and referenced in the licensee's self-assessment [25]) considers the impact of the additional fire loading on the compartment fire barrier ability to withstand energy from an all-consuming fire involving both fixed and transient fire loads.

EDF NGL identifies and demarcates predetermined laydown areas at each location for temporary and permanent storage. EDF NGL reports that storage of combustible items is risk assessed by the location Fire Safety Co-ordinator, considering existing risks and control measures and noting any restrictions or control measures to be applied. It also reports that checks are made of the laydown areas during plant walkdowns ensuring all laydown areas are compliant with these measures. Further details of these and other walkdowns are provided in the licensee's self-assessment [25] along with the on-site roles who perform them.

A-I-3.1.2.1 Key examples of fire strategies

General EDF NGL has station and fleet wide standards documented and communicated for managing the following:

- Laydown and work area – control of combustibles which specifies the control of laydown areas, their inspection, their proximity to ignition sources and how flammable or combustible material should be stored.

Flammable and chemical storage control which specifies how such locations are approved and registered, the ownership and limitations of such locations, and how the flammable materials should be stored and located.

- Oil leak management which specifies the reporting, recording and catching of oil leaks. EDF NGL sites, in conjunction with its scaffold contract partner, implemented a standard of using aluminium scaffold boards in place of wooden boards removing the introduction of fire loading into plant areas where access platforms were required. EDF NGL reports that this also removed a vast amount of fire loading in scaffold storage areas and buildings.

Further detail is provided in the licensee's self-assessment [25].

EDF NGL reports that each plant area and building has been risk assessed with identified risks and control measures recorded in an area specific fire risk assessment report. It also reports that each area/building is allocated a fire risk rating based on the risk assessment findings. The ratings are High, Medium or Low. EDF NGL aligns the frequency of re-assessment with the area risk rating with High-risk areas being re-assessed yearly, Medium-risk ratings every 2 years and Low risk ratings every 3 years. The risk assessments record the following for each area/building its construction, main use, occupancy characteristics, key hazards and processes, fire protection measures and the

means of escape strategy. EDF NGL derives the overall risk rating by assessing the following:

- Risk of fire occurring by considering control of combustibles, sources of ignition/heat, building construction and any flammables or explosive atmospheres present.
- Potential for fire to affect people by considering the area risk profile (type of fuel and people present), means of escape, fire safety signage present, emergency lighting provisions, presence of fire detection and alarm systems as well as fire barriers, suppression systems and portable fire extinguishers.
- Potential for fire to affect nuclear safety with reference to nuclear safety case claims made on the area or plant located within the area.
- Potential for fire to affect the commercial operation of the station.

In addition to area fire risk assessments, EDF NGL reports that each site has a DSEAR (Dangerous Substances and Explosive Atmospheres Regulations) risk assessment which specifies the presence and extent of potentially explosive atmospheres along with record of plant and other components located within these DSEAR zones that may provide an ignition source. EDF NGL states that it reassesses each zone along with its plant and other ignition sources on a 3 yearly frequency.

A-I-3.1.3 Licensee's experience of the implementation of the fire prevention

A-I-3.1.3.1 Overview of strengths and weaknesses

EDF NGL reports that hot work control arrangements had been recognised as industry best practice both within the UK and within the World Association of Nuclear Operator Fire Safety Peer Groups.

EDF NGL considers each station's organisational arrangements for fire safety process implementation, governance and oversight to be strong with responsibility for Fire Safety built 'into the line', promoting strong cross functional engagement and ownership of fire safety performance and improvement.

EDF NGL recognises that station operations are dynamic with ongoing maintenance and operational activities taking place involving core staff and contract partners. It also reports that fire safety culture, behaviours and standards always need re-enforcing to minimise fire risk associated with these tasks.

Another potential ignition source is from electrical circuits. EDF NGL states that there is a preventative maintenance programme of work on all electrical equipment, which includes inspection of lighting and small power circuits, electric motors, and portable and transportable equipment. This gives EDF NGL confidence that the electrical supplies provided are robust and that the potential for electrically induced ignition sources are minimised. EDF NGL supports this through routine fire risk assessments.

A-I-3.1.3.2 Lessons learned from events, reviews fire safety related missions, etc.

EDF states that all major and minor fire events are shared across the sites as well as with the regulator and that it shares the outcome of regulator fire safety inspections across sites for learning and proactive action to address any similar shortfalls elsewhere in the EDF NGL fleet.

EDF NGL currently holds the position of Deputy Chairperson of the UK Nuclear Industry Fire Safety Co-ordination Committee where events and learning are shared with other UK nuclear licensees. EDF NGL is an active member and participant on the WANO Industry Fire Protection Working. EDF NGL reports that all learning opportunities for the fleet are shared and tracked at the Fleet Fire Safety Task Team.

A-I-3.1.3.3 Overview of actions and implementation status

General - Actions and implementation of the actions are managed by the Fleet Fire Safety Manager and deputy Fleet Fire Safety Manager. EDF NGL has two Fire Safety Engineers in EDF NGL's Engineering Function, who also provide hazards advice to the Design Authority. EDF NGL records Action Requests (ARs) in the station management system, tracking commitments e.g. from the engineering change process in the station management system. EDF NGL Technical Governance processes include compliance trackers. There is a Corrective Action Programme including condition reports this assesses all identified issues.

EDF NGL reports that there are fire safety action teams at all the stations, which hold regular meetings with ONR. It also states that there are WANO reviews and and Periodic Safety Review actions. EDF NGL deals with anomalies through the safety case anomalies process until closed, tracked to completion by the Design Authority. EDF NGL stations have System Engineers allocated to ensure that fire protection arrangements are maintained. Regular user groups are convened to share operating experience. EDF NGL's company Independent Nuclear Assessment (INA) provides an oversight of company and station safety arrangements.

Fire Safety Metrics

EDF NGL tracks fire safety metrics for fire safety system health across all sites. The metrics track defects relating to detection, suppression, fire barriers, fire doors, fire dampers etc. to identify at a glance whether the stations are meeting the requirements to maintain safe systems under fire safety. EDF NGL reports that long standing defects and those recently raised allow station Fire Safety Co-ordinators (FSCs) to highlight these and work closely with the Engineering departments to ensure work is planned to bring systems back into line. EDF NGL considers that the Fire Safety Metrics allow the central fire function to see the progress of any required maintenance activities, and where necessary, the central fire function provides support to the individual stations. In addition, FSCs support other stations as appropriate. EDF NGL reports that monthly discussions allow cross station support and co-ordination.

A-I-3.1.4 Regulator's assessment of the fire prevention

A-I-3.1.4.1 Overview of strengths and weaknesses in the fire prevention

The process described by EDF NGL for fire load accounting and management meets the expectations in ONR's Internal Hazards TAG [16], which expects the safety case to be underpinned by surveys of combustible substances, which should be systematic and demonstrably complete. This should include consideration of solids, gases, liquids, vapours and transient loads. The licensee has demonstrated a process that is in accordance with the expectations of IAEA SSG-77 [18] that procedures should be established for the purpose of ensuring that amounts of combustible materials (the fire load) and the numbers of ignition sources be minimised. EDF NGL has described a process for management of hot work that meets this expectation.

A-I-3.1.4.2 Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

ONR undertakes regulatory interventions across EDF NGL sites including inspections covering fire prevention matters from both a nuclear fire safety and life fire safety perspectives. There have been no issues of note in relation to fire prevention at EDF NGL sites.

A-II New Build Facilities – NNB GenCo

A-II-3.1.1 Design considerations and prevention means

The general principles for preventing a fire from starting or reducing the likelihood of a fire are outlined in PCSR3 Section 13.2 [129], the FAD [48] Section 4.2 and HPC fire strategy document [130] are to limit fire loads, to separate them or effectively remove them with passive fire protection (enclosure or encasement), and to minimise potential ignition sources near combustible equipment. NNB GenCo reports that prevention is achieved by the following design specifications which it included in equipment procurement specifications (reproduced literally from NNB GenCo's self-assessment):

- **Choice of material:** *Materials used shall preferentially be non-combustible (e.g., A1 or A2S1d0 in accordance with EN 13501-1). The use of combustible materials in the fresh nuclear fuel storage room is heavily restricted. Materials which are not Class A1 must be at least type Ba1d0 or Cs1d0, in accordance with EN 13501, and must be chosen to reduce smoke production and toxicity.*
- **Mechanical equipment characteristics:** *Cooling systems shall only use non-flammable coolants. Reactor coolant pumps shall be provided with level transmitters to monitor oil levels in the tank and equipment. Pumps and motors with more than 50 litres of oil shall be fitted with collecting systems and holding pans with sufficient capacity for all the oil that might leak. Crane reducers containing combustible fluid should be separated from the control and power cubicles or cabinets by 3 metres or more. Tanks used for storage of toxic, radioactive, flammable, corrosive or explosive liquids shall be leak tight and able to withstand the physical and chemical properties of their contents.*

The risk of fire associated with sumps which may contain combustible liquid should be assessed on a case-by-case basis.

In addition, the use of oil filled transformers or switchgear equipment should be avoided as far as possible. All oil filled transformers and switchgear should be provided with fixed firefighting systems. Oil filled transformers should be separated from each other and from nearby buildings by fire and blast walls with at least 2 hours fire rating. The use of combustible materials in dry nuclear fuel storage rooms is strictly forbidden.

- **Electrical equipment and cabling:** *The fire resistance standards of cabling and wiring depend on the type of cabling or wiring but include the modern standards NF C32-070, BS EN IEC 60332-3-23, BS EN IEC 60332-3-24. Limits are imposed on the mass of cable per metre. Specific provisions are required for transformers containing flammable dielectric materials. Cabinets shall be metal construction. Connections shall be as short as possible and enter the cabinet from the underside through the floor. Arcing shall be considered in the arrangement of electrical equipment. Junction boxes should be metallic and rated to IP55 according to IEC 60529.*
- **Layout rules:**
 - **Staircases and corridors:** *Fire loads and fire risks shall be minimised in main staircases and corridors.*
 - **Piping:** *Hot spots which could ignite sprayed fuel fluid leaks shall be provided with heat insulation with a leak tight lining. Pipe connections shall be welded to limit the risk of leakage from flammable fluid lines, and where flanged joints cannot be avoided, they shall be socket weld type and all nuts shall be locked. The number of fittings and hoses shall be minimised, and any hoses that cannot be designed out shall be chosen from those which have the best fire performance. Pipes containing hydrogen should be routed through areas or rooms with limited fire risk, and kept away from high voltage equipment, electrical cabinets or pumps containing oil.*
 - **Tanks and storage areas:** *The layout rules for flammable liquids include requirements for fire resistance of floor areas and requirements for spill collection and holding tanks or bunds with sufficient capacity for the tank contents and firewater runoff. Areas for handling liquid or liquefied flammable or explosive products must be leak tight and have provision for leak recovery. Explosive or oxidising gases must not be stored in rooms containing safety related systems. Storage of flammable liquids and gas lines in SFA or SFP should be avoided.*
 - **Electrical:** *Cable raceways shall be at least 1m away from ducts or equipment containing hot or flammable fluids, except for connection of equipment installed on such ducts.*
 - **Hot works and transient ignition sources:** *HPC is not yet operational so a full set of procedures is not in place, but it is intended to implement a permit to work system for all hot works outside areas such as maintenance workshops that are designated for such works, in accordance with European Mutual Associated for Nuclear Loss Control Standards (EMANI) [131], [130].*

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

HPC is currently under construction, so the arrangements and procedures for controlling fire load and ignition sources are not yet in place for once the reactors become operational. However, the operational procedures are expected to include measures to restrict the fire load and ignition sources to those assumed in the fire hazards assessments. NNB GenCo reports that any changes will be subject to the station modification control process. NNB GenCo expects these procedures to include restrictions on quantity and flashpoint of combustible materials permanently present in the plant or temporarily brought in for maintenance, and strict controls on hot work and any other transient hazards associated with maintenance. NNB GenCo also states that combustible content of waste brought into processing or storage facilities would also be subject to procedural controls.

The HPC Fire Strategy Document [130] indicates that procedural measures to be introduced to control fire load and ignition sources for nuclear safety and life safety include procedural controls, firefighting equipment, and spill kits where necessary when vehicles enter buildings for deliveries. NNB GenCo reports that Atmosphere Explosible (ATEX) rated equipment will be installed for hazardous zones as required by the DSEAR regulations, based on building specific DSEAR assessments. It also states that any handling of liquid or liquefied flammable or explosive products will be carried out in leak-tight areas that are laid out for recovery of leaks. NNB GenCo expresses its commitment to follow standard HSE guidance and good practice for on-site receipt and handling of flammable and combustible materials at designated storage facilities, procedural controls, provide firefighting equipment, and spill kits where necessary, when vehicles enter buildings for deliveries.

A-II-3.1.3 Licensee's experience of the implementation of the fire prevention

A-II-3.1.3.1 Overview of strengths and weaknesses

NNB GenCo considers that the fire prevention measures described have been developed from the modern standards described in Section 1.2 and judged them to satisfy WENRA requirements.

NNB GenCo summarises the main adaptations made when applying UK context to the French-derived ETC-F codes below, based on the HPC Codes and Standards Review [132] Section 7. Please note the text is taken literally from NNB GenCo's self-assessment:

- *The original intention was to omit modelling studies to demonstrate robustness of fire compartmentation for rooms which are served by automatic fire extinguishing systems. The scope has now been extended to include such rooms, rather than omitting them from further study based on claims on the active fire protection systems. This brings the approach in line*
- *Differences between the accepted practice of fire resistance duration between the EPR design and other stations in the UK fleet.*
- *The fire resistance ratings for the different fire zones have been modified. The fire resistance of the Access Fire Compartment (SFA) has been increased from one-hour to*

two-hours. The requirements for the 'insulation' fire resistance ('I' requirement in the EN 13501 classification scheme) for some fire barrier elements within the conventional fire compartments (those not directly claimed for nuclear safety) have been amended to be more consistent with UK practice.

A-II-3.1.3.2 Lessons learned from events, reviews fire safety related missions, etc.

Feedback from the French nuclear fleet reported in the HPC Fire Strategy document [130] suggested that the fire risk posed by electrical cables is low. Self-ignition events outside gallery spaces all involved high voltage cables and some form of installation error, and only a very small number of fires have been reported within cable galleries.

A-II-3.1.3.3 Overview of actions and implementation status

No actions were identified by NNB GenCo.

A-II-3.1.4 Regulator's assessment of the fire prevention

A-II-3.1.4.1 Overview of strengths and weaknesses in the fire prevention

The licensee's self-assessment [49] identifies fire load accounting and management as an area of focus for future operational procedures. It also acknowledges the need to develop administrative procedures for the management of hot work. NNB GenCo's procedures are not yet developed, however, this is commensurate with the stage of the HPC project and ONR will monitor progress through normal regulatory business and with reference to ONR's Internal Hazards TAG [16] and IAEA SSG-77 [18].

A-II-3.1.4.2 Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

ONR has carried out a number of life fire safety inspections at the HPC construction site, providing regulatory intelligence on the management of fire safety during the build process. A life fire inspection in 2023 [133] identified shortfalls relating to the control and management of combustible materials and ignition sources at the construction site, and the failure to adequately manage and monitor fire alarm systems required immediate intervention. A 2022 life fire inspection [134] found that there were inadequate procedures for controlling hot works in the HGE gallery (the raw water supply and storage liaison gallery). These centred around inadequate control of hot works, including the absence of a task specific hot works permit and fire watch arrangements. Many of the issues identified have been resolved but others are still being addressed. ONR continues to undertake fire safety interventions at the construction site.

Whilst the shortfalls related to fire issues in the construction site and are not per se representative of the future operation of the site, ONR stressed the importance of reinforcing safety culture for fire safety (from both a life protection and nuclear safety perspective).

B Research reactors

The UK has no research reactors in operation.

C Fuel cycle facilities

To avoid duplication, reprocessing facilities at Sellafield are reported alongside all Sellafield waste storage facilities in section E. The text in Section C has been prepared by Urenco UK Ltd (UUK) and Springfields Fuels Ltd. Background information on the sites and the range of installations considered in the scope of the assessment is provided in Sections 1.1.2 and 1.1.3.

C-I Enrichment facilities – Urenco UK Ltd (UUK) Capenhurst

C-I-3.1.1 Design considerations and prevention means

UUK's basis of design for fire prevention in new build facilities and refurbishment standards for existing facilities are based upon BS9997 (Fire Risk Management Systems – defining requirements with guidance for use) and BS9999 (Fire Safety in the Design, Management and Use of Buildings Code of Practice). Subsequently UUK reported three primary objectives at Capenhurst:

- Minimise potential for fire to occur
- Reduce fire incidences
- To safeguard all persons from harm in the event of fire

Fire protection refers to measures taken to prevent fire from becoming destructive, reduce the impact of an uncontrolled fire, and save lives and property. Fire prevention measures at UUK include:

- Fire-resistant building construction materials conforming to a facility specific Fire Strategy.
- Safety planning, including Departmental Emergency Arrangements, management of temporary lay down areas, Standard Operating Procedures for Incident Response Service.
- Safe operations, including management of fire loading, location of nuclear inventory, and ignition sources such as control of hot work, etc.
- Providing education on fire risks and safety.
- Implementing safety planning practices and drills.
- Training and testing of mitigating systems, including fire detection/suppression and automatic shutdown systems.
- Conducting research and investigations.

The recommendations and guidance given in the British Standard assume that under normal circumstances (i.e., except in the case of arson) a fire is unlikely to start in two different places in a building at the same time.

UUK considers that fire is most likely to start within the occupied or operational areas subject to use of the facility rather than in the protected areas, access routes or stairwells, as these are designated areas and kept in a 'sterile' state. UUK states that a fire occurring anywhere within a compartment of a building has, therefore, to be regarded as presenting a hazard to all occupants within that compartment, even though in the initial stages of fire development it might seem that the hazard is small, and people are in no immediate danger. The speed at which a compartment becomes untenable is dependent upon many intrinsically linked factors including spatial volume and geometry; fuel load and fire growth rate; passive and active fire precautions. These factors are particularly important when dealing with potential nuclear safety fire hazards/inventory and/or life safety of persons.

UUK states that all personnel working on the Capenhurst site, irrespective of employer, are recognised to have a part to play in implementing the Fire Safety Policy and reducing the risk from fire. UUK expects all working on site to act, appropriate to their role, to ensure that the general fire precautions are implemented by:

- Reducing the risk of fire starting and spreading within their area of work by controlling sources of ignition and fuel particularly through maintaining good housekeeping standards.
- Ensuring that means of escape from the premises can be safely and effectively used at all times.
- Ensuring that fire extinguishers remain in their designated location and reporting any defects or issues with extinguishers in the building where they work.
- Reporting any faults or issues with the fire detection and alarm system immediately.
- Understanding the action to be taken in the event of fire on the premises.
- Participating in fire safety training and evacuation drills as required.

UUK's fire prevention strategy for new facilities is for build in accordance with building regulations utilising BS 9999 methodology, taking a holistic approach to the design, management and use of buildings and fire risk management systems in accordance with BS 9997 (Annex C) providing a methodology and mechanism for the scoring of fire risk assessment documents.

The Capenhurst HSSE Shared Service carry out assurance activities in relation to fire safety such as formal audits, formal inspections as part of fire risk assessment review, routine inspections of general fire safety provisions, fire logbook checks and witnessing of fire evacuation exercises. UUK states that it supplements these by self-verification activities such as local inspections and management walk downs which are arranged and recorded according to Company specific arrangements. UUK's goal is to ensure an integrated approach (using the Plan-Do-Check-Act model) to deliver continuing improvement.

BS9997 presents a strategic approach to fire risk management at organization level, and forms part of the BS999X series. Particular attention is given to BS9999:2017, Section 4, which provides guidance for those designing fire risk management into buildings.

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

UUK governs hot works by a Control of Hot Works Standard based upon the principles of the Fire Protection Association (FPA) 'Recommendations for Hot Works' (FPA RC7 & Guide) which provides definition of associated terms, principles and requirements for risk assessments including control of ignition sources, fuel and associated activities with emphasis made on heightened precautions where work is undertaken in close proximity to insulated sandwich panels.

This document also includes hot work licensed area inspection checklist, Hot Work Certificate to permission work alongside the general Safe System of Work (SSoW) process and training requirements with supporting documents (the Golden Thread).

UUK states that a Hot Work Certificate can only be issued by personnel who are appointed to the role, having completed a Job Profile & Competency Assessment interview. UUK's pre-requisites include:

- Fire Protection Association Hot Work Passport
- Annual Theoretical & 3-yearly Practical Fire Training
- Oxy-fuel equipment maintenance
- Use of the RS PRO RS700 Thermal Imaging Camera
- 5-yearly DSEAR ½ Day course
- Annual DSEAR e-Learning
- Safe System of Work framework
- Control of Hot Work Standard
- Electronic Hot Work Certificate
- Hot Work Licensed Area Inspection Checklist

UUK reports that, subject to work location, hot work applications are made 72-hours in advance of the work being undertaken via the established Permit Offices. It also states that work and competency documents are included in the General Work Permit and Risk Assessment/Method Statement and positively verified via the Area Owner/Duly Appointed Person/Senior Shift Operator and/or Shift Manager. UUK limits the Hot Work Certificate to a duration of 12 hours (i.e. one working 12-hour shift), issued by an Appointed Person in accordance with SSoW and Control of Hot Work Standards.

UUK determines fire loadings by generating a list of items manufactured from or contain combustible/flammable materials. UUK records the number of items, mass or volume. It then converts the information into combustible load (in MJ). UUK defines the fire load density (MJ/m²) as the total fire load in the room divided by the floor area, to provide an

indication on the potential severity of a fire initiating in the room. Further to this, UUK applies limits on fire loading within high risk areas, means of escape, etc.

BS9999:2017 – Table 3 provides examples of Fire Growth Rates relevant to Category (1-4), Fire Growth Rate (*Slow, Medium Fast & Ultra-fast*), Fire Growth Parameter (kJ/s^3), Description and Typical Examples. The acceptable maximum fire load is determined through a combination of reviewing the Fire Strategy, Fire Risk Assessment, building construction, assessing the constituents, quantity and circumstances and operational experience noting that a building/compartment with a high fire load density will not necessarily have a rapid-fire growth rate, and a low fire density will not necessarily have a slow fire growth rate.

UUK captures the limits identified/quantified within the Fire Risk Assessment (FRA) and communicates them to Buildings Owners and Workplace Operators. UUK reports that these are subject to periodic inspections, audits and walkdowns to verify compliance. UUK states that, as far as reasonably practicable, specific laydown areas (permanent or temporary) are designated within non/low risk areas and subject to licensing to ensure levels of housekeeping and the reduction of combustible materials is kept to acceptable levels. UUK reports that the business site-wide (and the building fire strategy) has a requirement to restrict the use of wooden pallets/scaffold boards on plant and stores/equipment are removed from combustible packaging prior to entering plant. UUK states that this is further reinforced through the Building Fire Strategy, FRA review and 5S Lean Process for workplace inspection which are underpinned through BS 9999:2017 methodology and legal requirements under the Regulatory Reform (Fire Safety) Order 2005 and FPA Guidance.

Following the significant fire event in the UK (Grenfell Tower Fire), external to the nuclear industry, UUK carried out a review of building cladding combustibility and the impact on life safety and nuclear fire safety for all buildings. UUK developed a cladding fire testing strategy and then inspected buildings. UUK reports that for buildings under construction at the time of review, it completed a desktop study of the designs and construction. Where UUK did not have documented information on the type of insulation then it took the following actions for each building (reproduced literally from UUK's self-assessment):

UUK Fire Testing Strategy

Where documented information on the type of insulation was not available then the following actions were taken for each building:

- 1. inspection of the cladding from internal and external elevations ensuring that representative samples were taken/inspected. This determined any areas where the insulation was exposed and, if sufficiently exposed, a judgement was made on the composition of the cladding.*
- 2. where the cladding was fully sealed and no areas of insulation were exposed, arrangements were made to safely expose the insulation and an assessment made.*
- 3. if the material had a rigid foam appearance, the material was assumed to be combustible without further testing.*
- 4. if the material had a stone wool appearance, depending on the location it was either assumed to be combustible or a fire test (using the BS 476-11 fire test with small samples) carried out to determine if the material was either non-combustible or of limited combustibility.*

UUK carried out the inspections in consultation with nuclear safety case assessors to determine the level of fire assessment that was appropriate based on the radiological risks identified within the safety case. UUK then produced a register of external building cladding which detailed the cladding specification for all buildings with a nuclear inventory.

In relation to life safety, the outcome of the review required the update of fire risk assessments and Building Information Packs for all buildings with cladding of unknown or combustible insulation. UUK then updated the fire risk assessments for all buildings as part of the normal review cycle.

The review identified that some buildings containing a nuclear inventory were constructed with either combustible or unknown cladding and, therefore, required further consideration. UUK states that due to the Long Term Periodic Review cycle and timescales, several of the safety case Continued Operations Safety and Environmental Reports (COSER) included assessments of nuclear fire risk that were not in line with modern safety case standards and that updated assessments would be carried out as part of the COSER delivery, adoption and implementation programme.

In line with the fire testing strategy and pending formal assessment as part of the COSER programme, UUK's safety case assessors reviewed the impact of building cladding on nuclear fire safety risk and the safety case owners assessed the impact of these findings to determine if any immediate retrospective work or acceleration of their COSER programme was required.

UUK's assessments concluded that the nuclear fire safety risk from all buildings was acceptable and that the nuclear fire safety risk from building cladding did not require any acceleration of the planned Long Term Periodic Review of the safety cases.

UUK's post-Grenfell review also provided key findings in relation to:

- Fire Risk Assessment, frequency of review
- Training and competency
- Use of accredited 3rd party/certified contractors
- Due diligence of materials used in construction or refurbishment
- Project sign-off following internal Com-T01 procedures
- Verbatim compliance with Building Regulation 38

UUK states that the learning provided a focus for review of Capenhurst process and procedure with an outcome resulting in:

- An explicit ban on the use of combustible cladding on buildings regardless of height and remedial actions to determine constituents of installed cladding/aluminium composite materials.
- Job profiles and competency assessments of staff and contractors have been reviewed to ensure demonstrable SQEP currency and continuation of professional development.
- Review and update of Building Information Packs.

UUK states that it took actions above and beyond subsequent regulatory changes, specifically to reduce totality of combustible loads, maintenance and assessment of fire compartmentation.

UUK states that flammable liquids and gases are assessed within processes for management of hazardous substances aligned to the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR), Health and Safety Executive Guidance HSG 51 and British Compressed Gas Association Guidance (BCGA), resulting in area classification where appropriate, and designated storage cabinets designed to BS EN 14470-1 and ANSI/NFPA 30. The storage of flammable and non-flammable cylinders are otherwise in accordance with BCGA CP44 'The Storage of Gas Cylinders Code of Practice Rev. 1 2022' noting that the site security strategy currently prohibits the establishment of a centralised gas cylinder storage facility.

UUK reports that the use and storage of portable gas cylinders on site follow the hierarchy of risk control methodology such that consideration is given to:

- Elimination – storage locations remote from uranic inventory and occupied building areas
- Substitution – use of alternative gases of lower hazard potential where possible (propylene in preference to acetylene)
- Engineering controls – smallest possible volume cylinder, protective devices and associated Engineering, Maintenance, Inspection & Testing (EMIT)
- Administrative controls – 'Just In Time' stock control, Hot Work licenced area and certificates, Hot Work training, Hazardous Area and equipment specific training (i.e. oxy-fuel maintenance) and advanced fire training.

UUK states that cylinders, including transient materials, are stored in low risk areas of plant within well-ventilated locations and are subject to periodic audits and inspections. UUK reports that it has also worked closely with suppliers to reduce the number of cylinders collectively on site and has adopted an 'in time' re-supply strategy.

UUK reports that it undertakes DSEAR risk assessments specific to facilities on a periodic cycle, with annual reviews and periodic inspections/audits at least quarterly. UUK's identified DSEAR hazardous areas include:

- Bulk hydrogen storage and associated pipework system
- Natural Gas feed to steam boiler systems
- Diesel/Kerosene tanks
- Hot oil heat transfer systems
- Battery charging stations
- UPS systems
- Gas cylinder storage and use (within defined workshop)

UUK reports that it establishes requirements for additional prevention measures through the hazardous area classification process:

- Hydrogen gas monitoring and plant shutdown systems include automated nitrogen purge to minimise potential for the generation of explosive concentration conditions;
- Plant design provides mechanical integrity in the event of a deflagration event;
- UUK reports that it assessed the use of thermal and optical sensors to detect burning hydrogen taking into consideration the area/volume of potential coverage, and noting optical sensors operate in the ultraviolet or infra-red spectral region. UUK discounted them based on the installation of the safety system and other consideration (i.e. areas of natural ventilation).
- General EMIT of systems associated with DSEAR and specific CompEX maintenance programmes for ATEX equipment within hazardous areas;
- Control of ignition/heat sources (Hot Work Standard) and designation of appropriate ATEX equipment, safety signage and associated inspection and maintenance routines by competent (CompEX) personnel. UUK states that it provides specific training for persons operating within these areas is via a three tier system which includes e-learning and specialist instructor led training.

UUK reports as key learning the following points:

- replacement of transformer oil with a non-combustible alternative
- review and update of arrangements for information, instruction & training
- reduced combustible gas cylinder sizes
- programme of lead acid battery replacement with VRLA batteries to reduce the potential risk of hydrogen.

UUK reports that fires of an electrical origin are controlled throughout the lifecycle of electrical systems and equipment.

UUK states that the design of electrical systems is carried out in accordance with the required company, national and international standards with an appropriate level of control and oversight by the Design Authority and Senior Authorised Person Electrical (SAPE) providing a governance framework for the production, assessment and approval of design documentation.

UUK reports that it has arrangements in place to ensure safe work on or with electrical systems and electrical equipment including construction, installation, commissioning, modification, maintenance, testing, operation and decommissioning of electrical equipment. These arrangements specify the appointments and competency required for those persons with responsibilities for electrical safety and those persons undertaking electrical work. UUK produces this Company Instruction to comply with regulatory requirements and associated guidance documents.

UUK reports that detailed instructions exist which comply with the relevant Codes of Practice for the specification and execution of preventative and reactive maintenance of the fixed electrical equipment. Electrical maintenance includes Examination, Inspection, Maintenance and Testing. UUK acknowledged that the normally dormant state of electrical switchgear, distribution systems and associated control and protection equipment does not automatically draw attention to emerging faults, deterioration or danger resulting from neglect and the consequent need for maintenance. UUK states that it therefore implements an organised system of maintenance is to facilitate continued safe and acceptable operation of an electrical system with the minimum risk of failure and consequent interruption of supply. It listed that, for high voltage equipment, evidence and experience led checks ranged from functional checks, non-intrusive testing, progressive sampling (to assess the continuing condition of the equipment and its potential failure risk), through to complete replacement. UUK reports that it gathers evidence from the performance of the system, operational history, environmental exposure, physical condition, age and consequence of failure. It also referred to experience from similar systems, manufacturer's maintenance guidance in addition to the process driven experience on failure modes unknown to manufacturers.

UUK's maintenance is generally on a fixed periodic basis derived from a technical basis of maintenance assessment but can be extended or brought forward using a technical risk based approach to provide justification. UUK states that, where possible and practicable, it uses non-intrusive techniques (for example, thermographic imaging/inspection, partial discharge detection), to monitor the condition of plant and equipment between intrusive maintenance.

C-I-3.1.3 Licensee's experience of the implementation of the fire prevention

C-I-3.1.3.1 Overview of strengths and weaknesses

UUK reports that assessment of nuclear fire, life fire safety and asset protection risks have culminated in comparable recommendations in terms of prevention, mitigation and detection.

UUK states that following re-organisation in 2020, it placed an increased focus was made on fire safety management and identified deficiencies. This was specific to the understanding and responsibility for the application and maintenance of life safety systems and adherence to the fire safety strategies through the implementation of a coherent prevention-protection-response approach.

UUK reports that continued assessment and review of fire prevention strategy implementation identified the following areas of strength:

- Fire-resistant building construction materials conforming to a facility specific Fire Strategy
 - Robust programme of production of Fire Strategies as part of new build and refurbishment activities supporting FRA's (Golden Thread);
 - Use of drone technology to facilitate detailed inspection of existing facilities in relation to fire compartmentation;

- The planned application of building information modelling (BIM) for three-dimensional (3D) visualization and data/information storage for planning and maintaining upcoming building projects.
- Safety planning, including Departmental Emergency Arrangements, management of temporary lay down areas, Standard Operating Procedures for Incident Response Service
 - A fundamental review and creation of a single suite of Standards covering the Management of Fire Safety, Hot Works, DSEAR/CoSHH, Automatic Fire Detection System Testing & Maintenance, Fire Compartmentation and Emergency Lighting.
 - Robust Change Management Processes
 - Designated/Licensed Lay Down Areas
- Safe operations, including management of fire loading, location of nuclear inventory, and ignition sources such as control of hot work, etc.
 - The identification and appointment of Building Owners, Workplace Operators & Safety Case Owners with accountability for fire prevention and corrective actions.
 - Proactive reporting of non-compliance in fire safety related disciplines directly to the Urenco Intelligent Customer from the outsourced Incident Response Service as part of 'business as usual' activities.
- Providing education on fire risks and safety
 - Refreshed E-Learning packages, 3-year theoretical and practical fire training and periodic issue of Fire Prevention Briefing Notes promoting workplace and home related fire safety
- Implementing safety planning practices and drills
 - Fire Inspections, Auditing and Assessment programme established
 - Weekly Safety & Environmental Walk Downs
 - 5S Standard (Quarterly Audits)
- Training and testing of mitigating systems, including fire detection/suppression and automatic shutdown systems
 - Transfer of fire detection/suppression EMIT to a specialist contractor with dedicated oversight and management from Urenco to ensure timely undertaking of routine maintenance with bi-weekly progress meetings identifying work schedules as well as reviewing remediation programme progress.
- Conducting research and investigations

- Investigation and Action Tracking via electronic platform following a reported thermal event on Urenco owned/occupied assets
- Bi-annual meetings of Nuclear Industry Fire Safety Co-ordinating Committee and regular information sharing between scheduled events. With collective representation at British Standards Institute working groups for standard setting.
- Attendance at national and international fire safety related events i.e. FireEx International.
- Membership of the Fire Protection Association enabling direct access to their resource library, webinars, access to experts and sharing of Learning from Experience.

UUK reports the following points as self-identified weaknesses:

- Underutilisation of the site risk register to promote visibility and priority of areas of identified weakness;
- Transfer of Actions to Projects, but then deferred/cancelled with no impact assessment undertaken. Recognised improvement opportunity with remedial work underway
- Delay in progressive development of an established team of internal SQEP resources to support fire risk assessment programme to support significant increase in demand
- Not all role holders with accountability for fire prevention and safety have completed formal training to demonstrate SQEP resulting in greater demand on process owner
- High turnover in Incident Response Service personnel and recruitment shortfall in required skillset resulting in loss of corporate knowledge and capability shortfalls.

C-I-3.1.3.2 Lessons learned from events, reviews fire safety related missions, etc.

The Capenhurst site has been in operation for over fifty years, with assets varying in age up to present day with further development underway. UUK reports that the lessons learned from events/fire safety-related missions are limited to the following incidents:

Methoklone Cleaning Tank Fire – February 2012: A degreasing bath caught light through system errors. The incident was further compounded by zonal isolation of fire detection without those involved in the process understanding the ‘cause and effect’. The root cause identified the failure of third-party contractor to implement SSoW, such that the equipment was left energised despite attending to fix the equipment with a known thermostatic fault. The resulting conflict with simultaneous operations (SimOps) subsequently led to an initial change of degreasing agent to reduce risk, and improved SSoW and SimOps control. UUK reports that, shortly afterwards the equipment was removed, and that an alternative method was successfully trailed and implemented.

Uninterruptible Power Supply (UPS) Fire – January 2015: UUK reported on a third-party specialist investigation and learning from experience following the UPS fire incident. The investigation identified the limitations of thermographic imagery as an EMIT technique as the fault condition was affected by system loading, contributed to a fault condition not being

seen through inspection. The incident led to cascade failure of installed battery units due to poor maintenance and life cycle management. UUK's options for improvement included change over to new battery technology, Valve Regulated Lead Acid (VRLA); Hot Connection Indicators to provide a permanent indication method.

Process Pump Fire – July 2015: UUK undertook a forensic investigation by a fire specialist and reported that the identified root cause was an imbalanced fan element causing the bearing to overheat and eventually fail. Contributing factors included poor quality control of spares and the balancing of fans by the manufacturer and the relocation of emergency stop buttons purportedly made several years earlier.

ONR regulatory intervention – December 2019: During a scheduled fire inspection, the ONR inspector noted several warnings/faults on the main fire alarm panel. Further investigation identified that EMIT had not been completed in accordance with BS5839 by the appointed Contractor. UUK reported remediation and subsequent improvements to fire detection faults and system warnings driven by a site-wide survey of functionality and maintenance records. The business identified significant inaccuracies of third-party assurance certification and their failure to remediate faults and warnings within a suitably adequate timeline. This led to the formulation of oversight described in Section C-II-3.1.3.1 including:

- User Requirement Specification document for suppliers
- Weekly Maintenance Scheduling and Review meetings with key stakeholders
- Governance meetings
- Identification and Replacement of obsolete equipment
- Installation of L1/P1 Automatic Fire Detection Systems for existing buildings and all new builds.

UUK reported the subsequent lessons learned included improvements to maintenance schedules, audits and inspections and introduction of innovation (such as use of drones for fire compartmentation surveys), appointments to specific roles with assured competencies, improved collaborative working (including oversight and governance) with specialist suppliers undertaking compliance activities (inspection and maintenance) and focus on continual improvement.

C-I-3.1.3.3 Overview of actions and implementation status

UUK reported the following as key findings of recent assessments:

- Emergency Lighting improvements: a site-wide upgrade to emergency lighting systems and functionality is now fully installed with one asset awaiting final commissioning.
- Fire compartmentalisation: initially specific to operating assets, then extended to all occupied assets. Review and upgrade completed.
- Fire Detection and Fire Alarm System upgrade: scope extended to include maintenance, operational and obsolescence challenges across the site to a single standard Category

L1 (Maximum Life Protection)/P1 (Maximum Property Protection) as defined in BS 5839-1:2017. All operating assets due for completion by February 2024.

C-I-3.1.4 Regulator's assessment of the fire prevention

C-I-3.1.4.1 Overview of strengths and weaknesses in the fire prevention

Fire prevention strengths:

UUK described that its arrangements for preventative measures included a site fire prevention strategy to drive the implementation of relevant good practice, including BS9997: 2019 Fire Risk Management Systems and BS9999 [71]. UUK provided specific examples in relation to preventative measures that are aligned with ONR expectations in the ONR internal Hazards TAG [16]:

- Adequate arrangements for the control of hot works.
- Arrangements are in place for the quantification of transient fire load, the capture of this information via fire risk assessments, communication to building owner and monitoring through area walkdowns.
- Specific examples regarding reduction of combustibles are described including, for example, control of pallets/wooden scaffolding and a ban on the use of combustible cladding in buildings.
- The approach to the control of flammable liquids and gases is described with reference to RGP in the form of the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR), Health and Safety Executive Guidance HSG 51 and British Compressed Gas Association Guidance (BCGA Flammable liquids and gases).

Fire prevention weaknesses:

UUK's self-assessment does not demonstrate significant weakness in terms of preventative measures.

C-I-3.1.4.2 Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

A recent ONR fire intervention identified minor shortfalls in housekeeping during walkdown, which emphasises the need for ongoing focus in this area. A Regulatory Issue (level 4 – lowest level) was raised following ONR's most recent inspection regarding UUK's understanding of combustibility of insulated core panels however the required actions have been adequately addressed and understanding demonstrated.

C-II Fuel Fabrication Facilities – Springfields Fuels Ltd

C-II-3.1.1 Design considerations and prevention means

Hot Works

UK fire safety legislation namely the Regulatory Reform (Fire Safety) Order 2005 [20] requires that the responsible person for fire safety must ensure that suitable preventative and protective measures are implemented to control potentially hazardous activities one of those being hot works.

Springfields Fuels Ltd reports that hot works on site are only to be undertaken if all other avenues have first been exhausted i.e., cold cutting, pre-fabrication etc. It also states that all hot works on-site are subject to a Hot Work Fire Risk Assessment (HWFRA) and that the assessments are undertaken by the Springfields site Fire Service who must have completed a hot work course prior to being permitted to carry out assessments. Springfields Fuels Ltd states that HWFRA's are produced with SQEP with sufficient knowledge of the hazards and associated processes (i.e., Plant manager, duly authorised person, fire nominated person(s)). Springfields Fuels Ltd concluded that, once completed, the assessment must be signed onto by all parties involved in the hot work.

Springfields Fuels Ltd states that the HWFRA's is normally issued for a fixed period for plant specific tasks. After completion of the risk assessment, Springfields Fuels Ltd considers that the assessment is valid for up to seven days. The validity of HWFRA's may be extended beyond a seven-day period, but only at the discretion of Springfields Fuels Ltd's Inspecting Fire Officer. Springfields Fuels Ltd requires daily gas monitor testing to ensure there are no explosive atmospheres present. In rapidly changing environments, Springfields Fuels Ltd may require constant gas monitoring in addition to all other requirements listed on the HWFRA.

Springfields Fuels Ltd's HWFRA process for hot works approval is available in the licensee's self-assessment.

C-II-3.1.2 Overview of arrangements for management and control of fire load and ignition sources

Springfields Fuels Ltd defines the goal of its fire loading limits as to ensure that in all areas the fire loading is less than the fire resistance of the fire compartment boundaries or structural fire resistance of building elements.

Springfields Fuels Ltd states that fire loads in areas where there may be vulnerable equipment is strictly controlled and that limits are typically communicated for nuclear fire safety in the first instance through Operating requirements in the facility HAZANs an example of which is given below:

Operating Requirement: *The accumulation and use of combustible materials (paper, polythene, cardboard etc.) MUST be minimised, consistent with operational requirements.*

Springfields Fuels Ltd undertakes regular management safety walkdowns which include housekeeping to ensure this Operating requirement is met. It also states that a global Corrective Action Programme (CAP) is raised to the appropriate building owner/business unit head where improvements to premises keeping is required based on subjective judgement of those undertaking the safety walkdowns. Springfields Fuels Ltd communicates limits to workers on a day-to-day basis by signage in certain areas prohibiting storage of combustible materials, through toolbox talks and the CAP process.

Springfields Fuels Ltd does not use specific processes within facilities storing radioactive wastes: buildings where waste is stored prior to processing (LLW and ILW) are subject to the same site wide processes as any other building where waste is processed. Springfields Fuels Ltd reports that the effects of fire on safe geometry containers/safe geometry bins are considered.

SSI 688 [135] requires Building Owners to ensure that the Plant Managers/Building Managers carry out inspections on the housekeeping and fire safety arrangements within their plant. Springfields Fuels Ltd reports that it ensures consistency across facilities by having a fire nominated person for each building each of whom have undertaken a fire nominated persons course. It also states that adequacy of control is confirmed by Core Fire Nominated Persons (CFNP's) & Building Fire Nominated Persons (BFNP's) whose duties are detailed in SSI 688 (Fire Safety at Springfields) and which includes fire risk assessments that are undertaken on a three yearly basis, visits to buildings by the site fire service and ad hoc visits to buildings by the site fire safety manager.

SSI 688 [135] requires that CFNP's review their "live" Fire Risk Assessments on a 3 yearly/5 yearly (maximum) basis or after any material or structural changes to the building, changes to material usage or storage, or any significant changes in occupancy or workplace practices along with assistance from the BFNP and ensure that the MSC endorses the original and all subsequent revisions to the Fire Risk Assessment.

SSI 688M [136] requires that Flexible Temporary Covering Materials on the Springfields site must, as a minimum be manufactured to conform with Loss Prevention Standard 1207 [137]; and any flexible temporary covering material used for scaffold cladding must, as a minimum be manufactured to Loss Prevention Standard 1215 [138].

Springfields Fuels Ltd uses the Joint Industry Guide for fire safety on construction sites [139], as an example of external good practice guidance for construction and decommissioning activities. Springfields Fuels Ltd states that other standards such as Loss Prevention Council (FPA) standards, Factory Mutual (FM) standards are consulted with respect to specific process fire hazards.

As an example, Springfields Fuels Ltd reports that ablative coatings have been used in the oxide fuel production facility to prevent fire propagation on cables. This was primarily to avoid providing structural protection to unprotected steel in an operational building. In this instance the cables were the primary fire load and once coated there was no other permanent or transient fire load in the vicinity that could result in a failure of the ablative paint and subsequent involvement of the cables. Springfields Fuels Ltd reports that ablative coatings are examined as part of COSR reviews where any damaged coatings would be identified and rectified.

Control and Storage of Flammable Liquids and Gases

Springfields Fuels Ltd stores flammable and highly flammable liquids and gases including aerosols in proprietary fire safe COSHH cabinets located within plant areas.

Acetone is used for cleaning new fuel assemblies in the oxide fuel fabrication facility. Acetone supplies are held in 2.5 litre bottles in a metal cupboard in the component

preparation room. Elsewhere in the plant, acetone is held in approximately 2 litre metal containers with a plunger dispensing system which allows wetting of cleaning wipes. When not in use containers are returned to COSHH cabinets.

Flammable gases e.g., those used as part of the fuel making process are stored in an open fronted weather protected enclosure at one end of the oxide fuel fabrication facility. Elsewhere e.g., for laboratories flammable gases are stored in purpose-built weather protected enclosures outside buildings. Flammable gases are kept separate from oxidising gases. The use of acetylene fuel gas on the Springfields site is subject to restriction.

Springfields Fuels Ltd reports that any areas where flammable gases e.g., hydrogen are produced during battery charging are subject to a DSEAR assessment. Areas where ammonia is used as part of the process are also subject to a DSEAR assessment. Springfields Fuels Ltd states that a hazardous area classification (HAC) paper is produced for each relevant building.

Hydrogen is used in reduction furnaces for the reduction of U_3O_8 to UO_2 and for producing fuel pellets. Nitrogen inerting is used to prevent ignition in the furnaces. Furnaces are purged with nitrogen before admitting hydrogen. e.g., in EURRP safety measures include Nitrogen purge integrator/interlocks to prevent the opening of the hydrogen supply valves until the initial purge has reduced the furnace atmosphere to less than 1% v/v oxygen and an additional $0.5m^3$ of nitrogen has been fed to the furnace. A second safety measure is provided by temperature trips to initiate a nitrogen purge if the temperature is below the autoignition temperature of hydrogen. If a high temperature within a furnace is detected by any one of eight independent temperature trips an inerting supply of nitrogen to the furnace is initiated.

There is some storage of zircalloy swarf in water in steel drums that has the potential to generate small amounts of hydrogen. Springfields Fuels Ltd keeps the drums in a ventilated steel ISO freight container on one of the external storage rafts remote from any building.

TBP/OK is used as part of a process in EURPP. TBP/OK is a combustible liquid with a flashpoint of $72^\circ C$. The areas where TBP/OK is used are covered by a foam water spray suppression. Oxidisers are used in certain processes such as 60 % Nitric acid and Hydrogen peroxide 35%. Nitric acid within buildings is contained in robust tanks and pipework within bunds to contain any leakage.

Springfields Fuels Ltd places reliance on good housekeeping practices to ensure that any leakages of oxidising agents do not come into contact with organic materials. Springfields Fuels Ltd reviews storage locations and arrangements as part of any PMP raised that involves relocating existing storage arrangements, creating new storage arrangements, or bringing new flammable liquids or gases onto the Springfields site. Bulk hydrogen is supplied as compressed hydrogen in tube trailers and the trailer parked in an open area on site. Hydrogen is drawn directly from storage and supplied by pipework on pipebridges to buildings throughout the site. The hazards associated with hydrogen storage are addressed in SAG R198 [74] Appendix D.

Sources of good practice include HSE guidance; [140], [141]; BCGA guides GN3 [142], GN11 [143], GN13 [144], GN41 [145], GN44 [146] and NFPA30 [147].

Control and Storage of Pyrophoric Materials

Springfields Fuels Ltd states that zirconium swarf was the only pyrophoric material which is present on site. It reports that the material is only present within the LWR fuel making facility and storage areas external to the building, and that coarse powders (>0.84mm) turnings, and shavings are not pyrophoric under ambient conditions but may burn if ignited [148]. Springfields Fuels Ltd also states that samples smaller than the 3mm will ignite if their temperature is raised and that swarf produced at Springfields with smallest dimensions of around 0.4 millimetres was deemed both pyrophoric and capable of ignition from an external ignition source.

Springfields Fuels Ltd states that Continued Operations Safety Case for the fuel making plants dismissed the potential for a zirconium dust explosion based on the understanding that accumulations of significant quantities of zirconium dust will not arise. The safety case concluded that even with an accumulation of dust, the activities undertaken are such that dispersion leading to an extensive explosive atmosphere is not envisaged. Springfields Fuels Ltd safety case includes an Operating Assumption as follows:

OA: Areas where zirconium dust can build up, including the repair lathes, gamma scanner inlet, rod loading area, wash tanks and wash tank pits, are subject to monthly inspections. If a significant build-up of zirconium dust is detected prompt appropriate action must be taken to remove the build-up.

Springfields Fuels Ltd states that zircaloy fines and dust produced as part of the LWR Canning, and Assembly processes are currently swept up by hand and stored under water or Midel 7131. Springfields Fuels Ltd reports that it chose Midel 7131 as it is less combustible than kerosene which was formerly used for this purpose. Midel 7131 is a biodegradable synthetic ester fluid with a fire point of 3160C. Good practice guidance and precautions are given in NFPA 484, and general guidance is given in Westinghouse, Western Zirconium, Safety Management Procedure E3, Handling of Flammable Metal Fines [149] and Westinghouse Western Zirconium Operating Procedure, Packaging and Shipping of Swarf [150].

Springfields Fuels Ltd states that the only operation involving cutting of zirconium which generates swarf is parting off tubes within the lathes (top and bottom end), this generates large swarf. It noted that whilst fine dry zirconium powders (<62µm) show extreme pyrophoricity, coarse powders, turnings and shavings are not pyrophoric under ambient conditions. Therefore, Springfields Fuels Ltd makes no special arrangements for cutting zirconium tubes in lathes. However, Springfields Fuels Ltd collects swarf routinely and stored it under water or Midel 7131 to reduce the risk of fires from external sources of ignition and as best practice.

Springfields Fuels Ltd reports that smaller swarf can be generated through rod pulling (pulling fuel rods into skeletons), and that this only occurs on the rod pulling machine. For this process Springfields Fuels Ltd reports a routine in place to clean down the machine and surrounding areas on a regular basis with hand tools and a specialist EX rated vacuum cleaner specifically designed for recovery of combustible dusts. Springfields Fuels Ltd states that during the procurement process for the vacuum cleaners, it made reference to

NFPA 484 [151], which addresses the use of portable vacuum cleaners for finely divided combustible dusts, and to relevant good practice at a UK MOD fuel manufacturing facility.

Springfields Fuels Ltd stores swarf material under water and uses no inerting systems associated with zircalloy machining processes. Springfields Fuels Ltd reports that its operational measures are derived, as per all other hazards, through the Safety Case process and specifically through Nuclear and Conventional fire reviews within the COSR/COSC methodology. Table 4 lists the Operating Assumptions, derived from the nuclear fire COSR review, which flow down into the Operational Clearance Certificate for the plant and then into local instructions and Operator Asset Care routines.

Table 4: Springfields Fuels Ltd Operating Assumptions associated with zirconium dust and zircalloy

OA	OA/LWR/xx	Normal Operations	Areas where zirconium dust can build up, including repair lathes, Gamma Scanner inlet, Rod Loading Area, Wash Tanks and Wash Tank Pits, are subject to monthly inspections. If a significant build-up of zirconium dust is detected prompt appropriate action must be taken to remove the build-up.	To prevent build-up of an explosive atmosphere
OA	OA/LWR/xx	Normal Operations	Zircalloy swarf under water or Midel 7131 oil may be stored in single containers. The containers must have a volume of 4 litres or less.	To define the normal operating limits with respect to the quantity of moderating material permitted for limited moderation areas.

Identification and Control of Ignition Sources

Springfields Fuels Ltd captures ignition source identification through Fire Risk Assessments (FRA's), review of PMP's, Task Risk Assessments, HWFRA's, DSEAR assessments and hazardous area classification reports. Springfields Fuels Ltd reports that hazardous areas such as battery charging areas would be identified during an FRA, which would then prompt a DSEAR assessment. It also states that potential ignition sources for new builds e.g., use of solvents or pyrophoric materials are captured in the fire safety COSC reports (Conventional and nuclear) that it undertakes in support of the design. Ignition sources would also be captured through the HAZOP process in support of the COSR. Springfields Fuels Ltd reports that the COSC papers for Nuclear and conventional fire safety also assess fire loading, ignition sources, etc where required. Plant modification procedures (PMP's) require fire to be specifically assessed and reviewed where necessary by the Springfields fire safety manager.

Springfields Fuels Ltd requires all buildings on site to have an up-to-date Fire Risk Assessment stored on the site Fire Actions Database and tracks fire risk assessment actions/significant findings via the Fire Actions Data base. Whilst these primarily address conventional fire safety and compliance with the FSO they provide a means for the identification of ignition sources. Springfields Fuels Ltd applies the following principles and procedures:

- *There are site arrangements for the maintenance of fixed electrical and portable electrical appliances to ensure they are inspected and tested on a periodic basis. The due date for PAT testing is interrogated during the FRA.*
- *Consideration is given through the PMP process to ensure that new equipment does not pose a risk of ignition.*
- *In hazardous zoned areas equipment is EX rated.*
- *Outside of hazardous areas good engineering practice is implemented.*
- *Flammable and highly flammable solvents and flammable aerosols are stored in flammables cupboards.*
- *In accordance with CLP regulations [152] flammable aerosols are subject to a DSEAR risk assessment.*
- *Wherever practicable, fire resisting hydraulic fluids are used e.g., in presses.*

As an example, as part of a COSR review of OFC Springfields Fuels Ltd determined that the potential for fires in Mechanical Area 1 and Mechanical Area 2 (requiring site fire service intervention and the use of water) was increased by combustible material storage and by the creation of open administration areas. Springfields Fuels Ltd identified a mitigation - the areas are manned on a 24-hour basis (and any fire should be discovered).

Ignition Risk Reduction

SSI 668 A [153] requires that A Hot Work Fire Risk Assessment (SSI 688J) form must be completed before any hot work commences in a building/plant as stated in SSI 688H instruction. Springfields Fuels Ltd states that it is the building owner's responsibility to ensure the assessment is carried out. It also reports that the area and works are assessed by a competent individual and appropriate control measures i.e., fireproof sheeting, ensuring areas are clear of combustibles, etc. are in place before the works are commenced.

A draft document [154] prepared in 2017, Use of Acetylene and Alternative Fuel Gases for Welding and other Purposes at Springfields describes the responsibilities and requirements for ensuring the hazards associated with the use of fuel gases on the Springfield's site have been adequately considered with respect to the potential for fire and explosion. This document covers preferred gases to be used for welding and cutting, procedures to be followed if acetylene is to be brought onto site as well as exempted use of acetylene for specific process and analytical activities.

Springfields Fuels Ltd determined that the use of acetylene fuel gas on the Springfields site should be restricted in line with practices for the use of acetylene on other UK nuclear licensed sites and to reduce the risk of fire and explosion associated with the use of compressed flammable gases to as low as reasonably practicable.

Springfields Fuels Ltd's Fire Safety Manager in consultation with the Resident Engineer restricted the use of acetylene on the Springfield's site including use by contractors, unless there is a specific chemical process or analytical necessity. A less volatile LPG type gas must be used as the alternative (such as Propane). Only under specific circumstances acetylene use would be allowed (e.g. where it forms part of a chemical process, is required for specific quality purposes, cryogenic brazing or is used in analytical equipment).

SSI 668A addresses the use of acetylene and states that the use of Acetylene is prohibited on site unless prior arrangements have been agreed by the Fire safety Manager/Emergency Planning Manager. Prior to this being permitted all other avenues must first have been exhausted, if permitted cylinders must be stored outside buildings when not in use and their storage locations agreed with both SFL Fire and Rescue and the site Fire Safety Manager.

Springfields Fuels Ltd reports that the requirement for hot work risk assessment is site wide. The restriction on the use of acetylene is also site wide. Springfields Fuels Ltd also reports the requirement that only scaffold boards meeting a EuroClass C as a minimum is used. It also requires plastic sheeting (for construction of tented areas or general protection against dust and dirt) to be Loss Prevention Certification Board (LPCB) approved to Loss Prevention Scheme (LPS) 1207 [137]. Plastic netting e.g., for protection of scaffolds is required to be LPCB approved to LPS 1215 [138]. Cladding on any new building is required to be EuroClass A1 or A2 when classified to BSEN13501 [155].

Characterisation and Control of Transient Combustibles

Springfields Fuels Ltd typically assesses transient combustibles qualitatively through daily walk downs by fire nominated persons and plant management; plant walkdowns (SSI 638C/D) are completed, fire risk assessments undertaken, and actions highlighted within the assessment tracked via a fire actions database. Springfields Fuels Ltd reports that the latter are undertaken on a three yearly basis. As an example, it provided that a criticality assessment derived an Operating Requirement for the control of transient combustible materials [156]:

*To reduce the potential for a developed fire requiring site fire service intervention and the use of water a second operating requirement is derived, this being: **Operating Requirement:** The accumulation and use of combustible materials (paper, polythene, cardboard etc.) MUST be minimised, consistent with operational requirements.*

Springfields Fuels Ltd reports that there are regular management safety walkdowns which include housekeeping to ensure the Operating Requirement is met. Further information on the control of transient combustibles is provided in Section II-2.3.2.

C-II-3.1.3 Licensee's experience of the implementation of the fire prevention

C-II-3.1.3.1 Overview of strengths and weaknesses

The licensee did not identify specific strengths and weaknesses however, examples of weaknesses which have been identified through fire events or other missions, and associated corrective actions are identified in Sections C-II-3.1.3.2 and C-II-3.1.3.3.

C-II-3.1.3.2 Lessons learned from events, reviews fire safety related missions, etc.

Following the Grenfell tower fire in 2017 and in response to a letter from ONR, Springfields Fuels Ltd reviewed all cladding systems on site irrespective of building height or location. Key actions arising from this review are discussed in Section C-II-3.1.3.3.

The Springfields site is a member of WANO and takes part in WANO Peer Reviews. In terms of Learning from Experience (LFE) relating to Fire Prevention, the site is an active member of the Nuclear Industry Fire Safety Coordinating Committee (NIFSCC) and utilises an external Chartered Engineer of the Institution of Fire Engineers with significant expertise in Nuclear Fire Safety, in particular nuclear fire safety arrangements at Springfields. The site has two yearly assessments by the Nuclear Risk Insurance Assessors one of which focused solely of Fire Prevention and Emergency Response. There have been no significant findings raised during these inspections. ONR conduct Fire Safety inspections under the Regulatory Reform Order 2005. System-based inspections (e.g. fire alarm system inspections) also address Fire Prevention. ONR conduct site visits for specific facilities and produce intervention records summarising findings which provide a RAG (Red Amber Green) rating.

C-II-3.1.3.3 Overview of actions and implementation status

A recent newly constructed single storey building on site has walls and roof cladding complying with LPS1181-1 [157] Ext B. LPS1181 tested or non-combustible insulated cladding is used for all new buildings that may store or process radiological materials.

Two buildings constructed over twenty years ago storing or processing radiological materials were found to have cladding with combustible insulation. Panels comprise an aluminium outer skin with a steel inner liner and polyurethane insulation approximately 25mm depth.

As a result, controls have been introduced to reduce the potential for ignition of the cladding. Examples of these are given below:

- SSI 668A requires that special attention must be taken when hot works are conducted within 5m of buildings with external/internal cladding systems in these cases a management control procedure will be put in place for any operations that require cutting, drilling, or exposing combustible inner core material to ensure that the potential for ignition of the core material is minimised. This may include cold cutting, inspection of cladding systems after drilling or cutting with a thermal imaging camera, etc, Any PMP that involves working on panels with combustible core material will be assessed by the Springfields fire safety department on a case-by-case basis.

- A timber garage used as a store/workshop next to a building with combustible cladding has been demolished.
- No smoking is permitted next to combustible cladding and smoking shelters have been moved to the side of the road away from the building.
- A timber roof on a receipt/despatch building next to a building with combustible cladding was replaced with a non-combustible roof. Limitations on the quantity of combustible materials permitted in this building is indicated by signage in the building.
- An assessment was made of the effect of changes in plant area where hydraulic presses were to be used. Cladding forms the outer wall of the area. As a fire could spread to the cladding which has a polyurethane core, a recommendation was made that fire resisting hydraulic fluid is used in the presses. Measures were also proposed to prevent the formation of a mist or spray of hydraulic fluid. An assessment concluded that provided these recommendations were followed no additional fire protection to the external cladding was deemed necessary.
- An office constructed next to the cladding inside a fuel making building was removed.

C-II-3.1.4 Regulator's assessment of the fire prevention

C-II-3.1.4.1 Overview of strengths and weaknesses in the fire prevention

Strengths

Range of Fire Prevention Measures

Springfields Fuels Ltd identified a wide range of fire prevention measures including initiatives focussing on processes and site-specific risks. These included hot work fire risk assessments, processes requiring building owners to carry out housekeeping inspections, assigning a fire nominated person on a building-by-building basis, use of local protective measures to prevent damage to equipment, inerting of zircaloy swarf etc. These initiatives are built from a strong foundation of referenced sources of good practice. ONR judges that these arrangements implement recognised sources of good practice and are in alignment with WENRA Safety Reference Level SV 6.11 [1].

Fire prevention is a key expectation of the ONR Technical Assessment Guide on Internal Hazards [16]. ONR judges that the range of measures outlined by Springfields meets the expectations of ONR SAPs [15] and the Internal Hazards TAG [16].

Weaknesses

In fire prevention and for Springfields Fuels Ltd, ONR questioned that the relationship between temporary laydown spaces and the assessment of the adequacy of fire loading should be clearly outlined, as the adequacy of passive fire boundaries are initially based on a quantitative assessment of fire loading. Springfields Fuels Ltd responded that *designating laydown areas as might be encountered in Nuclear Power Stations for storing large quantities of combustible materials such as scaffold boards is not practiced in any of the buildings at Springfields Fuels. Small transient laydown areas are used that are task*

specific and are only present during the task and potentially for a short period of time before removal when the task is complete.

As an example, a temporary timber scaffold lay down area was assessed as part of the OFC fire loading study. The temporary timber scaffold lay down area comprised a small number of scaffold boards (8 x 2.4m boards) - 66.4kg, a timber pallet 20kg and a 3.5m timber ladder (12kg timber). The total fire load density calculated for the lay down area was based on 89.9 kg of timber and was calculated at 19.5MJ/kg.

The total fire load for the area (electrical cabinets, cables and a crane festoon) was calculated as 4392MJ equating to 21MJ/m² = 1.13 Mins Fire Resistance. As such there is very wide margin of safety before even unprotected steelwork could become affected. Any stored combustible materials that are not removed are identified during building management safety walkdowns, fire officer inspections or the fire risk assessment process and if necessary, a corrective action (CAP) raised.”

ONR judges that the type of laydown space described (small, temporary and project specific) is unlikely to challenge nuclear safety significant passive barriers. The use of the Ingberg method for calculating fire severity in this context is part of the engineering judgement applied.

Following the Grenfell tower fire and as per statement in section C-II-3.1.3.2, ONR wrote to all GB licensees so that the use of combustible cladding and linings was reviewed. ONR subsequently assessed the adequacy of the responses and actions taken by licensees to reduce the risks to life and nuclear safety. The closure of actions and implementation of controls, such as those reported Springfields Fuels Ltd in section C-II-3.1.3.3, were subject to scrutiny by ONR at the time and will continue to be, as per planned inspections highlighted in section II-2.3.7.3.

C-II-3.1.4.2 Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

ONR’s arrangements for regulating the Springfields site are described in Section II-2.3.7.2. ONR fire safety inspections (with a focus on life fire safety) have identified minor shortfalls in the control of combustibles. Following an inspection in 2021 [158] a Level 4 Regulatory Issue (lowest level) was raised on the standard of housekeeping in relation to combustibles. This has since been closed out and improvements confirmed in a follow-up inspection.

D Dedicated spent fuel storage facilities

Spent fuel storage facilities associated with reactor sites are reported on under Section 0 - Nuclear power plants. Spent fuel storage facilities at Sellafield follow the same licensee arrangements as those reported under Section E - Waste storage facilities.

E Waste storage facilities

E-I Sellafeld facilities

The text in this section (bar the regulator's assessment subsections) has been prepared by Sellafeld Ltd, with only minor changes for clarity and conciseness. For avoidance of duplication, all Sellafeld Ltd. facilities, including waste processing facilities are reported in this section.

E-I-3.1.1 Design considerations and prevention means

Stakeholder meetings provide specific advice in relation to risk control measures when hazards are identified for a project or work package. Sellafeld Ltd. uses a form to document stakeholder's advice and recommendations. For any hot work the stakeholders Sellafeld Ltd. identifies stakeholders as the Duly Authorised Person, Safety Advisor, Building Manager, Fire Protection Advisor or SF&RS. This then allows the stakeholders input to be written into the Task based Risk Assessment to ensure relevant controls are put in place.

Sellafeld Ltd. states that its processes encourage personnel to follow a hierarchy of control. Size reduction work during demolition and decommissioning projects should utilise cold-cutting where possible. Where hot work is required due to the nature of the objects that need to be size reduced, Sellafeld requires the use specific guidance on controlling hot work produced by the Fire Protection team. This pays particular attention to minimising combustible materials near the hot working area and highlights the requirements of fire watch. There is also guidance on hot work for Contractors working on the Sellafeld Site (SCS 029) [159].

Sellafeld Ltd. classifies hot work into routine and non-routine. Routine is usually in a dedicated workshop carried out by teams who perform hot work including welding, to then supply the rest of the site with pipework for example. This would involve a risk assessment that would be updated when any new processes, procedures or equipment were introduced. Non-routine is associated with decommissioning, construction, and other project work. Non-routine hot work would usually be captured in a task-based Risk Assessment with appropriate stakeholders, to identify any hazards and controls required for the work.

Sellafeld Ltd.'s Duly Authorised Person (DAP) is responsible for Nuclear Safety on their facility. Sellafeld Ltd. states that the DAP must sign onto any hot work that is being carried out on their plant and ensure the Risk Assessment is suitable and sufficient. For hot work on non-nuclear facilities, the stakeholder meeting and associated task-based risk assessment requires signatures from key stakeholders, to allow the work to go ahead.

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

See section I-2.5.2.2 for details on how fire loading assessments are completed and how the data is used during the lifecycle of the plant to manage and control fire loads. Sellafeld Ltd. reports that ignition sources are identified during Fire Risk Assessments (FRA) which are reviewed periodically depending on the category of building (one, two or three years). Sellafeld Ltd. states that any ignition sources such as battery charging areas would be

identified during an FRA, which would then prompt a DSEAR assessment. Sellafield Ltd. recognises that relevant good practice is to eliminate combustible materials around sources of ignition or, where this is not possible, reasonable segregation to be put in place e.g. 3 metres.

Sellafield Ltd. states that it has detailed Engineering and Maintenance arrangements on the maintenance of fixed electrical and portable electrical appliances to ensure inspection and testing on a periodic basis. It also states that the Process Fire Analyses, Conventional Fire and Nuclear Fire Analysis identify ignition sources and any control measures necessary so that the risk is ALARP. Sellafield Ltd. states that it identifies requirements throughout the whole lifespan of equipment and, when designing plant, the risk of ignition will be considered. Sellafield Ltd. implements maintenance and asset care procedures when the equipment is introduced, and this is prompted and recorded electronically. The specific procedures cited included requirements for Portable Appliance Testing appliances, which are detailed on the Sellafield Ltd. Management System.

Sellafield Ltd. states that ignition risks associated with specific tasks are analysed and assessed during the task risk assessment process, and controls would be documented in the Risk Assessment and Operating Instruction as required. Sellafield Ltd. then implements the findings from the assessment and the control measures identified to eliminate or reduce the risk of ignition. The processes written in the Sellafield Ltd. Management System (SLMS) are arrangements for the whole site/enterprise. Sellafield Ltd. has local management procedures within facilities, but overarching processes such as the Hot Work, Electrical Maintenance and Fire Risk Assessment are site-wide.

E-I-3.1.3 Licensee's experience of the implementation of the fire prevention

E-I-3.1.3.1 Overview of strengths and weaknesses

Sellafield Ltd. identified a positive reporting culture allowing trending and learning from fire events and near misses. This has allowed Sellafield Ltd. to share learning within the nuclear industry and increase visibility of obsolescence/maintenance issues which had led to electrical fires. Identifying likely causes of fires (electrical failures) allows more targeted assurance to be carried out. Section E-I-3.1.3.2 below outlines self-identified weaknesses from Sellafield Ltd.'s experience of implementing fire prevention.

E-I-3.1.3.2 Lessons learned from events, reviews fire safety related missions, etc.

Combustible management and segregation from ignition sources were identified as an area for improvement by WANO, Sellafield Ltd.'s own internal regulator (Nuclear Intelligence and Independent Oversight; NI&IO) and through inspections from Fire Protection and Building Management. These were identified at Sellafield's Waste Vitrification Plants during a WANO review in 2021 and during Sellafield Ltd.'s own review of the plants' Fire Risk Assessment in 2022. Following the identification of combustible management as a concern in multiple facilities, Sellafield Ltd. is developing a Key Performance Indicator (KPI) to highlight areas of concern (e.g. where combustible waste has been stored in a facility for a significant period) at a site level. Sellafield Ltd.'s checklists for Building Managers now include a section to highlight areas holding significant combustible inventories or posing ignition risks.

E-I-3.1.3.3 Overview of actions and implementation status

Sellafield Ltd.'s Building Manager inspections and Fire Risk Assessment reviews produce actions if shortfalls or fire safety deficiencies are identified. Sellafield Ltd. categorises these by cause e.g. fire alarm and detection system, ignition sources or maintenance. It then loads the actions onto the ATLAS system and tracks them to completion, holding the dutyholder and competent person responsible for closing out the action to rectify the issues.

The Waste Vitrification Plant is a member of WANO and takes part in WANO Peer Reviews. The most recent peer review was in 2022 and one Area For Improvement (AFI) in relation to Fire Protection, this was around Combustible Management. An action plan will be implemented to address shortfalls.

Sellafield Ltd. has its own internal regulator: Nuclear Intelligence and Independent Oversight. NI&IO has provided a higher degree of oversight since September 2019 with the addition of a Fire Protection subject matter expert (SME) being utilised within the Team. During this period of time the following upskilling and oversight has been carried out.

The Waste Vitrification Plant received a letter of NI&IO (internal regulator) concern in 2022, following deficiencies relating to inadequate control of combustible materials. This was highlighted during the Fire Risk Assessment Review and escalated to the internal regulator. Sellafield derived an action, and the internal regulator supported the plant to resolve and mitigate this and future issues relating to waste management. Sellafield Ltd. reports that learning from the findings is cascaded throughout the organisation through internal communications including Building Manager forums, Toolbox Talks and bulletins on the internal website.

Sellafield Ltd. reports that, during ONR's Licence Condition 15 Inspection in December 2015, a query was raised regarding the potential fire risk specifically the Diesel Alternator Set (DAS) housed within, poses to the structural stability of Pile 1. Following completion of the inspection, an action was raised to undertake a fire safety review of DAS. Sellafield Ltd. produced a nuclear fire assessment and fire engineering calculations in response. Whilst it recommended no physical improvements, a number of recommendations to control the further control the risk, such as preventative maintenance and combustible control requirements, were identified and implemented.

E-I-3.1.4 Regulator's assessment of the fire prevention

E-I-3.1.4.1 Overview of strengths and weaknesses in the fire prevention

ONR assessed Sellafield Ltd.'s process for fire load accounting and management and judged that it meets the expectations in ONR's Internal Hazards TAG [16]. This expects the safety case to provide reference to surveys or studies of combustible substances, which should be systematic and demonstrably complete. This should include consideration of solids, gases, liquids, vapours and transient loads. The licensee also demonstrated that the process is in accordance with the expectations of IAEA NS-G-2.1 in that procedures should be established for the purpose of ensuring that amounts of combustible materials (the fire load) and the numbers of ignition sources be minimised [117].

Sellafield Ltd. identified the implementation of combustible management in some facilities as an area for improvement against SRL SV 6.11 and ONR is content that this is being addressed as part of Sellafield Ltd.'s fire safety improvement programme.

IAEA NS-G-2.1 expects administrative procedures to be established and implemented to control maintenance and modification activities that necessitate the use of a potential ignition source or that may themselves create an ignition source [117]. Sellafield Ltd. described a process for management of hot work that meets this expectation. However, ONR are aware that there have been recent fire events at Sellafield related to the implementation of this process.

E-I-3.1.4.2 Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

ONR undertakes regulatory interventions such as inspection for both nuclear fire safety and life fire safety. When it comes to implementation of the fire protection concept these are intrinsically linked and life fire safety findings provide regulatory intelligence in support of ONR's internal hazards activities. A 2023 pre-assessment engagement with Sellafield Ltd. on the Pile 1 chimney demolition highlighted the licensee's positive attitude towards learning from experience, specifically in relation to fires caused by hot cutting activities. Sellafield Ltd.'s intention to continue engagement with the fire and rescue service on a familiarisation basis was seen as a positive by ONR. However, Sellafield have reported an additional fire related to hot cutting on the Pile 1 chimney demolition project following this engagement.

F Facilities under decommissioning

To avoid duplication, the Pile 1 facility at Sellafield is reported under Section E.

The text in the Sections below has been prepared by Dounreay Site Restoration Ltd. Background information on the site and the range of installations considered in the scope of the assessment is provided in Sections 1.1.2 and 1.1.3.

F-I Dounreay

F-I-3.1.1 Design considerations and prevention means

Prior to commencement of any hot work, Dounreay requires a Hot Works Permit to be issued, including the following (taken from Dounreay's self-assessment):

- *DFARS are the Appointed Persons for issuing hot works permits after an inspection of the work area and equipment. All fire safety prevention measures are detailed on the permit.*
- *A permanent fire permit is issued for areas where the use of flames, heat-producing apparatus, or fire is part of the routine work. A permanent fire permit is valid for one year and is renewed and re-authorised by DFARS.*
- *Prior to commencing any work, an inspection of the work location and fire prevention equipment must be carried out by a member of the DFARS and a building representative.*
- *A Temporary Use Permit for Hot Work Form must be completed at the start of each shift prior to the specified hot work commencing. Any changes to the conditions must be reassessed by DFARS. The Fire Safety Advisor and DFARS have the authority to carry out checks at any time.*

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

General Arrangements

Dounreay reports that there are no limits on fire loading at PFR. There is a site general requirement to minimise combustibles, and this is communicated to personnel in the site induction, toolbox talks/pre-job briefs and working instructions. The DFRA considered fire loading across the facility. Dounreay states that the Fire Risk Assessment is revisited annually and any modifications that may impact on the fire risk assessment are considered with advice from the Fire Advisor. Dounreay reports that it carries out planned General Inspections routinely, and that it considers fire and housekeeping as part of these inspections. The site waste strategy requires that no waste is generated until a waste plan is approved for its disposal.

Dounreay's Fire Safety Standard refers to the management of combustibles under housekeeping. The standard outlines the need for tidiness, cleanliness, minimisation of combustibles and the removal of waste. Dounreay ensures compliance with its standard

through the annual fire risk assessment of buildings; ad-hoc walk rounds and through planned general inspections carried out by safety representatives and building management.

Dounreay reports that it gathers information on external good practice and cascades it through the Dounreay Learning from Experience and Professionalism team. It cited a variety of sources including the Operational Experience Learning group, NDA working group, NDA flash alerts (SHE alerts), industry bodies including fire safety good practice taken from the Nuclear Installations Fire Safety Co-ordinating meeting.

Dounreay reports that a DFRA recommendation was made pertaining to the use of wooden scaffold boards: storage racks have been subject to rationalisation to minimise combustible inventories; combustible boards have been replaced with metal boards. The review of scaffold boards within the PFR complex confirmed that they are all fire retardant.

Flammable Liquids and Hazardous Substances

Dounreay reports that it has a site-wide mandated limit on the storage of flammable liquids within buildings to a maximum of 20 litres, or to the inventory required for day-to-day operations, whichever is less. Dounreay mandates that flammable liquids must be stored in an approved flammable liquids cabinet.

Dounreay reports that DSEAR zones are reviewed annually as part of the fire risk assessment process. It also reports that they are reviewed should there be a change in use of the facility and should there be any increase or decrease in the inventory. Dounreay reports that only a small number of hydrogen cylinders are held external to the PFR facility.

Alkali Metals

Dounreay reports that bulk sodium from the PFR Reactor Vessel (RV) has been destroyed. A heel pool remained and the majority of was recently removed from the RV and is currently stored within a dedicated Sodium Receipt Vessel awaiting treatment. Dounreay states that only undrainable hold-ups, known as residues, remain within the RV and that these would be treated in-situ as part of a future treatment project. Dounreay considers that the removal of bulk sodium has substantially reduced the potential for widespread release of activity via a fire or explosion and treatment of the residual alkali metal residues will further reduce this risk.

Additional bulk sodium and sodium or NaK contaminated components are stored at several locations within the PFR facility. The STF Tanks 1 and 2 still contain bulk tritiated sodium.

The Dump Tanks contain Tritiated eutectic NaK. Dounreay reports that the material is held in a stable condition at ambient temperature under a nitrogen pad, and that it had assessed the reaction and ignition risks to be low. Dounreay acknowledged that a vessel breach and leakage of NaK could lead to a fire and that an in-leakage of air could also lead to fire within the vessel.

The NaK Bowser is located on the 14ft floor level of the facility and contains eutectic NaK. Dounreay reports that the material is held at ambient temperature under a nitrogen pad and acknowledged that vessel breach and leakage of NaK could lead to fire. Similarly air in-leakage of could lead to fire within the vessel.

Dounreay reports that the PFR Turbine Hall stores a large amount of Alkali Metal (either in drums, small vessels or pipework sections) which have been placed within ISO containers at ambient temperature. Dounreay states that gross damage to drums would be required to expose the sodium or NaK to air as they primarily contain only residues or thin films of sodium. Damage to the packaging around pipework sections or small vessels that contain alkali metal residues may lead to exposure and/or spillage of very small amounts of sodium or NaK which may ignite, but combustion would be limited by low quantities.

Dounreay also reports that, in general, it manages the risk of ignition by ensuring that all alkali metal materials are held at ambient temperatures. It states that sodium metal is a solid at all normal ambient temperatures (below 98°C) and that sodium would generally only catch fire if heated to above 150°C. It considers that reactions at room temperature are generally slow and predictable. Dounreay states that the associated SSSCs are subject to a maintenance regime and periodic inspections, as expected from substantiation and in support of the periodic review.

Dounreay referred to the unit instructions in place for the management of alkali metals, and these outline the relevant controls. An Alkali Metal Specialist provides expertise regarding their control and storage. The safety case considers the associated faults and identifies the relevant controls in place. Dounreay states that in all cases of work involving exposure (or potential exposure) of liquid alkali metal to air, the project team must provide details of the work to the Fire Service in advance. The Fire Officer decides whether their attendance for any or all of the work is necessary and work must not proceed until Fire Service permission is granted.

Dounreay reports that all work that has the potential for an ignition source requires a hot work permit. The permit requires an inspection of the work area and the equipment to be used. This permit sets out conditions to be used. All electrical equipment used on site must be subject to Portable Appliance Testing (PAT). There is also an onus on the individual using the equipment to carry out a visual check prior to use. For areas that will use equipment that is used daily this is covered in a permanent fire permit. These areas are reviewed annually and also when the FRA is carried out.

Dounreay surveys transient combustible inventories on plant and reports that it keeps them segregated from other waste. It also reports that waste is held in allocated temporary laydown areas from where it is collected regularly, generally weekly, and removed from the building to be processed. Dounreay referred to Project Specific Waste Plans (PSWPs) as the arrangement to allowing site to authorise projects or facilities to generate and consign waste in accordance with regulatory requirements and the Conditions for Acceptance of the receiving facilities. Dounreay states that the PSWPs must be produced and approved before waste is generated.

F-I-3.1.3 Licensee's experience of the implementation of the fire prevention

F-I-3.1.3.1 Overview of strengths and weaknesses

Given its remote location, Dounreay has a retained on-site fire service. DFRAs are subject to periodic review as part of the safety case. Dounreay states that it seeks to gain and share experience of implementation of fire prevention methods by not only reviewing the outcome of site UNORs, incidents and DFRAs but also by exchanging information with

other licensees and subject matter experts. It reports that two DFARS representatives are members of the NIFSCC. Dounreay's also cites the Operational Experience Learning group, the NDA working group, NDA flash alerts (SHE alerts) and reports that external good practice is cascaded through the Dounreay Assurance Departments professionalism team. Specific Information is gathered from the Operational Experience Learning group, NDA working group, NDA flash alerts (SHE alerts).

F-I-3.1.3.2 Lessons learned from events, reviews fire safety related missions, etc.

No specific fire prevention missions have been recorded. Lessons learned from fire events which have occurred at the PFR facility are recorded in Section I-2.6.6.2.

F-I-3.1.3.3 Overview of actions and implementation status

Dounreay states that recommendations to improve fire prevention had been made as part of the deterministic fire risk assessment process and that all actions have been closed. An example of such a recommendation is provided in Section F-I-3.1.2.

F-I-3.1.4 Regulator's assessment of the fire prevention

F-I-3.1.4.1 Overview of strengths and weaknesses in the fire prevention

Strengths

Dounreay identified that reviews of fire loading are undertaken through multiple different processes. These include Fire Risk Assessments for life safety purposes, safety cases for modifications, and any required DFARs. ONR considers that Dounreay's waste characterisation process also offers an opportunity to reduce fire loading. ONR assessed the multiple recommendations attached to fire loading and general fire prevention identified as part of the Deterministic Fire Risk Assessment for PFR produced during the LC15 safety case review. These recommendations included removal of unnecessary fire loading, replacement of equipment with a less combustible alternative and relocation of fire loading away from vulnerable area. ONR confirmed through inspection [128] that these have been adequately closed out meeting that requirement in WENRA SRL SV 6.11 [1] that "in order to prevent fires, procedures shall be established to control and minimise the amount of combustibles and the potential ignition sources.

Weaknesses

Dounreay has identified that the PFR facility contains multiple sources of fire loading and that there is the potential for waste to accumulate locally. ONR TAG [16] for Internal Hazards provides expectations guidance on the surveying of fire loading and states that any such data should be "systematic and demonstrably complete". The PFR complex is largely open plan, with limited compartmentation with fire localised fire loadings. Dounreay quantifies fire loadings in the context of specific identified scenarios rather than surveyed globally as ONR Internal Hazard TAG expects. Additionally, as described in Section F-I-3.1.2, Dounreay has not defined explicit fire loading limits within PFR. IAEA SSG-77 I.25 [18] for NPPs could be considered in this context, and this expects the recording maximum permissible fire loads within defined compartments. It should be noted that this IAEA guide is not directly applicable to a reactor under decommissioning, however, ONR recognises as

good practice the development of combustible inventory limits and has already identified t an area of improvement related to the assessment of fire loading in Section I-2.6.7.1 (proportionate methodology for surveying fire loading).

F-I-3.1.4.2 Lessons learned from inspection and assessment on the fire prevention as part of its regulatory oversight

ONR has undertaken targeted inspections at PFR in July 2022 [160] and February 2023 [128] which both sampled Dounreay's fire prevention measures. During the 2022 inspection ONR found accumulation of combustibles within the Sodium Tank Farm at PFR. This was inactive waste. ONR revisited the facility in 2023 and was satisfied that housekeeping had improved in the area. During the 2023 inspection, ONR inspectors found wooden scaffolding boards temporarily stored against structural steel in the PFR reactor hall/decontamination area, in proximity to hydrogen pipework. ONR provided regulatory advice, Dounreay removed them on the day and responded that it was progressing an initiative to replace wooden boards with metal wherever possible.

3.2 Active fire protection

A Nuclear power plants

The text in the Sections below has been prepared by EDF NGL and NNB GenCo. Background information on the sites and the range of installations considered in the scope of the assessment is provided in Sections 1.1.2 and 1.1.3.

A-I Operating facilities – EDF NGL

A-I-3.2.1 Fire detection and alarm provisions

A-I-3.2.1.1 Design approach

General - Fire detection at EDF NGL sites is for mainly for life safety directly, but also for defence in depth for areas with a nuclear safety requirement. (except for the first generation AGRs – see below).

EDF NGL states that following features apply:

- There is Liner Heat Detection Cable (LHDC) at HNB and other first generation AGRs in the cable flats. However, these plants also have back-up auxiliary feed (added since the original design) which are available if they lose a cable flat.
- There are thermocouples on the Dungeness B Gas Circulator penetration tubes and associated panels to detect fire, initiate CO2 fire suppression and close dampers to protect the pressure boundary.
- The Infra-Red flame detection in the HNB gas circulator halls to bring in the foam systems is about to be deleted from the safety case. As noted, HNB is no longer generating.
- There is no fire detection provisions of nuclear safety significance at SZB/HY2.

First Generation AGRs (HNB) – EDF NGL considers that fire detection is highly developed at this station, as fire detection is claimed within the nuclear safety case.

Second Generation AGRs (HY2) - These stations were built utilising passive protection for the four safety trains. EDF NGL reports that, nevertheless, fire detection is provided regardless of how nuclear safety consideration are dealt with subsequently, i.e. EDF NGL states that, in the event of a fire causing the failure of operating systems or components, the reactor safety systems would detect any safety related effects on the reactor. Hence, for most fires, there is no specific need for additional detection systems. However, EDF NGL reports two locations for which specific detection systems are provided to trip the reactor. These are in the safety room and at the pilecap. In both cases it is expected that a fire would be unlikely and, should it occur, the faults created in the safety equipment or cabling would lead to a safe condition due to the failsafe nature of the equipment. Notwithstanding this, EDF NGL provides high temperature detection in these areas to ensure that a reactor

trip and initiation of post-trip cooling systems occurs before significant damage could be caused.

Sizewell B – EDF NGL reports that the function of the Fire Protection System (FPS) is to provide defence in depth in order to complement the principal fire barriers and to detect fires, to protect the plant against damage or to minimise damage from fire, and to reduce hazards to personnel. EDF NGL does not claim the fire detection system within the nuclear safety case.

Design Standards

General – EDF NGL reports that the design standards used were originally the relevant British Standards, BS 5839 part 1. It also states that each station has had a site-wide upgrade of the fire detection panels to help prevent the spurious activation of unwanted fire alarms, and that all new fire alarm systems are designed and commissioned by accredited companies.

Automatic vs manual

General – EDF NGL states that each station has a good mix of manual call points and automatic fire detection systems, and that each fire detection system is specific to the environment that it is intended for, which is covered within the design.

Coverage

General – Each station has its own mixture of coverage and network arrangements, however all the stations have their own building and site-wide fire detection networks to inform the Control Room and site personnel that a fire has occurred. EDF NGL states that the Control Room staff can then take the necessary actions, which includes informing the station fire brigade.

EDF NGL reports an upgrade at HY2 which is that the Security Gatehouse fire panel is networked to the Civil Nuclear Constabulary buildings using a Fibre Optic cable. It also states that there is also a fibre optic link between the two Administration Building fire panels.

Design approach

General – EDF NGL reports that general smoke detection is provided through the plant in electrical switchgear rooms, cable flats, plant rooms, administration facilities etc. There is no common system throughout the fleet; different sites have equipment by different manufacturers.

EDF NGL provides heat detection for the turbo generators – this is part of the turbine fire protection system as smoke detectors may give false alarms. It also reports the use of frangible bulbs as heat detection throughout the plant where water suppression is installed. It also uses frangible bulbs on compressed air lines, which on fracturing lower the air pressure and activate the deluge valves and water spray pumps, as described in Section A-1-3.2.2. EDF NGL also typically uses frangible bulbs for external transformers, diesel generators, gasturbines, turbo-generators, sprinklers and fuel stores.

EDF NGL does not generally use Beam Detection as the beam can easily be obstructed by cranes etc.

EDF NGL provides Liner Heat Detection Cable (LHDC) on all AGRs in cable routes and cable risers. This is due to the requirement for fast acting detection and suppression if there is overheating or fire in sensitive cable routes. These activate a metron head device which fires a pin and fractures the Quartzoid bulbs quickly. It is therefore a fast acting suppression system activated by the LHDC.

SZB also has LHDC on cable flats but does not have metron heads. As stated in Section A-I-3.2.1.1 relevant British Standards are used for the design, e.g. BS 5839 part 1.

First Generation AGRs (HNB) – HNB has aspirating fire detection within the main stores, workshops, and document centre. CCTV is located in the turbine halls for flame detection. In addition, fourteen new aspirating smoke detection panels are mounted in various locations.

Second Generation AGRs (HY2) – Heat Detectors are installed along the Turbine and Generator Centre line. EDF NGL reports that detectors initiate an alarm at the panel located in the Fixed Firefighting (FFF) room. Operators would then respond to the alarm signal. If a genuine fire is found, the deluge valve is manually opened to suppress the fire. EDF NGL notes that the Turbine Hall contains no nuclear significant plant.

EDF NGL reports that the offsite stores buildings are protected by Beam Detection. LHDC protect Cable Tunnels, Flats and Risers. The conventional areas are covered by aspirating systems.

SZB – EDF NGL reports that numerous designs are used across Sizewell B. The main features taken literally from EDF NGL's self-assessment are as follows:

- **Reactor Building Manual Valves:** in the event of fire and subsequent operation of the frangible bulbs, loss of air from the detectors initiates local alarms and Control Room signal only. The water spray through the open nozzles is activated by a remotely operated manual valve which vents the air off the deluge valve closing circuit, thus allowing the valve to open and permit water flow to the fire. Pressure switches signal low air and system discharged in the Control Room. Isolation, test and reset is identical to the manual test for automatic water spray systems.
- **Charcoal Filter Valves:** the Charcoal Filters contain a quantity of combustible carbon contained in trays. A sparge pipe with a valved instantaneous hose connector is sited above the trays. A fire in the filter raises an alarm in the HVAC system panel prompting the operator to connect the hose and open the valve. The Charcoal Filters in the Reactor Building are operated from the Fire Sector Panels (FSP) in the Auxiliary Building. In a fire the operator opens one or two of the Reactor Building Fire Protection Containment Valves to allow water supplies up to the Charcoal Filter Valve Skid. The valve skid is then operated by pushbutton from the FSP. The valve skid is automatically closed after a period of one minute. Further detail is provided in the licensee's self-assessment [25].

- Internal Fixed Hose Reels: EDF NGL provide hose reel stations provided within the Radwaste Building and inside the containment.
- General: SZB has aspirating fire detection within their main stores, workshops, document centre and the Dry Fuel Store. Linear heat detecting wire is used within the containment building. Beam detectors are used within the water treatment plant building and Flame Detection is used in the Dry Fuel Store. CCTV is located in the turbine hall to detect flames. EDF NGL noted that the Turbine Hall contains no nuclear significant plant. FM200 (fire suppressing gas) is used in the server rooms within the Administration building and document centre archive.

Fire alarm actuation

EDF NGL states that fire alarm actuation provisions are station specific:

First Generation AGRs (HNB) - EDF NGL provides one Pyrogen Dry Powder system in a number of electrical panels at HNB. It also uses CO₂ to protect the high-pressure stages of the turbo-generators in the Turbine Hall. The LHDC activates a metron head device which fires a pin and fractures the Quartzoid bulbs (thus this is a fast-acting suppression system) activated by the LHDC.

Second Generation AGRs (HY2) - EDF NGL provides Inergen to protect the sub-floor cable rod controls (Control Room, back-up Safety Rooms, etc.).

SZB - The fire alarms do not actuate the fire protection in the safety classified areas – these use frangible bulbs. However, the fire alarm system closes fire dampers to contain the spread of smoke and actuates the overpressure systems for the stairwells and fire escape routes.

Actuation of controls

General – EDF NGL states the following (taken literally from the licensee’s self-assessment):

HVAC systems can be linked directly to the fire alarm system and respond automatically to fire alarms (e.g. fire damper closure, stairwell pressurisation, fans stopped). Independently of the fire alarm HVAC systems can also respond to indications of a fire. There is a subtle difference between the two. For instance, the fire alarm can be activated by the fire alarm system, from by a call point or sensor.

The HVAC system itself can respond to a HVAC smoke detector without necessarily setting off the fire alarm. For example, the Control Room HVAC System at SZB will respond to smoke in the HVAC inlets by automatically switching the system’s dampers to full recirculation mode, but this does not automatically set off the building’s fire alarm. Also for this system, the building’s fire alarm would automatically activate the Control Room’s HVAC recirculation mode.

Regarding nuclear safety and reactor control, shutting down the HVAC system has the potential to lead within a relatively short time to the overheating of rooms that house equipment important to nuclear safety, and consequently the equipment could overheat and

possibly malfunction. Therefore, following a fire alarm there needs to be an appropriate response by the HVAC to avoid a room overheating scenario. The optimal decision making in the design process has defined how these systems operate. When Radiological Safety is involved, the way that the system responds will be based on a balance of risks. A 'control protocol' is needed to take the optimal approach.

EDF NGL concluded by stating that the automatic closure of dampers is problematic in contaminated ventilation systems and that guidance is provided in EDF NGL documentation.

A-I-3.2.1.2 Types, main characteristics and performance expectations

General – EDF NGL requires early detection and automatic suppression for nuclear safety related plant with redundancy and diversity in operation. For example, the LHDC and Metron Heads trigger the sprinkler systems as early as possible, and frangible bulbs actuate the sprinklers on a longer timescale if the early detection/suppression fails. EDF NGL states that the cable race sprinkler systems are designed specifically to match the cable fire load and cable disposition. EDF NGL notes that fire suppression on main turbines is not automatic, and fire suppression on turbines is not required for nuclear safety.

First Generation AGRs (HNB) – EDF NGL reports that the control room and nuclear island security office are covered by the Winmag system, which is a software system showing building layout and specific device location should they initiate. Every time a new device is installed the software requires to be updated to reflect its location.

The 10 Gent panels display a device number and location that has initiated but there is no graphic to show its exact location within a room.

Second Generation AGRs (HY2) – EDF NGL states that there are numerous fire panels across HY2, all Fire Panel Alarms repeat to the Control Room fascia panel and a Data Processing alarm is also received on the station computer.

SZB – EDF NGL reports that SZB utilises the Fire Protection alarm Supervisory System (FPASS). The FPASS System comprises two VDUs, each one connected to a Rack-mounted PC located in each Interface Panel. VDU page selection is via a built function keyboard located on the control desk. A Data Link is provided between the PCs in the Interface Panels to allow common information to be displayed on either VDU. In addition to the display system, a number of controls are available at the control desk. The information delivered to the Technical Support Centre (TSC) is displayed on a remote terminal. The information is identical to the information recorded in the Control Room.

A-I-3.2.1.3 Alerting control room operators

General – EDF NGL reports that any fire alarm on station plant is repeated in the Control Room. The Control Room operators can then direct any required operations.

First Generation AGRs (HNB) – The fire protection system at HNB displays the activated device location on a plan view of the area that has initiated. Sounders within the loop provide audible warning and the Control Room is provided with a Tannoy system to call the shift operations fire team.

Second Generation AGRs (HY2) – EDF NGL reports that in the event of a Fire Alarm at HY2, the Control Room receive a Visual/Audible alarm on the Facia panel and the shift operations fire team will be called to muster via a Tannoy.

SZB – EDF NGL reports that alarms on the plant are repeated through local fire alarm panels to a Fire Protection Alert System (FPAS) and the Distributed Process System in the Main Control Room. The Main Control Room staff then interrogate the alarm and muster the Fire Team via the pager system.

A-I-3.2.1.4 Emergency power supplies

General – EDF NGL reports that all systems are designed to British Standards. The fire detection has battery backup, the fire pumps are diesel driven and fire separated with local fire suppression. Activation of sprinklers and water spray systems is primarily mechanical. On loss of pressure in an air or water systems this results in water valves opening, the fire suppression water flow is initiated and fire pumps start using their local batteries/starter panels.

First Generation AGRs (HNB) – The fire protection panels at HNB are supplied from no-break systems (e.g. emergency lighting fuse boards). The systems used in cable flats have Power Supply Units (PSUs) which are backed up by 24-hour batteries, although some of these are also fed from no-break systems. The PSUs are designed such that they can be supplied and charged from normal electrical supplies.

Second Generation AGRs (HY2) – EDF NGL reports that all plant fire panels at HY2 are supplied from the station 110V a.c. Uninterruptible Power Supply systems, and the alarm bells are supplied from the 250V d.c. UPS boards. EDF NGL states that the fire protection panels are backed up from their own local batteries, and the Inergen and LHDC panels are supplied via 110V a.c. UPS systems.

SZB - EDF NGL states that the fire panels are supplied from the 110V a.c. main UPS system and the 110V a.c. diesel-backed power supplies.

A-I-3.2.1.5 System Resilience

General – EDF NGL Technical Specifications govern actions to be taken in the event of one of more parts of the fire protection system failing. These actions include prompt reactor shutdown with establishment of posttrip cooling for the most severe cases. Where necessary mitigations are put in place e.g.a fire watch to mitigate any system failures.

First Generation AGRs (HNB) – EDF NGL states that an addressable device is contained within each circuit isolator; each isolator protects against open circuit, short circuit and earth circuit failures and ensures that a single cable failure poses no significant detriment on the system operation. EDF NGL reports that therefore upon a single cable failure, all loop wired devices would continue to operate as normal with no effect on system response times. It also enables EDF NGL to locate cable faults.

Second Generation AGRs (HY2) – EDF NGL reports that defects raised for the fire System at HY2 are prioritised depending on the impact to fire detection or Alert. EDF NGL

states that a faulty device that does not operate but is in the vicinity of other detectors could be tolerated as a scheduled maintenance activity.

EDF NGL reports that a detector which cause false alarms would have their respective zones isolated and the isolation would be captured on Fire System Manager. For the duration of the isolation, EDF NGL Operations initiate a Fire Watch which is carried out by Shift Operation staff. EDF NGL finally reports that Addressable panels have a function which allows a device to be isolated rather than the complete Zone.

SZB – EDF NGL reports that fire detector faults are defected and prioritised by Operations using defined guidelines. The Fire System is not included in Technical Specifications. Where detection in an area remains covered by adjacent Fire Loops then EDF NGL schedules repairs as resources allow within normal process. Otherwise, where all detection is lost in a specified area EDF, NGL sets a higher priority (scheduled at earliest opportunity or scheduled with an execution plan). In addition, EDF NGL puts in place a fire watch with a fire impairment notice to define further mitigations and any additional actions in case of fire.

A-I-3.2.1.6 Fire hazard tolerance

General – EDF NGL reports that all fire alarm and detection systems are installed to British Standards.

First Generation AGRs (HNB) – EDF NGL reports that the original installation was cabled in RADOX FRI. Later ‘Standard’ fire resistant cable to BS EN 50200 (PH 30) and ‘Enhanced’ cable BS EN 50200 (PH 120) were used. In some instances fire resistant power cable to BS EN 60332-1-2, BS EN 60332-3-24 was used

Second Generation AGRs (HY2) – EDF NGL reports that fire systems in HY2 “equipment buildings” are wired in 2H2.5 MICC, rated at 36A and that the MICC cable is fireproof and non-aging. It also noted that the majority of “non-equipment buildings” fire systems are wired in ‘Standard’ fire resistant cable to BS EN 50200 (PH 30) and ‘Enhanced’ cable BS EN 50200 (PH 120).

SZB – The SZB Fire Protection System (FPS) is a two-way segregated, Safety Category 2 system (i.e. supports the Safety Category 1 systems but is not essential for achieving adequate nuclear safety). EDF NGL reports that the FPS is designed to remain operable during a fire for sufficient time to alert operators locally and in the Control Room. It quoted that, where required, short-term fireproof cable is qualified to function for a 20 minute duration when exposed to a temperature of 1000 °C. It also states that where required it is used for the Station Public Address system, the Station Siren system, the Direct Wire Telephones, the Station VHF and UHF Radio Links, the Audible Alarm Power circuits, the Fire Detector Circuits, the Cabling of the Firefighting Equipment, Selected Unit Main Protection Connections and the Unit Emergency Stop Button.

A-I-3.2.1.7 Cable wrapping etc

General – EDF NGL states that fire protection is provided as necessary to meet the requirements of the EDF NGL Nuclear Safety Principles (NSPs).

First Generation AGRs (HNB) – At HNB the main cable rays running around the reactor are split into 4 quadrants by the application of four sections of fire rated materials which prevent a fire on one the tray from spreading and affecting another of the four quadrants of plan. EDF NGL claims this for nuclear safety. With regard to cable wrapping, this is not carried out on fire detection cabling, but only on cabling supplies to nuclear significant equipment.

Second Generation AGRs (HY2) – EDF NGL reports that addressable detectors at HY2 are rated to suit the environment they are installed i.e. Ingress Protection (IP)21, IP32, and IP54. Sounders are rated IP31 and IP66.

EDF NGL reports that LHDC Panels are located outside of the area they are protecting to maintain their integrity and new seals have been fitted to the doors of LHDC panels where required as water ingress had been found inside some panels. It also states that cable races at HY2 are protected by Sprinklers and metron head devices which provide fast acting water suppression. EDF NGL has no requirement for cable wrapping.

SZB – EDF NGL reports that, in general, all major cables at SZB are segregated within the four respective fire areas. There are a small number of cases where this was not possible due to redundancy requirements (i.e. it was necessary to locate a cable from another fire area to meet reliability requirements). EDF NGL states that, where this was the case, the cables were boxed in using a three-hour fire barrier. The required fire segregation was therefore maintained. There currently are no examples of cable wrapping on the station.

A-I-3.2.1.8 EMIT Claims

General – In general, one of the main means EDF NGL uses to satisfy Licence Condition (LC) 28 is through the implementation of Equipment Reliability (ER) requirements. Compliance Arrangements for LC28 are addressed in company documentation, which summarises the process documents that satisfy the different elements of LC28. EDF NGL confirms that any fire protection systems that are claimed in the nuclear safety case are included in the EMIT schedule.

EDF NGL notes that LC28 – Examination, inspection, maintenance and testing, is not just about the nuclear safety case, the EMIT definition used is ‘systems which may affect safety’, i.e. not specifically nuclear safety. The EDF NGL suite of fire engineering documents detail the different aspects of ER process, covering things such as ER Reviews, Plant Walkdowns, Component Criticality, Maintenance Strategy etc.

EDF NGL states that the systematic application of ER (in addition to appropriate safety case management for identification and implementation of safety case-related routines/activities) ensures that the appropriate maintenance, inspection, testing etc. is in place for the particular system/plant area. Civil Fire barrier inspections are included in the above ER activities.

EDF NGL reports that there are site-specific arrangements in place at each site. There are a series of Equipment Reliability Reviews (ERRs) for the fire protection systems, which confirm the adequacy of the arrangements or identify corrective actions. These corrective actions are recorded and tracked using the station management system in the same way as

all the other maintenance activities. EDF NGL states that periodic ERRs are produced for all plant systems on each Station on a 3-yearly or 6-yearly basis, depending on the system significance, as defined in the relevant specification document.

A-I-3.2.1.9 Alternative/temporary provisions

General – This topic is addressed in company documentation which considers impairment of fire protection systems. This sets out the requirements and procedures to be followed when a fire protection system (active, passive or semi-passive) is impaired (i.e. taken out of service or otherwise changed so that its effectiveness is reduced). It provides a formal process to meet EDF NGL insurers' requirements for the provision of suitable compensatory measures to be implemented when fire systems are impaired as a result of either planned or unplanned maintenance, or by discovery of a defect.

In addition, it provides support to Technical Specification requirements for additional fire prevention measures when called for, and where these need expanding and detailing. It provides a means of recording and implementing the means of reducing and controlling the increased risk from fire when systems are taken out of service.

The arrangements and responsibilities for notifying the local Fire and Rescue Service and EDF NGL Insurance Group when a major fire system is out of service in excess of a pre-determined time period (e.g. cable flat water spray fire system) are also set out.

Alternative provisions are assessed and deployed by means of fire risk assessments with reference to Technical Specification requirements and company specifications, which detail the period of time a detection and alarm system may be isolated and necessary compensatory measures to be deployed during the period of isolation or unavailability. Further detail is provided in the licensee self-assessment [25].

EDF NGL reports that fire detection maintenance is carried out at intervals in accordance with the relevant EDF NGL internal company technical standard. Within this standard the general rule is to follow British standards, however, there will be some deviations from this code or another guidance is utilised such as EPRI standards. Additionally, where any further deviations are required, an engineering advice note would be authored at a suitable verified grade, using a suitable guidance document.

It is required that each station is compliant to a suitable audit scheme.

A-I-3.2.2 Fire Suppression provisions

A-I-3.2.2.1 Design Approach

General – Fire suppression standards for all the stations were defined by the then operator CEGB (Central Electricity Generating Board). The water spray systems, whether within cable flats using water sprinklers with or without LHDC (Linear Heating Detection Cable) or deluge systems with open head nozzles, were sized appropriately to ensure that fire growth could not spread, and as in the case of deluge systems the water would be of large enough quantity and velocity to extinguish any oil/diesel fires that did start. EDF-NGL considers that this is compliant with the IAEA reference Safety Standard No. SSG-64 'Protection against Internal Hazards in the Design of Nuclear Power Plants' which suggests that fire

suppression should be installed to quickly detect and extinguishing those fires which do start, and thus limit the damage.

EDF NGL summarises the requirements in its own documentation on fire protection and the management of water spray fire protection systems and firefighting ring mains.

EDF NGL considers that engineering judgement for fire suppression is not normally relevant, as the water systems are always designed with the IAEA philosophy in mind by third-party accredited companies and that is a mandatory requirement within EDF NGL's internal Company Technical Standards. In terms of standards for sprinkler systems, EDF NGL uses BS EN 12845:2015+A1:2019 (Fixed Firefighting Systems. Automatic Sprinkler Systems, Design, Installation and Maintenance) [161].

First Generation AGRs (HNB) – The HNB design predates the Browns Ferry fire of 1975, thus has many more nuclear safety claims upon water spray systems. As stated previously, it was designed more with the fire influence approach when compared with IAEA safety guide SSG-64 'Protection against Internal Hazards in the Design of Nuclear Power Plants' [17].

Second Generation AGRs (HY2) – HY2 is a post-Browns Ferry fire design and is therefore designed with the fire containment approach in mind. However, EDF NGL reports an issue with cable segregation in one critical area raised during the PSR1 review. As a result EDF NGL claims some sprinkler systems in the HY2 fire safety case.

SZB – EDF NGL reports that SZB has no direct nuclear safety claims on fire suppression systems. Water spray systems are only claimed as part of the defence in depth arguments and this is mainly because the 4-train system is well segregated. EDF NGL considers that the containment approach as per IAEA guidelines is applied.

A-I-3.2.2.2 Types, main characteristics and performance expectations

Key Characteristics

EDF NGL divides the water spray systems into two fundamental types (and this applies to all of the three reference stations described in this report). The two fundamental types are systems designed to extinguish a fire, and systems designed to control a fire and prevent damage (but not to extinguish it). Both are collectively known as 'deluge' systems in order to distinguish them from sprinkler systems.

High velocity extinguishing systems are designed to extinguish a fire and achieve this by delivering a large volume of water onto the fire through specially designed spray nozzles. Such systems are known as high velocity water spray systems. The deluge of water achieves extinguishment by a combination of effects which may include cooling of the fuel, emulsification of the fuel and the local exclusion of oxygen from the flame region due to the evaporation of water to steam.

First and Second Generation AGRs (HNB and HY2) – Sprinklers are located in various positions across the plant. The cable races for HNB and HY2 use metron head devices attached to LHDC (Linear Heating Detection cable) to act as fast acting detection and suppression.

Other types of fire suppression at HNB include Inergen, Pyrogen and, Fluorine Free foam. Systems currently being retired at HNB include the turbine bearing CO₂ systems and some foam suppression systems.

Other types of fire suppression used for HY2 include Inergen, protecting sub-floor cable rods (Control Room, Safety Rooms, etc.). HY2 does not use any fixed foam systems. Only mobile foam is used for firefighting capability.

Sizewell B – SZB does not have any active systems claimed and does not use any fixed foam systems. Only mobile foam is used for firefighting capability. There are sprinklers in all the cable races but no metron head devices are incorporated.

Arrangement for Ensuring Capacity and Coverage

General - All of the station designs assessed here are in line with Section A-I-3.2.2.1 above.

First Generation AGRs (HNB) – At HNB the Hydrostatic tank of the fire protection system accommodates the initial pressure drop when a deluge valve opens. When the pressure decreases to set levels the diesel pumps start in sequence.

Second Generation AGRs (HY2) – The fire protection equipment generally consists of fixed water spray and sprinkler systems, internal hydrant/foam generating and inergen/inert gas systems together with portable appliances and an external underground conventional hydrant system.

The protection against fire by means of the fixed high/medium velocity water spray and sprinkler system is provided by a series of discharge heads supplied by a trunk main system. Three 50% fully automatic diesel fire pump sets, dedicated to firefighting duties only, supply the water spray and sprinkler systems via the firefighting trunk main. Further information on the pumps, storage tank, external hydrant system ring main distribution, foam generating system and portable appliances is provided in the licensee self-assessment [25].

SZB – Water supplies for the fixed fire protection system are taken from the two towns water reservoirs and that there is internal segregation within the reservoirs ensuring a minimum capacity is maintained. Delivery is to three firefighting pumps. The water supply is maintained under pressure by the 3 pumps and a pressure tank containing 1/3 water and 2/3 compressed air. The main pressure is maintained by a charging water pump and a charging air compressor. Firefighting pumps are started automatically from pump start pressure switches in a pre-determined order on falling pressure.

Water supply arrangements

General – EDF NGL does not claim manual suppressing systems for nuclear safety, which is, where possible, based on segregation of redundant trains of equipment. It states that they are for defence in depth and designed in line with the required standards.

First Generation AGRs (HNB) – Hydrant valves at HNB are located station wide on the fire hydrant ring main where manual firefighting equipment can be connected. Adjacent to each hydrant point there is a foam tank and storage of the required equipment.

Second Generation AGRs (HY2) – At HY2 the Fire Hydrant System provides water for firefighting to the plant areas at risk. It also provides water for the Back-up Emergency Feed System, Decay Store Emergency Water Supply, Decay Heat Reserve Feedwater Tank (RFT) Emergency Supply and Pressure Vessel Cooling. System (PVCS) Alternative Cooling. It also supplies water to the hydrant ring main. Emergency Water supplies are provided to supply the hydrant ring main from three alternative sources (HYA hydrant system, towns water main, reactor sea water outsurge Chamber). There is also a pumping out point to supply the Heysham 1 Fire Hydrant System. These are from the Fire Hydrant Pump Electrical Supplies.

SZB – The Water Suppression System at SZB comprises a number of sub-systems. The fixed water suppression system includes the firefighting ring main, automatic and manual sprinkler sub-systems, automatic and manual water spray sub-systems, hose reel station. The firefighting pumphouse contains three fixed fire system suppression pumps, two hydrant ring main pumps and is supplied by two towns water storage tanks. The fire hydrant system includes an external hydrant system and dry risers.

Capacity of suppression systems

General – EDF NGL reports that all fire suppression systems are designed to the British Standards, with diversity, redundancy, independence, testability, failsafe requirements and segregation/separation as required. EDF NGL states that this provides a high degree of confidence that fires will be detected and suppressed with greater than a 95% probability of success. EDF NGL reports that water-based suppression system capacities are sized for the maximum credible demand on station (which is a full turbine centre line fire). The licensee's self-assessment report [25] provides further detail on the specific equipment provided at each station.

Balance between automatic and manual systems

General – EDF NGL reports that if a fire suppression system is claimed for nuclear safety and is not automatic, it makes no claims on operator actions for 3-hours after event initiation so, in practice, manually operated systems are not claimed for nuclear safety purposes, only for defence in depth.

First Generation AGRs (HNB) – At HNB EDF NGL uses the standard Engineering Change (EC) process to determine the individual system requirements and the consequences of failure to deluge to nuclear significant plant. As the station is now defueling there has been a reduction in the number of nuclear significant areas. EDF NGL is currently progressing a case to remove foam systems from the fire safety case.

Second Generation AGRs (HY2) and SZB – EDF NGL reports that this is not applicable at HY2 and SZB as the safety case is built upon passive fire protection (except for a small number of critical areas at HY2 as noted in Section A-I-3.2.2.1).

Accessibility considerations

General – EDF NGL states that, in general, the station designs considered do not present accessibility problems for firefighting. Off-site firefighting resources are managed by local authority services and are not owned by EDF NGL. Should a site require additional support in the form of offsite firefighting resources the site control room would activate a response by calling the emergency services number. The amount of resource that will arrive to site will be determined by the pre-planning developed between the site and the local authority. The plans would be activated along with the designated number of appliances for the event.

For HNB, HY2 and SZB there are no known accessibility issues for manual firefighting. See also Section A-I-,3.2.3.

A-I-3.2.2.3 Management of harmful effects and consequential hazards

General – EDF NGL reports that there are no seismically qualified fire suppression systems at HNB/HY2 or SZB which are required to function to meet nuclear safety requirements. However, there are cases where fire suppression equipment is seismically qualified in order to prevent spurious discharge or generation of a missile and damaging seismically qualified plant in a seismic event.

EDF NGL states that combined hazards involving fire and flooding are normally considered to be from an internal fire scenario which causes a flood within the nuclear safety categorised buildings. In these cases EDF NGL prevents flooding to adjoining compartments and safety trains by qualifying penetration seals. The penetration seals also prevent the spread of fire between adjacent compartments. EDF NGL states that in general the drainage capabilities of the fire areas considered provide for the internal flooding hazard arising from the fire suppression system.

EDF NGL considers that challenges to radiological containment are not applicable to the stations considered as there are no fixed water spray firefighting water spray systems in such locations. Where there are sprinklers fuel areas (such as within the fuel loading bay at SZB), EDF NGL considers them in the criticality assessments to demonstrate that the use of water, firefighting foam and Monnex do not cause a critically event.

A-I-3.2.2.4 Alternative/temporary provisions

General – EDF NGL assesses and deploys alternative provisions by means of risk assessment with reference to Technical Specification requirements and company specification for impairment of fire protection systems. This details the period of time a detection and alarm system may be isolated and necessary compensatory measures to be deployed during the period of isolation or unavailability. For further detail see the licensee self-assessment report [25].

A-I-3.2.3 Administrative and organisational fire protection issues

A-I-3.2.3.1 Overview of firefighting strategies, administrative arrangements and assurance

General – EDF NGL reports that the firefighting strategy for the sites in this report (HNB, HY2 and SZB) follow the same approach, which is also replicated across the EDF NGL fleet. EDF NGL develops safety cases to identify items of plant which are essential in safeguarding nuclear safety, which focuses on fire prevention, detection, suppression and segregation.

EDF NGL develops and maintains administrative procedures in the form of fire risk assessments in accordance with company procedures. EDF NGL states that it produces fire risk assessments for all areas of site including plant and non-plant areas. The procedures identify potential risks with respect to fire loading and provide recommendations to sites in terms of reducing those risks. The use of physical and procedural fire prevention methods are the main EDF NGL strategies, together with administration arrangements to maintain fire safety within normal operations outside of emergency response.

The emergency scheme/in-house firefighting capability staffed by Operations Incident Response teams is established primarily to manage and mitigate the commercial and personnel safety risk associated with fire, again noting that nuclear safety case requirements are satisfied by the established segregation provisions (which do not require manual intervention to operate).

In house firefighting capability including training requirements is detailed in Section A-I-3.2.3.2 and assurance in Section A-I-3.3.1.3.

Periodic Review

Nuclear Site Licence Condition 15 requires EDF NGL, as licensee, to carry out 'periodic and systematic review and reassessment of safety cases' for each of its nuclear installations this applies to all three sites featured in this report. The purpose of a Periodic Safety Review (PSR) is to determine if in this case emergency planning arrangements currently in place will continue to be satisfactory during the next PSR review period through the management processes employed.

EDF NGL prepares a Main Review (MR) report support the PSR for a specific NPP and identifies any issues of particular significance such as changes in nuclear fire safety case which may impact on emergency preparedness. The purpose of the PSR MR for fire is to identify any changes to fire safety standards and review emergency arrangements performance during the reporting period (the previous ten years) through exercise reports, Condition Reports (CRs), the developments of the Emergency Handbook, the management of emergency facilities and actual events. Based on this experience and knowledge the review will assess the potential impacts of legislation, operating status, management changes, learning from exercises and incidents and the advent of new technologies to identify any significant challenges to the Emergency Preparedness Programme.

EDF-NGL considers that the PSR of emergency preparedness will determine:

- 1 The adequacy of the emergency plans, response staff, facilities and equipment for dealing with emergencies including non-radiological such as fire.
- 2 If the operating organisation's arrangements have been adequately coordinated with the arrangements of local and national authorities including blue light services.
- 3 Scope and frequency of exercises and how learning is fed back into the organisation.
- 4 Form a view on the management system to identify, remediate shortfalls or adapt emergency planning practice.
- 5 Address the impact of issues identified in the significant issues review.

A-I-3.2.3.2 Firefighting capabilities, responsibilities, organisation and documentation onsite and offsite

General – EDF NGL reports that each site has an emergency plan and handbook which contains the procedures for response to events such as fire. They describe the roles and responsibilities for shift managers, emergency controllers and incident response team members.

The emergency handbook covers immediate and ongoing actions expected from the emergency response teams. EDF NGL expects the teams to understand their level of competence and the expectation placed on them by the company when faced with a fire event. EDF NGL states that it converts this in company procedures for firefighting capability specification, outlining the scope and limitations of the response capability to ensure a consistent approach is maintained across EDF NGL sites.

The specification lists the expected minimum firefighting skills and capabilities of the Incident Response teams which include undertaking investigation of fire alarms, controlling and extinguishing minor/moderate fires and searching for and rescuing casualties. A more detailed list of the expected skills is provided in the licensee's self-assessment report [25].

The firefighting capability specification was developed by EDF NGL to ensure a consistent approach to site based firefighting capability. EDF NGL states that while not all possible scenarios, the specification covers the installed fire detection and suppression system capability, and the capability that the incident response teams must have, supporting the development of a specific training program. Topics addressed include the investigation phase of a response, use of equipment and understanding fire plans. A more detailed list may be found in the licensee's self-assessment [25].

Roles and responsibilities – EDF NGL reports that a generic approach to maintaining emergency arrangements is adopted by all sites in the EDF NGL fleet, including HNB, HY2 and SZB. Each site produces a three-year training and exercise program and an annual training and exercise program, which are shared with on-site role holders and also off-site agencies including the local fire service.

EDF NGL states that each site runs on average approximately 14 exercises per year which range from full site live play exercises, drills, desk top exercises and classroom-based

workshops. Within these sessions changes in responsibilities, procedures or policy are communicated to those team members who are required to be made aware.

EDF NGL reports that response procedures within each site's emergency handbooks are reviewed on a three-year basis, however, handbook sections are also reviewed and amended following learning from exercises, real events or regulatory requirements.

Interface with off-site/local fire services

General – EDF NGL Site Emergency Preparedness Engineers maintain relationships with external agencies through two main meetings which are held bi-annually, the first is the Emergency Preparedness Consultative Committee meeting (EPCC). This meeting is attended by all external agencies including fire brigade leaders. The second meeting is the Emergency Services Liaison Group meeting (ESLG); this meeting provides the site Emergency Preparedness Engineer and Emergency services including the Fire Brigade with an opportunity to review at a tactical level fire brigade operating procedures for response to each site. This meeting is the platform in which a full discussion and review can be undertaken to identify any specific provisions required to update response documentation. Further detail is provided in the licensee submission [25] on the focus of these meetings.

Safety Culture – Emergency Response (Fire) – In addition to full site response exercises, sites are expected to carry out fire drills requiring the full site muster off staff to designated fire assembly points. EDF NGL carries these out annually as a minimum, however, scenarios associated with full site response exercises may also incorporate a fire hazard within the objectives. EDF NGL considers that incorporating fire drills into annual exercises provides site staff with the opportunity to practice muster arrangements. Response staff are able to familiarise themselves with the relevant emergency handbook.

A-I-3.2.3.3 Specific provisions, e.g. loss of access

General – Each nuclear power station has a minimum of two access routes to site in the event of an off-site release affecting access. Upon declaration of an emergency the site Control Room provides advice to the responding emergency services on which access route to site they should take. For a radiological release scenario this is determined by wind direction and potential hazards to responders.

EDF NGL states that the use of alternative access routes to sites are incorporated into site drills and exercises to ensure responding emergency services are familiar with all entry points to site. Learning from these events are shared with external agencies during external stakeholder meetings such as the Emergency preparedness.

A-I-3.2.4 Licensee's experience of the implementation of the active fire protection

The EDF NGL experience with fire protection is represented by HNB, but noting that diverse back-up safety systems such as BUCS were later installed to make the plant robust against a single unsuppressed fire.

The EDF NGL experience has been gained over a long period of operation of diverse AGR designs and has in particular been influenced by the Browns Ferry fire.

A-I-3.2.4.1 Overview of strengths and weaknesses

HNB – EDF NGL reports that at HNB, the fire influence approach was undermined by a lack of appreciation of the likelihood and severity of fires in certain critical areas. The originally installed fire-influence plant - high velocity water spray - was not adequate to control certain plausible fire scenarios. As a result, the plant was later hardened by additional fire detection and suppression equipment, leak prevention and leak ignition prevention measures, and passive fire protection of specific essential plant was provided.

In certain critical areas the original fire influence approach was not fully implemented i.e. not all fire scenarios were identified and assigned a suppression measure. The fire containment approach could not be physically applied in open areas by subdividing. However, EDF NGL considers the later provision of back-up plant remote from the critical areas e.g. back-up cooling systems is equivalent to the containment concept for the later installed equipment.

EDF NGL concludes that the fire influence approach can be effective but requires a comprehensive understanding of the fire and a comprehensive and reliable package of influence measures. Remote back-up plant is advised to compensate for the inherent reliability concerns in the fire influence approach.

However, EDF NGL's OPEX does not reveal any fires which have threatened nuclear or life safety and which have gone undetected or un-suppressed. This provides it with confidence that the fire prevention measures and fire protection measures are effective.

A-I-3.2.4.2 Lessons learned from events, reviews fire safety related missions, etc.

See Section A-I3.2.4.1.

A-I-3.2.4.3 Overview of actions and implementation status

No actions have been identified by EDF NGL.

A-I-3.2.5 Regulator's assessment of the active fire protection

A-I-3.2.5.1 Overview of strengths and weaknesses in the active fire protection

In line with previous sections, ONR has considered the information provided by EDF NGL against WENRA SRLs and IAEA requirements and guides as well as the ONR SAPs and internal hazards TAG.

EDF NGL described in section I-3.2.1 how fire alarm and detection systems are identified at the different stations dependent upon the claims made upon them within the nuclear safety case and how EIM&T is prioritised. This meets the expectations of the internal hazards TAG [16] and SRL SV 6.11 regarding EIM&T.

ONR expectations on the hierarchy of controls as described in para. 155 of the SAPs [15] are satisfied for the most modern station. For HY2 a small number of claims are made on fire detection systems in the safety room and the pile cap, whereas for HNB the nuclear safety case relies upon the fire detection system. Whilst this does not meet the ONR expectations on the hierarchy of controls (due preference to be given to passive measures

incl. fire containment approach), EDF NGL describes how suitable measures have been taken to add additional compartmentation and lines of protection so that the station can tolerate full compartment burn out (as described in section I-2.1.1.2).

EDF NGL notes that fire alarm and detection systems at its stations were originally designed against the British Standards of the time, but that each station has had a wide upgrade of the fire detection panels and that all new fire alarm systems are designed and commissioned by accredited companies. The licensee has also described (in section I-2.1.2) how the safety analysis assesses the risk associated with nuclear fire and identifies the requirements for designation of any fire protection systems for nuclear safety. This meets expectations of SAP EHA.16 [15] and SRL SV 6.8 that the fire detection, alarm and extinguishing systems provided should be commensurate with the fire hazard scenarios stipulated in the safety case and should be appropriately categorised and classified.

EDF NGL places claims on fire suppression in the candidate facilities (and across the estate) particularly in relation to fires in cable trays and in specific oil/diesel fire scenarios. This provision is consistent with SAP EHA.16 and IAEA SSG-64 [17] which recommend that fire suppression should be installed to quickly detect and extinguish those fires which do start.

Section I-3.2.3.2 describes the fire and rescue service provision on the sites which ONR judges to be a strength of the EDF NGL case. While fire service intervention is not credited in the fire hazard analyses, demonstration of robust arrangements for onsite firefighting and coordination with local fire and rescue services provides defence in depth. ONR judges this to meet the expectations of SRL SV 6.12, 6.13 and 6.14. In addition, the expectations of IAEA SSR-2/2 [69] (for nuclear power plants being commissioned or operated) that “periodic joint fire drills and exercises shall be conducted to assess the effectiveness of the fire response capability” are shown to be met.

A-I-3.2.5.2 Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

During a fire safety inspection [45] of the Torness AGR (a second generation AGR and “sister” station to HY2, ONR identified shortfalls in licensee’s compliance with LC28 (Examination, inspection, maintenance and testing). This is because EDF NGL’s fire damper maintenance records of the administration building (non-nuclear) sampled by ONR contained evidence of visual inspections only. ONR also raised regulatory issues related to life fire safety: these were primarily EDF NGL’s review of the station’s FRAs were outside of timescales set by EDF-NGL’s arrangements and fire compartmentation shortfalls in an administration building. EDF NGL has committed to rectifying these shortfalls and ONR is monitoring progress through Level 3 and Level 4 regulatory issues. In addition to the above, ONR carried out life fire safety inspections carried out at HNB [162] in 2020, HPB [163], HRA [164] in 2021, and HY2 [165] in 2022, all rated green with an ONR Level 4 Regulatory Issue (lowest level) was raised in relation to the siting of portable fire extinguishers for temporary accommodation units at HY2.

A-II New build facilities – NNB GenCo

A-II-3.2.1 Fire detection and alarm provisions

The text in this section has been prepared by NNB GenCo, with only minor changes by ONR as described in section 1.1.2.

A-II-3.2.1.1 Design approach

NNB GenCo reports that the Fire Detection System (JDT [FDS]) is a dedicated I&C system that monitors detection, actuates fire protection actions, and monitors the state of some interfacing fire protection systems. It is essentially separate from the HPC centralised I&C, the only interface being to send signals to the I&C system to be displayed for information. The JDT [FDS] system's role is detecting fire, transmitting the location of the source of any detected fire, and any smoke-filled zones, to a central operator station, and initiating the appropriate fire protection equipment.

The choice of detector type considers the environment in which it has to operate, such as temperature, flame, smoke, combustion gases and environmental conditions that restrict accessibility such as room temperature and humidity, ionising radiation and hazardous gases. NNB chooses the detector type in accordance with BS 5839-1, and the general principles are summarised in Appendix D of the NAR (from [130] Table 7). NNB GenCo uses diverse detector types in locations where spurious activation of fire suppression systems could release water onto safety systems.

For asset protection purposes, NNB GenCo reports that it will provide aspirating fire detection systems to electrical plant rooms containing Instrumentation and Control (I&C) cabinets and or electrical switchgear in accordance with guidance in BS 6266.

NNB GenCo also states that it will provide an independent fire detection system to areas with a critical cooling issue for closing fire dampers in associated HVAC systems with a Class 1 or Class 2 cooling function. It states that interfaces between the fire detection systems and fire dampers will be arranged such that a fault in one of the detection systems cannot lead to the spurious closure of dampers and the loss of cooling to the associated room.

NNB GenCo reports that components of the JDT [FDS] will be Safety Class 3, and precautions are taken to prevent the system having an unacceptable impact on safety class 1 or 2 equipment. It also states that electrical and I&C components in the JDT [FDS] system will comply with the electrical and I&C requirements associated with their safety class. The level of seismic requirements to be applied to the JDT [FDS] system components is related to the Safety Feature Group (SFG) to which the component belongs, and the consequences on other classified components of its failure, if it were not seismically qualified.

NNB GenCo states that the JDT [FDS] will be designed to enable sufficient Examination, Maintenance, Inspection and Testing (EMIT) activities taking account of access restrictions due to the installation environment such as ionising radiation.

The JDT [FDS] system interacts with other systems to ensure nuclear safety objectives are met, including closure of fire dampers in Nuclear Fire Safety Compartment (SFS)/Nuclear Fire Safety Cell (ZFS) barriers and in Intervention Fire Compartment (SFI) barriers in buildings which contain safety equipment required to reach and maintain the safe state of the plant. It also triggers automatic fixed firefighting systems in buildings which contain safety equipment required to reach and maintain the safe state of the plant and triggers an alarm in the main control room. The system also monitors the position of fire doors on the boundary of SFS/ZFS barriers, monitors fire during firefighting to assist operators or fire intervention personnel and opens smoke control dampers for certain fire volumes. The system will also initiate pressurisation of access zones adjacent to the affected volume to facilitate personnel evacuation and emergency services intervention.

NNB states that activation of the detection and alarm system will also prompt operators to carry out manually initiated actions such as operation of fire dampers and smoke control dampers, control of smoke management systems and managing deluge valve sets. The design of the JDT [FDS] system is ongoing.

Types, main characteristics and performance expectations

Fire Detectors – The fire detectors are linked to fire alarm control panels and automatic alarms. All fire detectors are permanently monitored, and any fault is shown in the fire alarm control panels. Detectors of Safety fire Compartments are generally Class 3 Safety Features.

Detection Zones – Fire detectors are grouped in detection zones, which correspond to areas, rooms, or a group of rooms.

Detection Lines or Loops – The detectors are linked electrically in such a way as to form electrical lines or loops, covering geographically designated zones.

Fire Alarm Control Panels (FACP) – Create visual and audible alarms in the Main Control Room (MCR), monitor the progress of the fire, as well as providing the logical processing of the fire alarms and the firefighting actions. Each one has its own back-up 24hr electrical supply and is provided for each safety train. One is located on each building throughout the plant, they are all connected to each other and the Fire Alarm Repeater Panel. The FACPs generate corresponding fire alarms and automatic firefighting actions. FACPs and local panels for Safety fire compartments are Class 3.

Fire Alarm Repeater Panels (FARP) – Located in the MCR the Remote Shutdown Station (RSS), it displays the state of all detectors (such as fire alarms, malfunction alarms, etc.), the control of the fire dampers and the automatic firefighting equipment. In addition, a

Graphical User Interface (GUI) is installed to show plan view drawings identifying the location of the fire and state of detectors. FARPs are Class 3.

NNB GenCo states that Fire Detection Systems will be provided with a diesel backed up power supply in addition to local batteries. Fire detection cabling will be rated C1 in accordance with NF C 32070 and enhanced fire resistance in accordance with BS 5839-1. Where aspirating smoke detection systems are used in the reactor building or SFS/ZFS

spaces that are inaccessible in service, NNB GenCo states that the extraction system featuring a fan should have two independent power supplies.

Hazard Tolerance: The design standards for hazard tolerance of the JDT system are specified in Tables 2 and 3 of the SDM Part 2 [166] and for the overall requirement in principle for no loss of more than one train of the system. For external hazards, the level of protection of the JDT system is dictated by the design standards of the building or structure in which it is installed. NNB GenCo reports that protection is considered for internal fire, earthquake, aircraft crash, marine corrosion, lightning, and electromagnetic interference.

Alternative/temporary provisions

NNB GenCo reports that the JDT system is designed to be continuously self-monitoring and any faults detected are indicated in the MCR, and detectors are designed and positioned to allow regular maintenance and testing as far as possible. The division of the system into zones, lines and loops allows one part of the system to be isolated for modification without having to shut the whole system down.

NNB states that the JDT system will be designed to enable implementation of a maintenance schedule. Details of the maintenance arrangements and frequency have not yet been finalised and NNB confirmed that they will be developed in consultation with the supplier but the requirements as BS 5839-1 (Section 6) will be adopted as the minimum standard.

NNB expects temporary buildings to be erected on the site during an outage and will normally be located between Turbine Halls (HM) and the Operational Service Centre (HBX) Building; NNB GenCo reports that connections to the site fire detection system via interface units and FIRE and FAULT signal feedback will be made when the temporary buildings are erected.

A-II-3.2.2 Fire suppression provisions

A-II-3.2.1.2 Design approach

The provision of fixed firefighting systems is based on a risk analysis approach taking account of the fire load and the presence of ignition sources in each relevant location. The criteria take account of nuclear safety, radiological containment, life safety and intervention, industrial property and availability aspects and are summarised in the licensee's submission [49].

Other factors considered by NNB GenCo include the presence of nuclear safety equipment, internal flooding issues that might be caused by activation of the system (damage to electrical components and non-water-tight equipment), layout impact and environmental issues from the suppression fluid.

NNB GenCo states that the Main Control Rooms (MCRs) and Remote Shutdown Stations (RSSs) will serve as the Fire Control Centres for the HPC site and are segregated to protect against common cause failure.

It also states that firefighting system safety functions for buildings and equipment are Class 3. Several of these systems also contribute to other safety functions which have been assigned a higher class for nuclear safety, but only the fire related safety functions are reported in this document. This does, however, mean that NNB may design some parts of the systems to higher standards than would be dictated solely by their fire SF classification.

The key characteristics of the firefighting systems are detailed in the HPC fire strategy document [130], Table 8 of which lists the key parameters based on the type of equipment protected (oil-cooled transformers, diesel generators or diesel driven pump sets, diesel storage, cable spreading rooms, server and I&C cabinet rooms, cable galleries flammable and combustible liquids, charcoal filters, storage spaces, hydrogen stores). These include the suppression system type, the density and area of coverage, relevant standards for the suppression system type (see Appendix I)). NNB GenCo listed the fixed firefighting systems as follows:

- (JPI) Nuclear Island Protection and Firefighting Water Distribution system (NIFPS) – Classified system for protection and distribution of firefighting water in the Nuclear Island (NI) including the reactor building and fuel buildings. The system predominantly uses water sprinklers with some water deluge systems [167]. The sprinkler systems are automatically activated by the JDT system or by detection of heat at the sprinkler heads. The deluge systems are operated manually from the MCR.
- (9JPI) Nuclear Island Protection and Firefighting Water Distribution System for other buildings containing radioactive material (ETBFPS) – Classified system for fire protection and firefighting water distribution for NI buildings for radioactive waste and effluent storage and handling and associated workshops and laundry facilities [168]. The system is predominantly water sprinklers but includes foam systems for solvent and oil storage facilities. The sprinkler response to a fire is similar to that for JPI. For the foam systems, opening of a motorised valve will activate the foam storage and dosing unit so that foam is ejected to the proportioner.
- (JPD) Firefighting System for Conventional Island – Classified system (with non-classified parts) for distribution of firefighting water for the Conventional Island, Balance of Plant, and site buildings [169], and is predominantly water sprinkler systems with some water deluge systems. The operating principles are similar to those of the JPI system except that the deluge systems are triggered automatically on detection of a fire by the JDT system.
- (JPV) Diesel Fire Protection System – Classified system for fire protection for the Diesel buildings [170]. This system includes automatically activated water or foam deluge systems and wet sprinkler systems.
- (JPH) Turbine Hall Oil Tank Firefighting system – System for extinguishing fires in the Turbine Hall oil tank [171], comprising water deluge systems for individual plant items. Most of the systems are activated automatically on detection of a fire by the JDT system, except the system serving the turbine generator bearings which is activated manually from either the MCR or locally within the Turbine Hall.

- (JPT) Transformer Fire Protection System – System for fire protection of the transformers [172], comprising an automatically activated deluge system. NNB GenCO does not claim the system for nuclear safety, so the protection is for life safety and asset protection only.
- (0JPU) HUM/HDU Fixed Fire Suppression System – System for fire protection of the Emergency Response Centre (HUM) and Emergency Response Energy Centre (HDU) [173] is a water mist system to protect the emergency diesel generator and its fuel storage tank rooms in HDU, water deluge for the plant room carbon filter housings in HUM, and inert gas suppression for other areas of HUM. The system is triggered automatically by 0JPU fire detectors but can also be activated manually via the local control panel.

A-II-3.2.1.3 Types, main characteristics and performance expectations

NNB GenCo reports that water supply for fixed automatic systems is from (JAC) the Firefighting Water Supply System, which is the classified system for the supply of firefighting water [174], comprising two water storage tanks, four firefighting water pumps (one per train with each train powered from a different division), and associated pipework, valves and control and instrumentation. The pumps' power supply is backed up from the emergency diesel generators, and two of the four are also backed up from the Ultimate Diesel Generator (UDG) in case of loss of the EDGs. The JAC system supplies JPI, 9JPI, JPV, JPD, JPT, JPH and JPS. The fire water is routed to the Nuclear Island via two separated JAC lines to loops which serve the relevant systems. NNB GenCo states that the system is designed with capacity for the most onerous fire.

NNB GenCo reports that the JAC system is designed to be kept on standby with the two water supply tanks full, the system primed and full of water. Activation of the sprinkler or deluge systems causes a significant decrease in pressure in the supply pipework which triggers the firefighting pumps to start up automatically to maintain sufficient pressure for the suppression system to be able to maintain the required flowrate and coverage. A jockey system is included to keep the circuit pressurised when in standby mode.

It also states that the water supply for manual suppressing systems including fire hydrants is distributed by the (JPS) The Distribution of Firefighting Water for the Site [175]. The system is supplied by the JAC system and is maintained primed and pressurised by the JAC pumps which start automatically on detection of low system pressure.

NNB GenCo reports that the choices between automatic and manually activated systems were based on balancing the potential consequences of the fire with the potential consequences of spurious operation of the suppression system such as internal flooding and asset damage or spread of radioactive contamination in runoff water.

NNB does not claim manual firefighting for nuclear safety, but considers it important for life safety and asset protection, and it makes provision for personnel access in the design of the building and fire compartments described in Section A-II-3.3.1. It provides dry risers as part of the JPD, JPI, 9JPI and JPV systems described previously for distribution of firefighting water to multiple levels of a building. The dry risers have inlet connections at the fire service access level and have outlets in the firefighting lobbies or in a location of low fire

risk and are positioned so that each room can be reached from the outlet with a hose length of 60m. The dry risers are normally empty, but if required for use they are charged with water from the external hydrants on the JPS system or from a fire truck, then hoses are connected to the outlets for firefighting.

NNB GenCo reports that the firefighting equipment will be maintained and stored at access control points in designated buildings for use by operations staff and they will PPE clothing, Breathing Apparatus equipment, portable firefighting equipment, such as fog gun backpacks and portable fire extinguishers (not provided externally on site) and an emergency response vehicle containing firefighting equipment to allow small fires to be tackled by the first response fire personnel and emergency response team.

A-II-3.2.1.4 Management of harmful effects and consequential hazards

NNB GenCo applies levels of seismic requirements to the fire suppression system depending on the safety feature group to which the component belongs, and the consequences to other components of their failure. NNB reports that some parts of the systems are seismically qualified and are separated from non-qualified parts of the system by isolation valves which are closed after a seismic event.

NNB GenCo recognises that the systems could also cause internal flooding due to rupture of pipework and tanks and provides isolation valves at various locations to limit the amount of flooding. The isolation valves are closed manually (either remotely from the MCR or locally to the plant), depending on the response time required, and the accessibility of plant for local operations. The system design also takes account of the possibility of flooding due to double-ended guillotine break, where appropriate.

NNB Genco also acknowledges that the JPI [NIFPS] system could carry liquid fluids containing small amounts of radioactive material under certain fault conditions and plant configurations. As such, it considers that it must contribute to both the confinement of this material with respect to the environment as a whole and the public, and to the control and reduction of radioactive waste discharges under accident conditions. Furthermore, it considers that it must be able to isolate itself from the JAC system or parts of itself in case of a pipe leak or break in the NI creates an internal flooding event. The JPV must also contribute to the safety function related internal flooding through this isolation.

A-II-3.2.1.5 Alternative/temporary provisions

NNB GenCo has no plans for alternative or temporary provisions, and reports that any emergent requirements for such systems will be assessed under the modification process.

A-II-3.2.2 Administrative and organisational fire protection issues

A-II-3.2.2.1 Overview of firefighting strategies, administrative arrangements and assurance

HPC is still under construction, and the full suite of administrative and organisational arrangements are being developed by NNB GenCo and are expected to include elements of the WENRA requirements including EMIT of fire barriers, detection, alarm features & extinguishing systems; an up-to-date firefighting strategy with clearly defined procedures;

emergency training; offsite response group familiarisation; and other organisational arrangements such as minimum staffing levels. NNB GenCo has produced a site wide Fire Strategy document [130] outlining the general principles, and is currently writing additional fire strategy documents for the main HPC buildings.

NNB GenCo plans to provide fire plans for all buildings on the site in the MCR's and RSS's and at firefighting entry points in each building. NNB GenCo plans for all operations staff to be trained in basic firefighting procedures (a smaller number of operations staff will be trained to extinguish small fires using portable extinguishers), e.g., how to raise an alarm, what to do in the event of a fire alarm, evacuation routes, location of muster points as per the International Guidelines for the Fire Protection of Nuclear Power Plants Clause 4-2.

In addition to the external muster points, NNB GenCo will provide internal muster points to HPC site, intended as safe locations in the event of an offsite nuclear accident or other incidents requiring an internal muster.

A-II-3.2.2.2 Firefighting capabilities, responsibilities, organisation and documentation onsite and offsite

NNB GenCo states that the key principles for management of the procedures, training role holders and ensuring the procedures are communicated are summarised in the emergency arrangements deployment roadmap [176]. NNB GenCo requires a programme of familiarisation and training to ensure emergency response personnel have the correct skills and knowledge to carry out their role effectively. It states that the training will be developed using the Systematic Approach to Training (SAT) and will be periodically reviewed to ensure it remains fit for purpose throughout the project lifecycle and into operations.

NNB GenCo states that the current Nuclear Generation (NGL) Generic Emergency Scheme Training (GEST) programme will be used as the basis for the HPC emergency response training programme. Further detail on how this has been developed, proposed training for emergency response for general on-site personnel and visitors and maintenance and inspection of SSCs is provided in the licensee's self-assessment report [49].

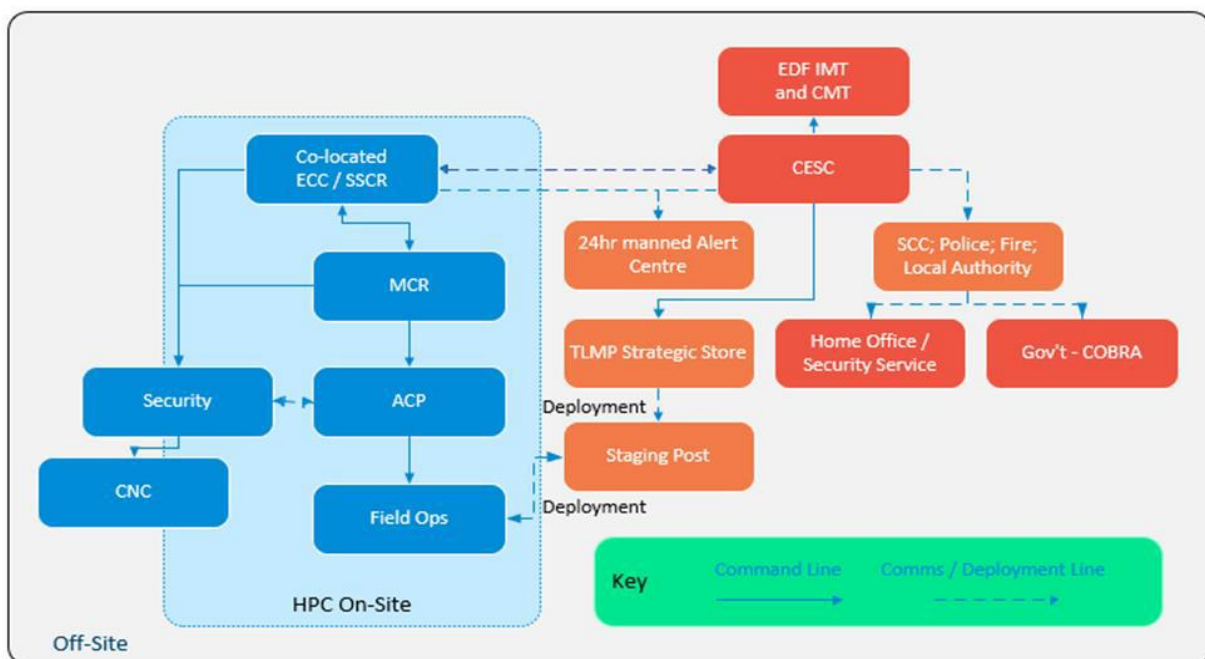
Regarding onsite firefighting capability and liaison with offsite facilities, NNB GenCo states that emergency arrangements are being developed for when the HPC site becomes fully operational and the current status of the arrangements and supporting references have been summarised for equipment and facilities [177], and for the organisational arrangements [176].

NNB GenCo reports that the arrangements and equipment for HPC will be developed using the NGL Integrated Company Practice (ICP), on the recognition that the emergency response for a Pressurised Water Reactor (PWR) requires a slightly different emergency equipment inventory to the existing fleet, even when compared to SZB (of a similar technology). NNB GenCo considers that the equipment, the storage arrangements, and deployment plans need to consider the technological differences, but also changes in regulations and best practice which have evolved since the design and construction of the existing nuclear fleet, particularly following the nuclear accident at Fukushima Daiichi in Japan.

The on-site firefighting facilities associated with operational buildings (detection, fire suppressing systems and their power and water supplies) have been described in previous sections. Additionally, an Emergency Response Garage will be located adjacent to the on-site Emergency Response Centre to provide storage of vehicles and equipment for emergency response, including response vehicles, specialist fire rescue PPE, specialist fire rescue tools and equipment and Breathing Apparatus storage [178].

NNB GenCo reports that additional emergency response equipment will be stored at a strategic location offsite including generators, pumps, vehicles etc. It also states that the proposed offsite emergency response organisation within EDF will use some of the same facilities currently in place for the generating EDF NGL stations. A detailed list is provided in the licensee's self-assessment and includes the Offsite support centre (currently CESC Barnwood). The interactions between EDF on-site, off-site, and other organisations are shown in Figure 5.

Figure 5: Outline of NNB GenCo's Emergency Organisation



NNB GenCo states that the safety culture for HPC will continue once the site is operational and will include regular fire drills, staff training, emergency exercise and specific safety initiatives, drawing on the extensive experience and high standards of safety culture achieved for the EDF NGL fleet.

A-II-3.2.2.3 Specific provisions, e.g. loss of access

HPC will have two vehicle entrances, and if the primary entrance is unavailable, the Fire and Rescue Services would be directed to the alternative entry point. When the Fire and Rescue Service arrive at HPC, they will be met at the primary or alternative access point by HPC staff; briefed on the situation and escorted at all times whilst on site.

NNB GenCo reports that Fire and Rescue Service personnel will use their own held-hand radios throughout the site, coverage will be ensured by a distributed antenna system (DAS) that will be provided to ensure full site coverage.

A-II-3.2.3 Licensee's experience of the implementation of the active fire protection

A-II-3.2.3.1 Overview of strengths and weaknesses

No specific strengths or weaknesses have been highlighted

A-II-3.2.3.2 Lessons learned from events, reviews fire safety related missions, etc.

NNB GenCo states that it has access to fire SQEPs within EDF NGL and takes account of their experience from many years of operating SZB and the AGR fleet. NNB GenCo is also in regular contact with EDF France and adopts their feedback and improvements/lessons learned where appropriate.

A-II-3.2.3.3 Overview of actions and implementation status

No specific actions have been identified in the licensee self-assessment.

A-II-3.2.4 Regulator's assessment of the active fire protection

A-II-3.2.4.1 Overview of strengths and weaknesses in the active fire protection

Section A-II-3.2.1.1 describes that NNB GenCo's classifies fire alarm and detection systems as Class 3 to ensure EIM&T is prioritised but are generally not relied upon for nuclear safety in the HPC safety case. ONR judges that this aligns with the internal hazards TAG [16] and SRL SV 6.11 regarding EIM&T as well as ONR expectations on the hierarchy of controls in ONR SAPs (para. 155) [15].

NNB GenCo reports that fire alarm and detection systems at HPC are designed in accordance with British Standards 5839-1 [179], which ONR considers relevant good practice. The licensee described how the risk analysis approach (summarised in the Fire Application Document [48]) assesses the risk associated with nuclear fire and identifies the requirements for designation of any fire protection systems for nuclear. ONR judges that these are consistent with SAP EHA.16 [15] and WENRA SRL SV 6.8.

Section A-II-3.2.3 describes the licensee's proposed provision of a fire and rescue service on the HPC site. While fire service intervention is not credited in the fire hazard analyses, the demonstration of robust arrangements for onsite firefighting and coordination with the local Fire and Rescue Service provides defence in depth. ONR judges NNB GenCo's approach as consistent with SRL SV 6.12, 6.13 and 6.14, and a potential strength, albeit one that is subject to further development during the build and commissioning on the plant, in alignment with other aspects of the HPC arrangements, commensurate with an installation under construction.

A-II-3.2.4.2 Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

ONR's fire safety inspection [180] of the Hinkley Point C construction site in 2021 identified issues regarding the capacity of the Fire Safety Team and ONR consequently raised a Regulatory Issue on the adequacy of the resourcing of the NNB GenCo Fire Safety Team. This was closely monitored to ensure that this important function would be capable of carrying out its role adequately. ONR required NNB GenCo to justify and carry out its Intelligent Customer role (audit and oversight) regarding fire safety over Tier 1 contractors. The action was closed out satisfactorily.

ONR's fire safety inspection at HPC in June 2022 [134] identified that several areas of the HPC construction site were lacking in adequate provision of emergency lighting, fire points (fire alarm activation) and directional emergency exit signage. NNB GenCo resolved the issues within 24 hours. A subsequent ONR inspection in January 2023 [133] identified shortfalls in the management of fire safety and that the general fire precautions across the contractor's area were being implemented inadequately. ONR identified a number of potentially serious conditions relating to the control and management of combustible materials and ignition sources, and the failure to adequately manage and monitor fire alarm systems. ONR raised a level 3 Regulatory Issue to track the necessary improvements. Whilst the shortfalls related to fire issues in the construction site and are not per se representative of the future operation of the site, ONR stressed the importance of reinforcing safety culture for fire safety (from both a life protection and nuclear safety perspective). ONR considers the integrated regulation of both fire safety purposes a strength of the GB regulatory regime.

B Research reactors

The UK has no research reactors in operation, all are reactors under decommissioning.

C Fuel cycle facilities

The text in the Sections below has been prepared by UUK and Springfields Fuels Ltd. Background information on the sites and the range of installations considered in the scope of the assessment is provided in Sections 1.1.2 and 1.1.3.

C-I Fuel enrichment facilities – UUK Capenhurst

UUK reports that active fire protection includes fire suppression systems, extinguishers, and fire alarms all which are incorporated into new starter induction and annual theoretical and practical fire training.

UUK states that every building incorporates a minimum package of fire protection measures to allow the occupants to escape from the building in the event of a fire ensuring life safety, asset protection and to ensure that there are appropriate management systems in place with enhancements subject to the facilities risk rating/categorisation.

C-I-3.2.1 Fire detection and alarm provisions

UUK's deterministic and, where required, probabilistic safety assessments drive the corporate requirements for any equipment or administrative controls to be designated as safety measures. UUK state that the designation of the safety measure and its relative importance is dependent on the hazard potential of the associated fault sequence. UUK designates measures in accordance with the SAH for 'Designation, Recording and Standards for Safety Measures'.

UUK states that fire detection and alarm provisions can be designated in line with this SAH guidance where required by the relevant safety case. If designated, then the safety measures would be subject to engineering or human factors substantiation as required by the quality of safety designation placed. Engineering substantiation, both substantiation of existing and new systems, would be cognisant of relevant British and International design standards.

UUK highlights that the designation and provision of a safety measure should be considered to determine if it introduces any domino hazards which could be significant. UUK states that this may be relevant to some fire suppressions systems where they could lead to excess moderator being introduced to nuclear inventories. Where these situations exist, UUK acknowledges that the balance of the safety argument must be considered.

As previously reported, regulatory interventions at Capenhurst identified that improvements were warranted and subsequently fire detection systems are undergoing upgrade to a single specification of Category L1 (Maximum Life Protection)/P1 (Maximum Property Protection) as defined in BS5839-1:2017 [179]. UUK states that the systems are not currently required to satisfy any nuclear safety classification. UUK also states that it considers all buildings on site to currently exceed the minimum legal requirement for manual systems and have automatic detection devices in the form of heat, smoke, aspiration, and beam masters. UUK reports it has made a business decision to deliver a single standard delivering cost efficiency and standardisation for inspection and maintenance.

UUK also states that activation of any fire detection system across the site alarm locally and are notified via the Supervisory Control and Data Acquisition (SCADA) system or auto-dial to the site Emergency Control Centre.

C-I-3.2.1.1 Design Approach

UUK reports that its design approach is based upon practical design and application taking into account devices available on the market compatible with the control system. Installation and maintenance are significant factors upon selection and system design as it does not require the systems for nuclear safety justification:

- Standard heat/smoke point detection is applied predominantly to office, small workshop locations.
- Beam masters are utilised to cover large compartments such as cascade hall, process and service corridors.

- Aspiration systems are installed in voids in excess of 800mm and within some areas of the above subject to physical configuration of the compartments.
- Bespoke flame detection for pressurised hydrogen systems.

UUK reports that the approach reduces the requirement for variations to the British Standard and introduces easily maintainable equipment within radiological areas providing worker protection during installation and maintenance.

UUK audible devices are installed in all areas (typically bell-type sounders) set to 65dB(A) +/- 5dB(A). UUK reports that visual alarm devices (meeting BS EN 54-23 [181]) will be installed in areas such as compartments with high background ambient noise (in excess of 65dB(A)) such as mechanical workshops, roof areas containing cooling towers and walkways where weather conditions may reduce audibility and accessible facilities to satisfy the requirements detailed in BS 9999 [71] & BS 5839 [182].

UUK states that, in specific applications, the fire alarm system activates automatic control measures including fire dampers, roller shutter doors and gaseous suppression systems. UUK's Colt ventilation systems are not directly linked to the fire detection system given the potential hazard of hazardous material release from nuclear safety significant buildings, manual actuation of the system in the event of a fire is subject to specific authorisation; however, UUK noted that given the volume of compartments and height of ceilings it is highly unlikely smoke/heat clearance would be required to maintain tenability.

C-I-3.2.1.2 Types, main characteristics and performance expectations

As described above notification of system activations to the Emergency Control Centre is through various methods, which range from SCADA, auto-dial and repeater panel functions. Upon activation the Control Room Operator alerts the on-site Emergency Response Service via radio alert, supplemented by building affected and relevant information passed by telephone.

UUK reports that whilst the Control Room Operator is reliant upon further information being provided through verbatim compliance with displayed Fire Action Notices, all replacement fire panels now display Device Type, Asset Number and Location with Mimic/Repeater Panels located within Lobbies/Foyers and Fire Break Corridors. It also reports that zonal plans are also displayed adjacent to all fire alarm panels and included in Building Information Packs. Panels additionally announce Warnings/Faults locally by way of lights and buzzer which are reported to the Site Emergency Control Centre (SECC) by building occupants where not automatically captured by panels in the SECC. UUK states that all nuclear safety significant buildings are provisioned with emergency diesel generators to ensure continuity of power supply and facilitate safe operational shutdown. It also states that all automatic fire detection systems however have, as a minimum, battery back-up in the event of electrical power outage with a contracted maintenance engineer response of one hour.

UUK considers that a number of failures can be tolerated within a facility, and each would be risk assessed to determine an appropriate response. UUK reports that it will be based upon the nature of the facility (office versus operational) and additional control measures deemed appropriate which may range from engineer investigation to additional fire patrols

or deployment of a temporary wireless safety system containing base station, call points and point detection/tolerable range i.e. number of heads. UUK concluded that all elements of the fire protection system are specified and installed to BS 5839 [182] and meet BS EN 54-23 [181].

In this context, UUK referred to BS 5839, Part 1, Clause 26 in that “*Standard fire-resistant cables that as a minimum have a duration of survival of 30 minutes when tested in accordance with BS EN 50200. Enhanced fire resisting cables should have a duration of survival of 120 minutes in accordance with BS EN 50200/BS 8434-2. Methods of cable support should be non-combustible and such that circuit integrity is not reduced below that afforded by the cable used and should withstand a similar temperature and duration to the of the cable while maintaining adequate support. Cables should be installed without external joints wherever practicable. All terminations and other accessories should be such as to minimise the probability of early failure on the event of fire.*”

C-I-3.2.1.3 Alternative/temporary provisions

UUK undertakes fire alarm inspection and maintenance testing in accordance with BS 5839. UUK reports that alternative arrangements such as system isolations are undertaken in accordance with site safety standards, recorded in the Fire Safety Logbook and authorised by the Shift Manager upon re-instatement the device/loop isolated is tested to ensure signal receipt/response and the serviceability state is again recorded in the Fire Safety Logbook. UUK concluded that arrangements for larger scale buildings are such that 100% testing is completed quarterly or bi-annual schedules.

C-I-3.2.2 Fire suppression provisions

C-I-3.2.2.1 Design Approach

UUK structures with fire suppression systems are derived through the Fire Strategy subject to specific fire risks based on fire loading, fire growth potential or specific design requirements (i.e. network data compartments, electrical switchgear). UUK states that whilst several electrical sub-stations have Carbon Dioxide suppression systems with ceiling mounted nozzles, a small number of office and server room accommodation are protected by an Argonite systems, with specialist diesel generator enclosures protected by Water Mist and the Network Data Centre with an NOVEC 1230 systems.

UUK reports that it undertakes design, installation, and maintenance of fire suppression systems in accordance with BS 5306/BS 8458 and that they are subject to detailed design by a third-party design accredited contractor. UUK also reports that compartments protected by suppression systems have been encapsulated in 30-, 60- or 120-minute fire resisting construction under the BMTRADA Q-Mark Accreditation Scheme.

C-I-3.2.2.2 Types, main characteristics and performance expectations

UUK reports that its arrangements for adequate capacity and coverage of water for firefighting was taken from Water UK ‘National Guidance Document for the Provision of Water for Firefighting’ [183] where it was stated that for industrial sites over 3 hectares 75 litres per minute must be achieved.

UUK also states that the existing fire main is of varying age from 1940 to 2018, comprising of materials of construction commensurate with those periods. Fire water is supplied to a site ring main from raw water ponds with feeds to a fire water storage tank with a capacity c.8800 m³ and 260 m³ accordingly. Under firefighting conditions, the fire main is pressurised by fire pumps with secondary pump sets comprising of electric and diesel supply. Under non-firefighting conditions the fire main is pressurised via a cross connection to the raw water mains network and typically pressurised to 3.3 Bar(g) via a jockey pump and non-return valve. UUK reports that there are no water suppression systems connected to this system.

UUK states that the location of hydrants for firefighting are such that there are no instances where distance is greater than 90m of any building on site. It also reports that standard 70 mm and 45 mm hoses are used (compatible with offsite emergency services equipment) with the additional availability of medium/high volume pump within 45 minutes of request via external Fire & Rescue Service.

C-I-3.2.2.3 Management of harmful effects and consequential hazards

With no nuclear safety claims made on fire suppression systems UUK has no requirement for seismic qualification of the systems installed. UUK suppression systems are gaseous and within fire compartmentation. UUK reports that the inventory provided for each suppression system will not extend beyond confined limits. UUK states that fire resistant compartmentation and segregation of flooding risks whether domestic or natural hazard given the geographical location of site and protected structures within do not present a credible risk. UUK also reports that suppression systems are to protect emergency power systems only and are not present in areas that may affect radiological containment, criticality or stored waste.

C-I-3.2.2.4 Alternative/temporary provisions

UUK Capenhurst does not have suppression systems in areas with claims of nuclear safety, therefore systems are primarily to minimise extent of equipment damage. In the event of requirement for alternative arrangements/temporary provisions, UUK reports that the Fire Safety Specialist assesses the case based upon duration and business risk from the affected system, with targeted response options provided via the on-site Incident Response Service (in terms of firefighting media and approach). UUK reports that the response may be supplemented by local operating teams where their locations are adjacent to business-critical areas, UUK states that these teams would be provided with specialist extinguishers and training to facilitate early intervention.

C-I-3.2.3 Administrative and organisational fire protection issues

C-I-3.2.3.1 Overview of firefighting strategies, administrative arrangements and assurance

UUK reports that the methods used in assessing, modelling, and managing conventional and nuclear fire/explosion hazards are similar. In general, the process will be to satisfy the requirements for conventional hazard management and consider what additional measures, or adaption of those present for conventional fire safety, are appropriate for the management of nuclear hazards. UUK's conventional and nuclear assessments are often

reported separately to aid delivery but should as far as possible be co-ordinated. UUK produces emergency procedures to reflect identified hazard and response scenarios and used to demonstrate compliance with the Radiation (Emergency Preparedness and Public Information) Regulations 2019.

UUK generally manages fire hazards by providing:

- Primary measures against fire propagation (e.g., fire barriers/compartimentation, separation, minimisation of combustible/explosive inventories).
- Risk reduction measures (e.g., minimising general fire loading).
- Personnel escape routes, detection, and alarms.

C-I-3.2.3.2 Firefighting capabilities, responsibilities, organisation and documentation onsite and offsite

UUK reports that written procedures (training, tactics & procedures) for firefighting capabilities are developed with relevant subject matter experts, taking guidance from external emergency services guidance documents and operational procedures (Fire service Manual vol 2, Operational Guides, NFCC). UUK personnel with identified roles have training and competency requirements defined within role profiles and are subject to a schedule of ongoing training and exercising alongside continuing professional development.

UUK states that a 12-month programme for training determines weekly, bi-weekly, monthly, quarterly, bi-annual, and annual exercise levels ranging from desktop to live-play exercises culminating in an annual assessment of service response capability. Training includes familiarisation with external emergency services and applies the 'Joint Emergency Services Interoperability Principles (JESIP)' to promote efficiency and effectiveness between different organisations.

Safety measures for conventional fire and explosion safety should be entered in the Plant Maintenance Schedule (PMS) and, or Computerised Maintenance Management System (CMMS). UUK states that these will be inspected and maintained in accordance to established practice to meet legal and good practice requirements forming the EMIT programme.

UUK reports that on-site Incident Response Service (IRS) deployment can be from directly deployed following automatic fire detection activation and responding to investigate with response escalation according to findings or through running calls (i.e., direct contact with IRS in person or telephone call). Subject to findings of the investigation a report is made to the Emergency Controller who may then make a local fire service support request to an ongoing incident or request further support to site if IRS is already committed to an incident. In support of this is an agreed Pre-Determined Attendance (PDA) response with the Emergency Services comprising seven levels of response (Capenhurst On Site Emergency Plan). Management of the incident is via the Emergency Controller until the arrival of the first attending appliance at which point the Urenco Emergency Controller then provides technical support. Although primary responsibility for the incident is the jurisdiction of Cheshire Fire and Rescue Service (FRS), command and control is maintained by the IRS Incident Officer with direct support via JESIP.

UUK states that there is an interoperability training and familiarisation schedule coordinated by the Resilience and Security Specialists supporting both on and off-site teams familiarisation training for geographical features, hazards and resources. All relevant information is collated through individual Building Information Packs which are provided to the first responding pump at the forward control point. Second and third copies are provided for Tactical and Strategic Command teams. UUK reports that it updates Building Information Packs in accordance with material changes to buildings as applicable, supported by the fire risk assessment process, all of which are formally reviewed annually. In addition to the above, the packs identify locations of gas/water/electrical isolations together with shutdown procedures and other key information.

The approach to safety culture and its enforcement follows the Capenhurst Management of Fire Safety Standard where the requirements of fire evacuation exercises and other similar drills are undertaken at least annually and supports the programme of training coordinated via the Resilience Specialist. UUK formally records with significant findings/suggestions for improvement are acted upon by the HSSE department.

UUK finally reports that safety culture initiatives are generally driven from calendar events published by the Chief Fire Officers association, Institution of Fire Engineers, Institute of Occupational Safety and Health (IOSH), Fire Protection Association (FPA). This in addition to fire related events/output from related assurance activities identified on-site and has included control of hot works; fire compartment penetrations, disposal of lithium-ion batteries, response to battery electric vehicle fires, Centre for the Protection of National Infrastructure (CPNI) 'fire as a weapon', licenced lay down areas.

C-I-3.2.3.3 Specific provisions, e.g. loss of access

The Capenhurst site maintains a number of permanent external access points which could be supplemented, if necessary, by off road access within the capabilities of responding vehicles. Within the site boundary all facilities can be accessed via multiple routes to facilitate safe access for responders irrespective of the nature of event (i.e. radiological event, wind direction, structural collapse, or other security related events).

C-I-3.2.4 Licensee's experience of the implementation of the active fire protection

Section C-I-3.2 describes the licensee experience and is not reiterated here for conciseness.

C-I-3.2.5 Regulator's assessment of the active fire protection

C-I-3.2.5.1 Overview of strengths and weaknesses in the active fire protection

Active fire protection strengths

UUK reports that no active systems are claimed for nuclear safety and that the fire alarm and detection system is provided for prompt personnel evacuation and to alert the on-site IRS. The licensee described a fire alarm and detection system improvement project to upgrade to BS 5839 (Reference) Part 1 L1/P1 standard with benefits in terms of life safety, property protection and emergency response. ONR considers that UUK's self-assessment

adequately describes emergency response arrangements on site and for liaison with the Local Authority, and the suppression systems in place to protect specific areas from fire risks to life safety.

C-I-3.2.5.2 Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

ONR has undertaken observation and inspection of emergency exercises at the UUK Capenhurst site which are part of the licensee's demonstration of compliance with LC 11. ONR's has also undertaken fire inspections at the site and the main learning relating to active fire protection was acknowledged in the licensee's self-assessment. These were the identified shortfalls in the provision and management of the automatic fire detection and alarm system in the building inspected. ONR raised a regulatory issue to track the licensee's implementation of fire detection and alarm updates across the site which has now been satisfactorily closed.

C-II Fuel fabrication facilities – Springfields Fuels Ltd

C-II-3.2.1 Fire detection and alarm provisions

C-II-3.2.1.1 Design approach

Fire detection and alarm systems are generally installed in nuclear facilities on the Springfields site for both life safety purposes and to provide a warning that systems essential to radiological or chemotoxic safety may be threatened by fire, to operate fire protection or to initiate closure of fire dampers and shut down of ventilation fans. In addition, they serve to warn occupants of the building of fire to allow escape to be affected and to alert the site fire service that there is a potential fire in the building.

Springfields Fuels Ltd reports that where there are claims made on multichannel engineered protection systems to prevent a fault from leading to an unacceptable consequence to a worker or member of the public, it is often the case that many of these have not been specifically designed with respect to fire. In addition, Springfields Fuels Ltd considers that the segregation provided would not in all cases prevent common cause failure due to fire. Examples could be safety systems using common cable routes, common electrical cubicles, or a lack of fire separation between cubicles. Springfields Fuels Ltd also reports that many safety mechanism (SM) electrical panels are in non-contact areas which have a higher level of detection coverage than some contact areas. Parts of the safety measures will however be in the area where the plant is located and where Springfields Fuels Ltd may not provide detection. Springfields Fuels Ltd considers that it would not be practicable to redesign the many systems to achieve robust fire segregation in all cases and as such it places reliance on a fire being revealed such that the plant can either be made safe, action taken to ensure that the safety measure is able to perform its safety function on demand or workers can move away from the hazard and/or evacuate the building.

Where Springfields Fuels Ltd makes claims on the attendance of the site fire service in the event of fire, as part of defence in depth, it states that a level of coverage commensurate with the risk of fire in each area is provided. Springfields Fuels Ltd states that the nuclear

safety classification of fire detection systems is typically safety related Instrumentation (SRI) and refers to the Table below.

Structure, System or Component	Safety Function(s)	Safety Function Class	Performance Requirements
Building Fire Detection and Alarm System	To automatically detect fire to send a signal to the Springfields ECC to initiate attendance of the Springfields Site Fire Service	SRI	To detect fire and fault conditions and operate in accordance with the requirements

The principal design standards utilised by Springfields Fuels Ltd are BS 5839-1 [179] and BS 5839-8 [184].

Manual only systems are generally not used on the Springfields site. An exception is a contractor's rest/tearoom building that has a manual-only system. The justification for this building is that it is a single room with escape direct to outside. Other buildings are typically provided with automatic detection even temporary accommodation units (TAU's) and small single storey buildings such as canteens, substations and change rooms.

Springfields Fuels Ltd reports that typical levels of coverage for all new buildings and where fire detection and alarm systems are being replaced is to meet L1/P1 Level of coverage as defined in BS5839-1, or as close to this level of coverage as practicable. Springfields Fuels Ltd also reports that older buildings may still have L2 or L5 Category systems, and that the adequacy of coverage it assesses as part of the FRA process for life safety and the COSR process for both life and nuclear safety.

Example of fire detection systems changes in OFC

Springfields Fuels Ltd reports that the fire detection and alarm system in OFC at the time of construction was an ad-hoc system that could be categorised as an L5 system in accordance with BS5839-1 [179]. As part of COSR reviews Springfields Fuels Ltd identified that claims were being made in HAZANs for fire detection in areas where radiological materials were present and where no detection was installed. Springfields Fuels Ltd reports that a complete review of the fire detection system was undertaken and a system meeting minimally an L2 level of coverage (but achieving L1/P1 in the majority of areas) was installed and completed in 2020.

C-II-3.2.1.2 Types, main characteristics and performance expectations

Fire Detection Types

Springfields Fuels Ltd states that in most cases and where possible standard heat/smoke point detection was historically fitted. Springfields Fuels Ltd typically chooses multisensor detectors for new installations or replacement installations such as the recent upgrading of the fire detection and alarm system in OFC. It uses heat detection where standard smoke detection may be vulnerable to false alarms such as where steam may occur, where HF

may be present, where dust could result in false alarms and where activities such as hot work could result in unwanted alarms.

Springfields Fuels Ltd provided the following examples where alternative technologies are used on site:

- In some buildings aspirating fire detection is used due to the height of the ceiling/roof.
- The computer suites are provided with aspirating detection located in the rooms and floor voids. This is due to high airflows and the need for very early detection.
- Aspirating detection is used in a cable mezzanine below a steel mezzanine floor due to difficulties of gaining access.
- Beam detection is used in the ceiling voids above offices in an Amenities area to reduce the need to remove ceiling tiles for detector maintenance.
- Beam detection is used in the component manufacturing building in each of two bays due to ceiling height and unsuitability of aspirating detection.
- A pilot plant due to height of the roof and large open area (single storey portal frame building) is fitted with beam detection. Due to the nature of processes being undertaken Springfields Fuels Ltd concluded that aspirating detection would be unsuitable.
- Flame detection is provided in a solvent extraction tower as the principal risk is a solvent fire TBP/OK.
- Flame detection is used in the turbine enclosures in the combined heat and power plant (CHP) for a fast response to fire and activation of carbon dioxide suppression systems in the turbine enclosures.

Fire Alarm Provisions

Springfields Fuels Ltd provides alarm sounders (bells or sirens) generally throughout all accessible areas of a building and in enclosures not less than 1 m² to provide a sound level of not less than 65 dB(A) in accordance with BS 5839-1. In areas where the background noise may be excessive or where a normal sounder may be ineffective e.g., in the ventilation plant rooms, Springfields Fuels Ltd uses visual indicators (flashing beacons) to supplement the audible alarms.

Springfields Fuels Ltd uses voice alarms in several buildings. It reports that all pre-recorded emergency messages are operated on each test to ensure that occupants are aware of the existence of the messages and their different meanings. There are no buildings on the Springfields site with phased evacuation. All buildings evacuate Immediately in a single stage alarm with the exception of OFC.

Example of fire alarm operation in OFC

In OFC if a detector operates or a manual call point is activated the system goes directly into evacuate, excluding the Central Control Room (CCR). This area sounds the standby

alarm for 30 minutes to allow the plant to be monitored and safety shutdown if required. The CCR moves straight to the evacuate stage if a fire device is activated within the CCR fire compartment.

Fire Damper Operation

Springfields Fuels Ltd reported the following characteristics of fire damper operation at the site:

- Where dampers are required for the protection of the means of escape (protection of escape routes and where compartment to compartment escape is claimed) fire/smoke dampers actuated by the fire detection system are used. Where dampers are identified for asset protection only then these may be either fire/smoke dampers actuated by the fire detection system or may be thermal link operated dampers.
- No fire dampers are required specifically for nuclear safety as there are no designated nuclear fire barriers e.g., for segregating safety trains with redundancy. At the time of construction of OFC, the fire dampers/fire shutters were mostly of the thermal link/frangible bulb type. These relied on the heat from a fire to activate the damper/shutter.
- As a result of post construction improvements to fire compartmentation additional fire dampers/fire shutters were installed. All these additional devices were configured to be actuated from the fire detection system. Some of these result in the fire alarm going to evacuate on closure, some are configured to provide a 'Damper closed' message only.
- In the event of fire ventilation fans in OFC remain running and there is no automatic shutdown on closure of fire dampers. Shutdown of the fans occurs if the flow rate is reduced so that damage to the fans is prevented. Fire doors that require to be held open for operational purposes are arranged to close on operation of the fire detection and alarm system. There are no filter blinding detection and alarms that initiate control measures with a specific confinement function.

Main Characteristics and Performance Expectations

The main characteristics and performance expectations of fire detections and alarm systems reported by Springfields Fuels Ltd are as follows (reproduced literally from the licensee's self-assessment):

- As defined in BS5839 ARC (Alarm Receiving Centre), which on the Springfields site is the ECC, the resolution built into the fire alarm system and information provided to the ECC is down to building level with some buildings e.g., OFC further split down into plant areas. As defined in BS5839, CIE (Control and Indicating Equipment) or the local control panels display down to individual device level for all newer panels, some older panels display detection zone containing several devices.
- All fire systems are connected to the ARC (ECC) via hardwire link. This is displayed on a purpose designed SCADA system giving visual and audible alerts to the operator. This is also displayed on a wall mounted site map mimic that shows all site buildings. On

receiving an alarm, the ECC operator alerts the On-site Emergency Response Team (via radios, Tannoy) etc. The ECC is manned on a 24-hour basis. Currently only fire signals are transmitted to the ECC.

- All individual fire alarm panels are provided with battery backup in line with BS5839 with a capacity of at least 24 hours standby + 30 mins alarm. Should the power fail to the ECC the uninterruptable power supply (UPS) takes over and has a 4-hour back-up.
- The local control panels in each building meet the requirements of BS5839-1. Typically, systems are designed to tolerate a single fault without detriment to the system. E.g.: Detector circuits are loop wired, which will tolerate one break in the circuit. Also, panels are provided with a battery backup as described above and the ECC has a UPS. Single device failures will not affect other devices on the loops.
- Fire detection system cables meet the requirements of BS5839-1 for circuit continuity under fire conditions. Typically, standard 60-minute cables conforming to BS EN 60702-1 are used. Cables are typically soft skin (e.g., Prysmian FP200). Detectors by their nature (e.g., plastic construction) have no fire resistance. No specific measures are provided to protect fire detection control equipment which typically are located in lobbies, or protected stairs where the risk of fire is low. Older systems are wired using MICC.
- Cable wrapping is not used for any fire detection cabling. Detectors are chosen according to the environment in which they are to be located. Smoke or multi-sensor detectors are the preferred choice. If there are high airflows e.g., in Electronic Data Processing (EDP) rooms an enhanced level of coverage such as that based on BS6266 may be used. However, there are some instances where smoke should be changed to heat due to steam or dust. IP rated components such as call points may be used externally or in areas subject to moisture or dust. Cable installations are compliant with BS5839 and BS7671, including the use of non-combustible clips to prevent cables dropping in the event of a fire.
- There are no claims made on fire detection systems for nuclear safety other than in some buildings for early warning of fire thereby allowing early attendance of the site fire service. As such the highest claim made on fire detection systems is that they are designed safety related instrumentation (SRI). Some systems are claimed as SRI in safety cases, most are not. Examination, Maintenance, Inspection and Testing (EMIT) is carried out in line with BS5839 and BS7671, the procedures for which are documented in local equipment instructions (LEIs) and SSI 635. Where a tripping function is included, this will be functionally tested. All maintenance is scheduled on a computerised maintenance management system (CMMS).

C-II-3.2.1.3 Alternative/temporary provisions

SSI 688 'Fire Safety at Springfields' [135] contains a procedure for when temporary works are required. This procedure is applicable to all work undertaken at both Springfields Fuels and Westinghouse Precision Fabrications by staff, contractors, sub-contractors prior to any isolations.

Springfields Fuels Ltd reports that additional controls to mitigate the risk to personnel and plant are implemented in the following circumstances (reproduced literally from the licensee's self-assessment):

- **Device Disablements** – Where a single or multiple devices are to be disabled due to permit maintenance or hot work activities these disablements can only be actioned by suitably qualified experienced persons (SQEP) and are risk assessed and reviewed by the Fire Nominated Person (FNP). Disablements are recorded on the SSI 688 form for the building. Where unsure of the extent of isolation impact, the Fire safety Manager (FSM) is included in the assessment as additional risk mitigation measures may be required.
- **Full Zone Disablements** – Where system cover is reduced significantly, areas of plant may be without automatic detection and annunciation. In this case zone disablements can only be actioned by suitably qualified and experienced persons and should be risk assessed and reviewed by the FNP or FSM. The disablements are recorded on the SSI 688 form for the building.
- **Planned System Outage** – Where the entire protection system is to be shut-down for maintenance a shut-down notice is used to notify key staff/stakeholders. The outage follows a safe system of work including risk assessment. Testing as per SSI 635 is completed post outage.
- **Unplanned System Outage** – In the event of an unplanned outage of the system, key staff/stakeholders are notified. Risk mitigation measures are used and the risk to personnel and plant assessed. Additional measures such as those listed below may be necessary, for example whether operations should cease. The fault is logged on the SSI 688E form. Testing as per SSI 635 testing procedure [185] is completed post outage.

Springfields Fuels Ltd reports that additional or alternative risk mitigation measures may be implemented as required. Examples of such measures and typical uses are provided in the licensee's self-assessment [9]. It also reports that key staff/departments that must be notified of temporary provisions include the Emergency Control Centre (ECC), Building occupants (including shift teams), Shift Plant Managers, Fire Safety Manager, Fire Team and Shift Monitors.

Interim Contingency Plan

Springfields Fuels Ltd reported the following considerations regarding interim contingency plans (reproduced below literally from the licensee's self-assessment):

- Additional fire patrols are implemented when smoke detection systems are isolated. The focus is typically on higher risk, business critical and unmanned areas. If detection is to remain isolated in silent hours regular fire patrols are undertaken.
- During hot work activities only local isolations of fire and smoke detectors are permitted. No hot work activities are carried out in buildings without an operational fire alarm system unless the work has been risk assessed with a contingency plan in place and authorised by the Fire Safety Manager.

- If disablements are to be longer term (>1 week) the building fire risk assessment must be re-issued, and consideration given to informing Insurers via the Head of Facilities Management.

Maintenance and Testing

Springfields reports that maintenance and testing are covered in site Procedure SSI 635 Fire alarm & emergency lighting inspection & testing procedure. The main considerations, reproduced below literally from the licensee's self-assessment [9] are provided below:

Weekly Operational Test of a Fire Alarm System

Every week, a building fire alarm system manual call point is operated, and it is confirmed that the control equipment:

- *Initiates a fire signal on the fire panel.*
- *Activates the fire alarm sounders.*
- *Transmits a fire alarm signal to the Emergency Control Centre (ECC).*

Monthly Inspection of Fire Alarm System Vented Batteries

Every month, the batteries and charger system are inspected and tested to ensure that:

- *All batteries are clean, with no sign of leaks.*
- *All battery levels are correct.*
- *Battery chargers are operating and charging parameters set correctly.*

On completion of each of the periodic testing regimes the following actions are required to be undertaken:

- *Report any outstanding isolations left on the fire panel to the Fire Nominated Person for the area.*
- *Record the weekly test and the identity of the manual call point in the Fire Alarm System Logbook (SSI 688D - Fire Safety Checklist).*
- *Record any faults found in the Fire Alarm System Logbook (SSI 688E - Fire Safety Action Sheet).*
- *Record the results of the check against the CMMS Work Order and raise any work requests that may be required if any parts were found to have failed the check.*

Springfields Fuels Ltd reports that only personnel holding a minimum of Category 'E' electrical authorisation as defined by SSI 716 Authorisation (Electrical) or service organisation personnel approved by the Area Electrical Engineer may carry out intrusive work on Fire Alarm Systems. It also requires third party organisations to be certificated to

LPS 1014 [186] or BAFE SP203-1 [187] approved and fully compliant with the standards quoted in the references contained in SSI 635.

Further details of required actions associated with three-monthly, six-monthly and annual inspections of the fire alarm systems are provided in the Springfields self-assessment report [9].

C-II-3.2.2 Fire suppression provisions

C-II-3.2.2.1 Design Approach

Springfields Fuels Ltd reports that it uses suppression systems when it identifies a need to protect nuclear safety or business continuity and is not practicable to provide mitigation by other means e.g., use of non-combustible materials, passive fire protection and/or fire compartmentation.

C-II-3.2.2.2 Types, main characteristics and performance expectations

Springfields Fuels Ltd reports the following types and characteristics of fire suppression provisions at the site (reproduced literally from the licensee's self-assessment):

- The only fire suppression system in a radiologically controlled area currently operational is the foam water spray system in the uranium reprocessing plant (EURRP).
- 'Firetrace' systems using a suitable agent e.g., dry powder may be used from time to time in fume cupboards or gloveboxes as temporary provisions for specific tasks. Once the task is complete the systems are removed. Springfields states that most such tasks e.g., processing small numbers of legacy fuel pellets are undertaken by the National Nuclear Laboratory (NNL) who are tenants on the Springfield site.
- There are no fire suppression systems on the Springfield site that are nuclear safety classified. The carbon dioxide fire suppression systems used in the CHP plant for turbine enclosure protection are designed and installed in accordance with BS 5306-4:2001- Specification for carbon dioxide systems.
- Any system required in the future will be designed in accordance with the appropriate British Standard or NFPA standard. There are no Springfields site specific design guides for fire suppression systems. Designs will be reviewed by the Springfields site Fire Safety Manager/Fire Engineer.
- There are no automatic fixed water based automatic fire suppression systems on site. In general, sufficient hydrant outlets are provided for each building and vehicular access for fire service vehicles in accordance with the requirements of guidance given in the Approved Document B Fire Safety (Volume 2) to the England Building Regulations [84]. There is one fixed firefighting foam system provided in the areas of the S.E.P in EURRP where TBP/Exssol and 60% nitric acid is used as part of the process. The system is used by the site fire service who have the ability to connect to the fire service inlet that serves the foam water spray. Foam concentrate is stored close to the inlet and an inductor is used to introduce foam concentrate into the foam system pipework. This

pipework runs up to the protected areas of S.E.P where there are open nozzles that distribute foam water spray within the protected areas. The pipework is normally dry, and system is for manual use only by the site fire service. The system is maintained in accordance with BS EN 13565-2:2018 [188].

- Hose reels for manual firefighting have been removed from the Springfields site due to the risk of legionella and hazards associated with untrained personnel having access to an unlimited water supply for firefighting.
- The site supply of borehole water is obtained from 4 pumps which are sunk into the ground at various depths within the site boundary. The pumps supply water into a ring main system maintained at 50-70 psig from which the CHPp, fire hydrants and various other buildings are supplied. CHPp & Utilities are responsible for operation and maintenance of this system. There is a low-pressure alarm, set at 40 psig, installed in the CHPp and an extra low-pressure alarm, set at 30 psig, is installed in the Emergency Control Centre. Further details on the site water ring main are provided in the Springfields submission to the NAR [9].
- In some buildings such as the fuel manufacturing buildings there is a potential for a criticality hazard and as such water-based systems (manual or automatic) are not permitted. The use of hydrogenous extinguishers and limitation on their use is determined as part of the criticality safety assessment for the building where a criticality event is deemed credible. Extinguishers including 50kg wheeled extinguishers for fire service use using a non-hydrogenous dry powder extinguishing agent are used in buildings where a criticality event is deemed credible.
- For buildings where a criticality event could not occur the process for determining if a manual or automatic system is appropriate in nuclear safety significant areas is based on a qualitative assessment of risk. As an example, fixed foam suppression was installed to cover a bulk tank of TBP/OK for a specific process which has now been completed and the foam system has been removed.

Firefighting Access and Facilities

Springfields Fuels Ltd reports that each multistorey building is provided with stairs for fire service access designated with 60 minutes fire resistance. Typically, it does not provide firefighting lifts and there is no pressurisation or ventilation of the stairs. Springfields states that 60 minutes fire resistance for firefighting stairs is typical for many buildings on the site (and other nuclear licensed sites) and it considers it acceptable given the presence of an onsite fire service and rapid attendance in the event of fire.

Springfields Fuels Ltd does not provide dry risers in some buildings due to the potential for criticality and restrictions on the quantity of water that can be used. To mitigate this, Springfields provides 50kg wheeled dry powder trolley units at locations around a plant close to the protected stairs for site fire service use only.

Springfields Fuels Ltd states that a dry riser designed and installed in accordance with BS9990:2015 [189] is provided in a Uranium Hexafluoride manufacturing facility (currently not in production) as there is no criticality hazard in this building. This riser was installed as

part of the last COSR review of the building to assist the site fire service running hoses to upper levels of the building.

C-II-3.2.2.3 Management of harmful effects and consequential hazards

Springfields does not consider combined hazards such as fire + flooding or fire post seismic events. It states that there are no water-based suppression systems that could result in flooding and the site is not prone to flooding. It also reports that all processes on site can be shut down and do not require ongoing power supplies, cooling or other services to maintain nuclear safety.

Springfields reports that there is no seismic qualification for fire suppression systems and no suppression systems are required for nuclear or chemotoxic safety. It also states that there are no suppression systems that if operated due to planned or inadvertent discharge would result in a radiological release. Finally, Springfields reports that the only automatic systems are total flooding carbon dioxide suppression systems for protection of turbine enclosures in the CHP plant: these would operate in response to a fire within the turbine enclosure and are for conventional fire safety/business continuity purposes only.

C-II-3.2.2.4 Alternative/temporary provisions

No alternative/temporary fire suppression systems to those described were identified in the licensee's self-assessment.

C-II-3.2.3 Administrative and organisational fire protection issues

C-II-3.2.3.1 Overview of firefighting strategies, administrative arrangements and assurance

Springfields Fuels Ltd reports the following types and characteristics of fire suppression provisions at the site (reproduced literally from the licensee's self-assessment):

- For new buildings on site (both conventional and buildings where radiological materials are process or stored) a fire strategy is prepared for conventional fire safety based on the guidance to Building Regulations i.e., the Approved Document B and/or BS9999.
- Fire engineering justifications are made where full compliance cannot be achieved or is perceived to be overly onerous or where additional requirements are deemed necessary.
- Building Regulations and associated guidance provides the minimum acceptable level of fire safety in a building. The objectives of the conventional fire safety strategy for a building are to substantiate the fire safety design using accepted guidance, codes of practice and fire engineering, such that the risk of fire in an operational building has been reduced to as low as reasonably practicable. The conventional fire safety strategy forms the basis for the nuclear fire safety strategy.
- The building is assessed for hazards that could affect the safe means of escape of the occupants or that could be a significant risk contributor to the safety of the building

structure, plant, or the environment. Please note that further details on the methodology for assessment are provided in Springfields Fuels Ltd self-assessment [9].

- The fire safety strategy for nuclear fire safety is considered primarily by review of the HAZANs by undertaking a detailed review of the fault sequences, safety measures (SSCs), operating requirements and operating assumptions to support the claims being made for a specific safety measure which could be affected by fire or secondary effects such as firefighting water.
- The potential for safety measures such as multichannel protection systems to be vulnerable to common failure due to fire or its effects is considered preferentially by deterministic fire hazard analysis and the fire protection measures put in place to protect them are passive measures where possible. Only if this approach cannot be used would other methods of protection be considered such as active protection systems.
- The process for periodic review both for conventional and nuclear fire safety is similar to that used for developing a fire safety strategy. A COSR review is undertaken on a 10-year rolling basis and a COSC paper produced that assesses all the areas considered as part of the fire safety strategy; any changes that may be reasonably practically implemented to meet modern standards and confirmation that the measures in place are suitable for continued operation.
- Measures resulting from PMP's that have been implemented between COSR reviews are incorporated into the COSC report as appropriate. Both the Conventional and Nuclear COSC reports are subject to internal peer review and acceptance by a management safety committee (MSC) for each individual plant building. Conventional and Nuclear COSC reports are made available to the UK ONR for Regulatory review.

C-II-3.2.3.2 Firefighting capabilities, responsibilities, organisation and documentation onsite and offsite

Springfields Fuels Ltd reported the following considerations regarding firefighting capabilities, responsibilities, organisation and documentation onsite and offsite (reproduced literally from the licensee's self-assessment):

- At Springfields the site fire response was outsourced (December 2021) to Mitie emergency response team who have adopted the Springfields site requirements and standards. Additionally, Mitie also adopted the brigade orders (Local Instructions) from Springfields Fire Service Instructions and updated in line with current national standards and operational guidance.
- At Springfields all site requirements are within Springfields Site Instructions (SSIs). These are site-wide procedures that must be complied with by Springfields Fuels Ltd personnel and, where relevant, by all other occupants of the Springfields site these are stored on the PRIME electronic database. SSIs capture and interpret, as appropriate, all relevant external requirements, including UK legislation, the Site Licence, environmental authorisations and consents, Company policies and contract requirements.

- The process for periodic reviewing, updating, and accepting written procedures adopted by Mitie Emergency Response are in the form of a Training Matrix outlining certain subject matter relating to site hazards and procedures. The Matrix is detailed in a traffic light (RAG) system indicating Green in date, Yellow a month before out of date and Red indicating out of date. Training is measured on a four monthly basis.
- The subjects outlined on the training Matrix are found in a training document explaining all the elements to be covered in the training. Mitie competency and requirements for roles are identified on (RPG) role proficiency graphs which identify the specific jobs/authorities required for that specified role.
- Firefighters, Crew Managers and Watch Managers are assessed against national occupational standards, learning and guidance. As part of this process individuals are assessed using different assessment methods such as assignments, projects, external courses, and practical demonstrations.
- Mitie provide a full-time on-site fire service who undertake regular training both on-site and off-site. As part of their ongoing training, they attend many off site courses these include REAX Specialist Access & Rescue (rope access), Hot Work Fire Risk Assessment, First Response Emergency Care (FREC), BAFE British Association of Fire Extinguishers (fire extinguisher service) and an annual hot fire course at Merseyside Fire & Rescue Service training facility (2 day). These are all accredited courses provided by 3rd party accredited suppliers.
- In addition to the ongoing training programme, they are required to prove competency on an annual basis through Level 1&2 exercises and demonstrate to the ONR that site is compliant with Licence Condition 11. There is also additional training for key members of the Emergency Team. Details on specific responsibilities for the training of Springfields staff are provided in the Springfields submission to the NAR [9].
- Springfields Fuels Ltd staff are required to undertake mandatory site/building induction training which is recorded on their proficiency passports which are audited internally by EHS&Q. In addition to this all office/plant staff are required to complete an on-line ATLAS course on the classifications and use of fire extinguishers and plant personnel must complete a practical session. Staff involved in hot works are required to attend a hot works fire risk assessment course and must have experience/competency in the areas in which they control the hot works. This information is covered in a folder designed/orchestrated by the site Emergency Planner in the ECC.
- The local authority fire service attends the site every six month. This is to allow them to be made aware of the hazards and buildings on the site. The visits to site cover aspects such as water supplies, access & egress, and rendezvous points. The objective is to provide site training alongside the local authority fire service for continuity when attending any potential incidents. The training covers toxic & radioactive material release incidents, concentrating on the decontamination procedure adopted by site emergency response, with the site emergency response covering their roles and responsibilities and then explaining what would be required from themselves in an operational incident command role.

- Local fire services have an MDT (Mobile Data Terminal) system on each appliance, that provides the Officer in Charge attending; the direction to the site, hazardous materials, which building type is involved, how many appliances are attending the site emergency from local fire services and rendezvous points.
- Upon arrival to the site local fire service will rendezvous at the external carpark and are provided with a building risk information folder (main plants) containing plans of the building, Information on the specific hazards within that building, Hazchem data and locations of hydrants, riser systems etc. Once briefed Mitie security will escort the fire service to the ECC so the Officer in Charge can be briefed and then to the fire ground taking into account safe routes.
- There is regular training undertaken by the site fire and rescue teams. The training covers Criticality, Toxic, Environmental, Fire, and Security. Springfields follow the National Operational Guidance model for firefighters incorporating site-based competencies which are completed on a quarterly basis.
- It is a requirement that all fire crews are trained to the same national operational guidance. This is achieved by using outside organisations who issue a qualification after each course. These courses are undertaken as rolling two/three yearly refresher courses. Please note that further specific courses undertaken are detailed in Springfields Fuels Ltd self-assessment report [9].

Emergency Exercises and REPIR

Under REPIR 2019 site as operators must prepare an emergency plan regulation 10(1) after completing an evaluation under Regulation 4(1) which show a radiation emergency may occur. Springfields' On-site plan is set out in SSI 519 'On-Site Emergency Plan'. Under REPIR 2019 [190] the site supplies an evaluation report to the UK ONR and Local Council. The Local Council then prepare the Off-Site Emergency Plan. The Off-Site Emergency Plan is then tested every 3 years during which Springfields provides support. Further details on the Springfields site approach to compliance with REPIR which includes any applicable fire related emergency with potential nuclear consequences is provided in the Springfields self-assessment report [9].

C-II-3.2.3.3 Specific provisions, e.g. loss of access

The local authority and emergency services have four pre-arranged Rendezvous Points (RVP) and three routes into site. Once at the site boundaries the site has four access gates North, South, East and West. Springfields site has access points to all high-risk buildings from multiple directions. The site has three agreed routes for offsite emergency responders with four access points and maintains a 24/7 on-site fire and rescue service on site.

C-II-3.2.4 Licensee's experience of the implementation of the active fire protection

C-II-3.2.4.1 Overview of strengths and weaknesses

Springfields Fuels Ltd reported as a strength that Mitie emergency response has brought in several initiatives since taking over the site fire service role, based on National operational

guidance (Incident command structure) and the JESIP model. The main characteristics of the approach (reproduced literally from Springfields self-assessment) as follows:

- If an exercise has been planned by Mitie emergency response, the watch manager will send an Exercise 1 form to all the departments involved. This form details the date and time of the exercise, the exercise name, who oversees the exercise (exercise coordinator), venue, rendezvous points, aims & objectives, exercise description, hazards involved (actual or simulated), preliminary briefing, scenario, general information, debrief arrangements and training elements applicable to the exercise.
- **Dictaphones.** When attending a site incident, the Officer in Charge will turn on the Dictaphone in the appliance cab and turn it off after the final debrief at the end of incident. This is to assist the Officer in Charge with the incident report, when they return to station.
- **Debrief 1.** After a protracted incident, a Debrief 1 form will be sent out by the Station Manager to all departments involved in the incident. This is for learning purposes for all departments to allow them to have an opinion of how the incident went and where improvements can be made and any new learning. This is a tool to determine peoples thought processes when involved in an incident.
- **MD4.** Mitie have introduced an MD4 decontamination tent for an easier decontamination process for firefighters and casualties. This also assists with environmental issues such as site water run-off, due to the MD4 having a 1000ltr clean tank of water that flushes through the decontamination tent, cleans individuals, then runs off or is pumped into a 1000ltr contamination tank. The contamination tank can then be taken away by an offsite specialist company. This prevents any contamination running into site drainage.
- Mitie emergency response has introduced a beginning of shift briefing with the site SPM's, ECC and Site Security. This is the opportunity for all parties to share their site information.

C-II-3.2.4.2 Lessons learned from events, reviews fire safety related missions, etc.

No further specific lessons learned regarding active fire protection are provided in the licensee self-assessment.

C-II-3.2.4.3 Overview of actions and implementation status

No specific actions have been regarding active fire protection are provided in the licensee self-assessment.

C-II-3.2.5 Regulator's assessment of the active fire protection

C-II-3.2.5.1 Overview of strengths and weaknesses in the active fire protection

Strengths

Springfields Fuels Ltd has identified several improvements made to emergency response arrangements and practices which are relevant to fire safety. The emergency response

approach now incorporates the Joint Emergency Services Interoperability Principles (JESIP) model which ONR considers relevant good practice. This represents an enhancement of the site's ability to deal effectively with a range of potential incidents. ONR judges this that meets the expectations of WENRA Safety Reference Level SV 6.13 [1] as well being a key part of demonstrating compliance with LC 11 – Emergency Arrangements.

Springfields Fuels Ltd has identified that no fire suppression systems are claimed for nuclear safety to prevent radiological releases. It also states that the fire alarm and detection system is generally only claimed for prompt personnel evacuation and to alert the on-site fire service as part of defence in depth. Springfields has stated the following in relation to the role of the onsite fire service. *“In accordance with IAEA safety standard – Safety of Nuclear Fuel Cycle facilities [19] a defence in depth approach is adopted for the Springfields Fuels cycle facilities with respect to fire. As identified in Section II-2.3.2 site fire service intervention is claimed in nuclear fire safety assessments as part of defence in depth [...] The on-site fire service provides the emergency response to any incident. In some cases, specific means for fighting fires can only be undertaken by the site fire service e.g., the use of 50kg wheeled non hydrogenous dry powder units in areas where a criticality event could occur”.*

ONR judges that the position is aligned with SAP EKP.5 – Safety Measures [15] which outlines regulatory expectations in the application of the hierarchy of controls. Passive safety measures that do not rely on control systems, active safety systems or human intervention are identified as preferable to active measures, administrative and mitigative measures. Please note that hierarchy of measures should not be interpreted to mean that the provision of an item towards the top of the list precludes provision of other items where they can contribute to defence in depth. ONR is content that Springfields Fuels Ltd onsite fire suppression approach recognises and delivers defence in depth.

C-II-3.2.5.2 Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

ONR's arrangements for regulating the Springfields site are described in Section II-2.3.7.2. Further to fire safety inspections at the site as reported previously, ONR has undertaken observation and inspection of emergency exercises undertaken at the Springfields site which are part of demonstrating compliance with LC 11. A 2022 inspection rated LC11 compliance as green (no formal action), and it was noted that the site exhibited positive behaviours in terms of innovation for site emergency response this including trialling the use of Microsoft teams to co-ordinate site response.

D Dedicated spent fuel storage facilities

Spent fuel storage facilities associated with reactor sites are reported on under Section A - Nuclear power plants. Spent fuel storage facilities at Sellafield follow the same licensee arrangements as those reported under Section E - Waste storage facilities.

E Waste storage facilities

E-I Sellafield Facilities

The text in this section (bar the regulator's assessment subsections) of the report has been prepared by Sellafield Ltd, with only minor changes for clarity and conciseness. For avoidance of duplication, all Sellafield Ltd. facilities, including waste processing facilities are reported in this section.

E-I-3.2.1 Fire detection and alarm provisions

E-I-3.2.1.1 Design approach

Safety case-driven approach to Classification for fire detection and alarm provisions

Sellafield Ltd.'s Nuclear Safety Case Processes and Methods require the identification of SSCs which are important to safety, and Safety Functions that define the required performance of the SSC. Sellafield Ltd. captures the safety function of the SSC within the facility's Engineering Schedule.

A Safety Designation is a name/label which determines the specific way that the limit, condition, instruction, equipment or parameter will be safely managed (implemented and complied with), adopting the tiered approach summarised in Sellafield Ltd. Procedure 2.17.02. How do I develop a Nuclear Safety Case?.

Safety Designation definitions from SLP 2.17.02:

- Safety Mechanism - A mechanism, device or circuit which is important to nuclear safety and required to provide a suitable and sufficient protection against accidental releases or exposures.
- Safety Feature - A structure, system or component (SSC) which provides a nuclear safety function and is usually passive, such as a vessel or cell wall.
- Safety Related Equipment - A Mechanism, device or circuit which is relevant to nuclear safety but not as important as Safety Mechanisms.

Safety Functions (and any associated Performance Requirements as stated below) detail what is required to maintain nuclear safety, and these effectively embody the limits and conditions in the interests of nuclear safety associated with the Hazard Management Strategy.

Safety Function Classes identify the relative importance to nuclear safety of the Safety Function (and the associated engineering SSC identified to deliver it), according to the scheme below:

- SFC1 - A Safety Function which makes a **major** contribution to radiological safety; a **very high** degree of confidence that the function will be achieved is required.
- SFC2 - A Safety Function which makes a **significant** contribution to radiological safety; such that a **high** degree of confidence that the function will be achieved is required.

- SFC3 - A Safety Function which makes a **minor** contribution to radiological safety; such that a **reasonable** degree of confidence that the function will be achieved is required.

Sellafield Ltd. reports that fire detection and alarms systems in buildings are given a nuclear safety categorisation (Safety \Related Equipment/SRE) if the system explicitly contributes to the retention of nuclear safety. It also states that Fire detection and subsequent intervention is not relied upon within nuclear fire analyses as there is a reliance on deterministically safe passive fire protection features instead.

Sellafield Ltd. lists Fire Protection systems on the site CMMS tool (including but not limited to): fire alarm and detection systems, emergency lighting, fire dampers, fire extinguishers and lightning protection where required by fire analysis and/or the Sellafield Ltd. management system.

Sellafield Ltd. noted that the fire alarm and detection systems are usually linked, such that if a fire is detected in one building, intermittent alarms will sound in the other buildings where they may be a knock-on effect on other plants. It also states that fire alarm and detection systems are linked to the Sellafield Fire and Rescue Service station, so any activations of alarms are automatically transmitted to the fire service allowing a swift response.

The Nuclear Fire Hazard Analyses assesses the risk associated with nuclear fire and identifies the requirements for designation of any fire protection systems for nuclear safety for inclusion in the Engineering Schedule.

Nuclear Site Licence Condition 11 (Emergency Arrangements) requires that arrangements are in place to deal with accidents and emergencies in a facility with nuclear inventory and it is implicit that there is therefore a requirement to have equipment to support those arrangements. Sellafield Ltd. reports that Equipment to support the requirements of Nuclear Site Licence Condition 11 may have already been designated SRE either using the computer tags as SR (1) Equipment Required to Mitigate Abnormal Events or SR (2) Equipment Required to Identify Leakage and/or Escape of Radioactive Material. Sellafield Ltd. requires EM&IT of fire protection systems which are designated as SRE to be included on the Plant Maintenance Schedule (PMS).

Standards and System Design

Sellafield Ltd. reports that the fire detection and alarm systems have been designed, maintained, and installed in accordance with the guidance provided for Building Regulations Approved Document B (ADB) Volume 2 [84], British Standard (BS) 5839 Part 1 [179], the primary design standards and BS European Norm (EN) 45 series for fire detection and alarm systems in the UK. Sellafield Ltd. Engineering Standards provide the process for assessing the fire risk to inform the category and details specific design system performance requirements for Sellafield Ltd. nuclear facility.

Sellafield Ltd. reports that the systems products, design, installation, commissioning and maintenance is in accordance with British Association of Fire Equipment (BAFE) third party accreditation scheme SP203-1 [191] which is considered relevant good practice. This is

described in the CE&I Legislation to Sellafield Engineering Standards flow down sheet in Figure 6.

Sellafield states that any reference to category of fire alarm system in the below sections is in line with the categories defined in BS 5839 Part 1 [179]. For life safety, Sellafield Ltd. reports that the minimum requirement for the fire alarm and detection systems for the plants in scope is in line with the recommendations of Building Regulations Approved Document B [84] which states this is a Category M fire detection and alarm system i.e. a non-automatic manually operable system as defined in BS 5839 Part 1 [179].

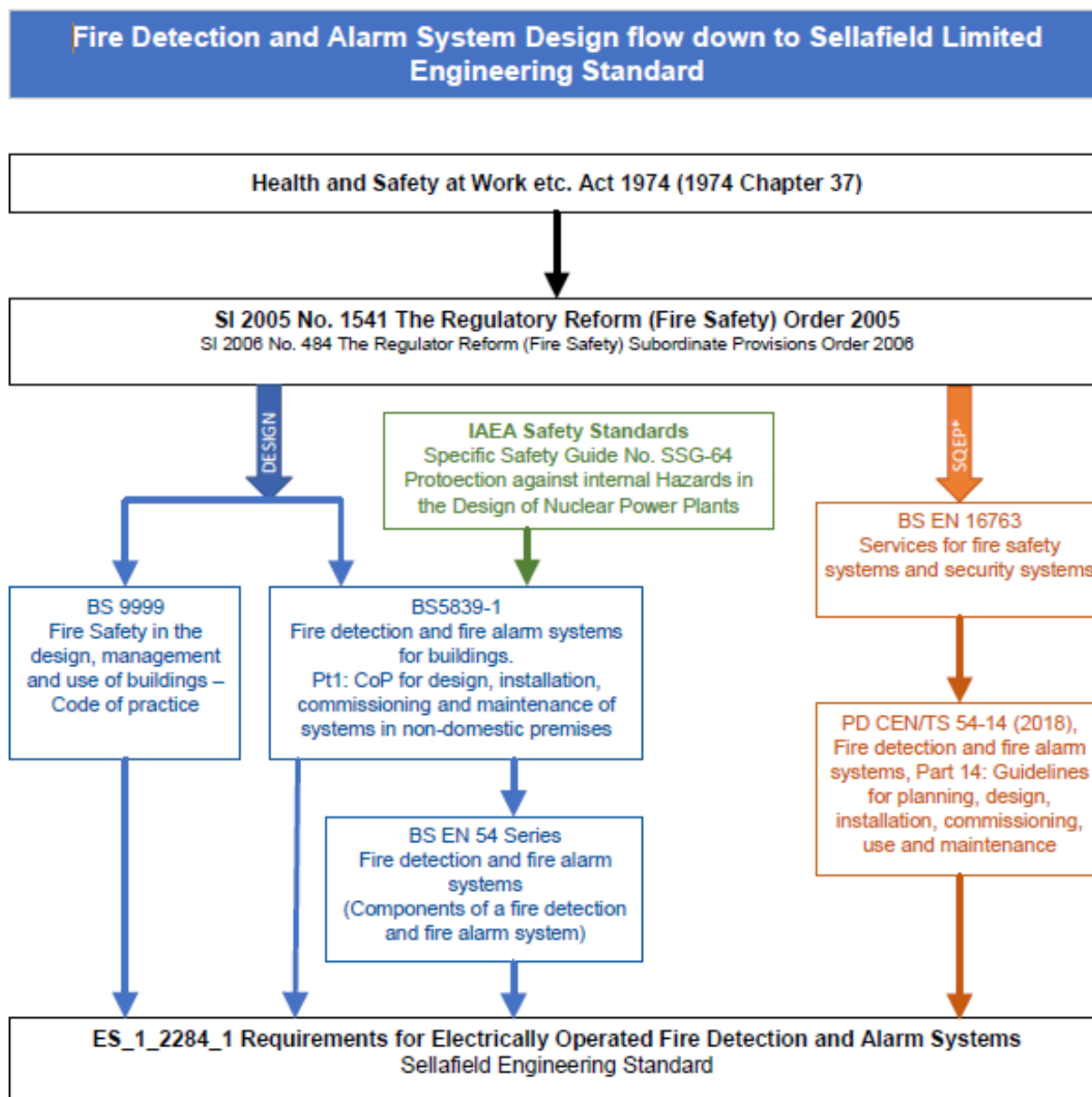


Figure 6: Sellafield CE&I Legislation to Sellafield Engineering Standards flow down sheet

Sellafield Ltd. reports the following considerations regarding fire alarm system design, reproduced below literally from the licensee’s self-assessment:

- Fire detection and alarm systems are designed with the defence in depth principle, ensuring requirements set in legislation and British Standards are met and anything reasonably above this that is justifiable under the ALARP principle.
- A fire risk assessment gap analysis is undertaken by Fire Engineering in line with the process identified within Sellafield Engineering Standards to identify the fire objectives for nuclear fire, life safety and property protection appropriate detection technologies are then identified to meet the fire, operational and maintenance requirements collaboratively with the relevant stakeholders.
- Point optical smoke and heat detectors are installed in accordance with BS 5839 Part 1 throughout all the nuclear facilities [179]. Where the building orientation, fire risk and type require different technology to detect the fire and smoke quicker alternative systems are utilised to supplement the main type such as beam detectors, flame detectors and aspirating systems
- Locations of heat and optical point detection is demonstrated on fire detection drawings for each facility.
- Plant walkdowns by suitably qualified third-party certified designers identify suitable locations for point optical smoke or heat detectors and this is reviewed during the Fire Risk Assessments. If the nature or use of a building or room changes, the smoke detection is reviewed to ensure it is still adequate and if it needs any additional detection. For example, if a meeting room is turned into a kitchen, the detection may be changed from smoke detection to heat detection.
- Optical smoke detectors are used within most areas containing fire detection unless there is the potential for false alarms or where access and maintenance considerations deem other types more suitable (e.g. smoke sampling pipe system).
- Maintenance and access considerations have led to the use of aspirating type smoke detection in areas where access to discrete detectors at roof level is difficult.
- Smoke detection is provided above false and suspended ceilings in accordance with the requirements of BS 5839-1 [179]. To allow for installation and maintenance of the smoke detection system in false and suspended ceilings, access panels in the ceiling have been provided.
- These techniques are used where standard detection techniques will not function correctly either due to environmental, disruptive operations (e.g. Welding and Cutting) or spatial consideration such as high ceiling heights. This is usually identified through the Conventional Fire Hazard Analysis.
- Standard alarm arrangements for Sellafield alarms are Entrance (Fire and Rescue), firefighter entry points, Control Room (Operations) and on-site Fire Station.
- There are interfaces between the fire alarm and detection system and other systems within the facilities, some of which initiate protection measures if the fire alarm sounds. These include: sending a fire alarm notification to SF&RS Fire Station, fire or smoke

dampers; building ventilation systems; suppression systems; and hold open door releases.

- Where deemed appropriate within the design process for the strategy of the building to maintain fire compartmentation or stop fire propagation, fire and smoke dampers, fans, fire doorsets etc. are controlled and linked to the fire alarm so they activate when the alarm is activated.
- Filters for ventilation etc. are monitored separately from any fire system as they are usually operated and maintained by the building process control systems.
- The use of addressable systems and resolution is dependent on size, complexity, and evacuation strategy of the facility. There is usually a fire alarm repeater panel within the control room of the facility, which identifies the area or zone in which the alarm is sounding. This is also visible on the firefighters entry panel or main fire alarm panel. The SF&RS tactical information plans identify where the fire panels are within the building, so upon arriving to the building the fire service can easily identify the panel and area where the alarm has activated.
- Sellafield Ltd. employs Self-Contained battery backed systems, on larger facilities or buildings with nuclear safety considerations they are supplied from the building guaranteed electrical system. Requirements are in accordance with BS 5839 Part 1 [179].
- Resilience toleration of failures is in accordance as defined by BS EN 54 standard products, for conventional fire safety. System health reports generated for the system, demonstrate the health, and identify any failures which can either be rectified or upgraded if the system is obsolescent with no spares.
- Fire rated products e.g. cabling are used within fire alarm and detection systems to meet the fire risk assessment and BS 5839 Part 1 [179].
- Facilities will utilise flame retardant coverings certified to Loss Prevention Scheme (LPS) 1207 or 1215 to mitigate issues such as leaks or condensation within the building. This is considered particularly when electrical items such as fire alarm systems and associated cabling are within the building and at risk to external factors e.g. dust or moisture.

Examination, Maintenance, Inspection and Testing of Fire Alarm and Detection Systems

Sellafield recommends all fire detection and alarm systems in nuclear facilities to be designated as Safety Related Equipment (SRE) as a minimum for life safety, property protection and any other claims required as part of the nuclear fire safety assessment. Fire detection and alarm systems is captured on CMMS, as part of its Examination, Maintenance, Inspection and Testing (EMIT) routines.

Sellafield states that where fire protection features are designated within the nuclear fire safety assessment as safety related, this is reflected on CMMS which ensures the EMI&T is

in accordance with the requirements within the Engineering Schedule. Where there is no designation in the nuclear fire analysis, Sellafield Ltd. reports that it considers good practice to identify the features as Safety Related to ensure EIM&T is prioritised for life safety and property protection, but it reports that it is not as critical as equipment designated within the nuclear safety case so it takes a prioritised approach and non-nuclear significant protection features are managed locally.

E-I-3.2.1.2 Types, main characteristics and performance expectations

Sellafield Ltd. reports the following considerations at the installations in scope of TPR. Please note that the statements in this section are reproduced literally from the licensee's self-assessment.

High Level Waste Plants

Beam detection is used in some areas of Waste Vitrification Plants as there is a large open space where point smoke detection would not be adequate to detect a fire quickly due to the large ceiling heights. The WVP lines contained within HLWP are reported below.

Waste Vitrification Plants 1 and 2

The Nuclear Safety Designations of the Fire Detection and Alarm systems in High Level Waste Plants is Safety Related Equipment.

Waste Vitrification Plants 1 and 2 is separated into two main areas (buildings), both have an automatic addressable system with one categorised as L3, P2, M and the other categorised as L2, P2, M. Both systems also have manual call points. Improvements have been identified to potentially upgrade the building to an L1, P1, M system, this was recommended in the Conventional Safety Case Fire Hazard analysis but is not integral to ensure either life or nuclear safety within the facility. No enhancement to the fire detection and alarm system for nuclear safety over and above that provided for conventional safety and property protection has been made.

The fire alarms are linked such that, given activation of the fire alarm in one the buildings, intermittent alarms will sound in the other buildings.

Waste Vitrification Plant Line 3

An L1, P1, M category comprehensive addressable type fire detection and alarm system is installed and maintained in accordance with BS 5839 Part 1 [179].

The fire alarm and detection system is designated as SRE within the Nuclear Fire Hazard Analysis. The Safety Function is to detect a fire and initiate an alarm.

No enhancement to the fire detection and alarm system for nuclear safety over and above that provided for conventional safety and property protection has been made.

Magnox Reprocessing

The Nuclear Safety Designations of the Fire Detection and Alarm systems in Magnox Reprocessing is Safety Related Equipment. The system is identified as an SSC to warn operators of the presence of a fire, the performance requirement is to annunciate upon detection of a fire.

An addressable system has been installed in most areas of the facility. The current fire alarm system is categorised as an L2, P2, M system with manual activation also available. The Conventional Fire Safety Assessment recommends an L1, P1, M category system in accordance with BS 5839 Part 1 [179]. There is an ongoing project to design and install and new fire detection and alarm system to upgrade it to a L1, P1 M system. There is also an in-cell fire alarm which alerts the Control Room if a fire were to occur in these areas.

The HAZAN concludes that it is not credible that a bulk solvent fire could occur in the cells, since the fire point of solvent could not credibly be reached except under circumstances under which water vapour was also present and would provide steam inerting. However, as the consequences of an In-Cell fire could be very high, the HAZAN has taken a pragmatic review of measure available to prevent such an outcome. The HAZAN has designated one BSM and one set of safety features to prevent an In-Cell fire.

Basket Safety Measure (BSM) 1: Fixed Fire Detection System

- Safety Mechanism (SM): In-cell Fire Detection and Alarm System
- SRE: In-cell Temperature Scanning System

The set of safety features which would provide additional protection against an In-Cell fire are:

- Safety Feature: CO₂ Firefighting Pipework
- Safety Feature: CO₂ Firefighting Bottles
- Safety Related Equipment: CO₂ Firefighting Instrumentation
- Safety Related Equipment: Cell Fire Dampers
- Safety Related Equipment: Cell Vent Fire Dampers Position Indicator

Although no credible initiators of an In-Cell fire have been identified, if a fire were to occur the in-cell fire alarm would sound in the Control Room and investigations would take place to confirm the fire using the temperature scanning system. On confirmation of a fire the CO₂ system would be deployed to the affected cell.

Currently the system is set to manual operation and the release mechanisms are “dowelled off” at the bottles (located in the firefighting bottle store on the ground floor). These dowels require to be removed prior to CO₂ release. This is to prevent inadvertent operation of the system whilst the cells are occupied by personnel.

The in-cell fire dampers are manually operated and are not linked to the fire detection and alarm system to automatically close them. The in-cell fire dampers are designated as Safety Related Equipment.

Encapsulation Plants

A number of rooms have an aspirating smoke detection, in areas where ceilings are particularly high (Class A to BS EN 54-20) system installed to meet loss prevention objectives only. The rationale for fitting them in these areas is for very early detection and also to enable safer maintenance as the fire panels can be fitted at operator levels and the pipework does not need to be accessed to undertake the regular smoke performance tests. Encapsulation Plants also utilise beam detection in areas where ceiling heights are particularly high.

There are no Nuclear Safety Designations of the Fire Detection and Alarm Systems in the Encapsulation Plants or any nuclear safety enhancements over that required for life and property protection. The facilities have analogue addressable fire alarm and detection systems, and the conventional safety function is defined as: to detect fires and initiate operator evacuation.

The two main encapsulation plants have an automatic L5, P2 and L4, P2 category system currently installed. The Fire Safety Strategies have recommended the systems be upgraded to L3, P2 and L2, P2 respectively. The strategies identify rooms that would benefit from more detection in terms of life safety and property protection. Note that these fire strategies do not supersede the nuclear fire safety case. The impact of fire on the radiological material in the building, and on those SSCs that are important to the radiological safety of the building is considered in the Nuclear Fire Safety Assessment (NFSA) Report for Encapsulation plants.

It should be noted that there is a contingency plan process in place that considers how Sellafield Ltd. would maintain nuclear safety in the event of a fire system failure (i.e. pre-planned risk mitigation, management controls and temporary limited fire alarm system provision).

SPRS

An aspirating smoke detection system is installed in several of the risers in SPRS due to the problems associated with maintenance of point smoke detection. Flame detectors are fitted locally to supplement building aspirating detectors to cover vehicle bays and these are sited at low level and have clear sight of the area. The flame detectors ensure that any flames are immediately detected as they do not operate on production of smoke. The aspirating system can be maintained from the individual panels associated with each system at ground level and therefore prevents the need for scaffolding in the areas where it is installed.

No enhancement to the Fire Detection and Alarm System for nuclear safety over and above that currently provided for conventional fire safety in SPRS have been made. The system is classed as Safety Related Equipment (SRE).

A comprehensive intelligent addressable L1, P1, M category automatic fire alarm and detection system has been installed throughout the SPRS facility as well as manual activation.

BEPPS-DIF

Maintenance and access considerations have led to the use of aspirating type smoke detection in some areas, to minimise the requirement to access high level equipment for testing and replacement such as the BEPPS-DIF roof level.

No enhancements to the Fire Detection and Alarm System for nuclear safety over and above that currently provided for conventional fire safety in BEPPS-DIF have been made.

The fire detection and alarm system installed is an L2, P2, M category automatic addressable system with detection devices in all areas of the building except areas not normally man accessible such as cells. The detection devices are linked via a fire alarm panel to both audible and visual alarms, and there is a direct interface to the ventilation systems to trigger fire dampers and stop fan motors.

The potential installation of fire detection in the vaults has been considered during the production of analyses and it is concluded that there would be no benefit from installing such a system, due to:

- The fire loading in the vaults is negligible.
- The vaults are not occupied areas.
- Fire spread into the vaults is prevented by the nature of construction (1.6m thick reinforced concrete).
- Maintenance of fixed fire detection would result in increased dose uptake to operators.
- Fire spread is not possible between the waste packages stored in the vault.
- The system is classed as Safety Related Equipment (SRE).

Pile 1

No specialist fire detection technology is installed within Pile 1 other than a standard point smoke detection. The fire alarm and detection system in Pile 1 has a Nuclear Safety designation of Safety Related Equipment (SRE). An L5, M system is installed within the facility. The HAZAN for Pile 1 identifies the system as a factor that could reduce the radiological consequence in the facility, should a fire occur. SSCs have been identified within the assessment as requiring to be considered as part of the Engineering Substantiation programme.

E-I-3.2.1.3 Alternative/temporary provisions

Sellafield Ltd. reports that when temporary works for fire alarm systems are required, the systems are disabled locally. It also states that managerial controls are usually put in place

when this occurs or if the fire alarm has failed. This could include a fire watch by the plant personnel or SF&RS, the periodicity of the fire watch patrols would be determined by the size and nature of the building. In facilities where a fire watch would not be adequate, alternative provisions would be provided such as a rapidly deployable fire alarm system. This has been utilised on the Sellafield Site where a Wireless fire alarm system has been installed to allow a facility to operate, while the existing fire alarm system was upgraded. Contingency plans are in place for the facilities that stipulate the preferred contingency for if the fire alarm system was to fail e.g. install a wireless fire alarm and detection system.

For larger scale maintenance of fire alarm systems, Sellafield Ltd. reports that a similar approach would be taken where local managerial control measures or temporary systems, would be implemented. The arrangements would depend on the size, complexity, and evacuation strategy for the building. Sellafield Ltd. also reports that maintenance is carried out by personnel or third-party certified contractors in accordance with the BAFE SP203-1 [191].

E-I-3.2.2 Fire suppression provisions

E-I-3.2.2.1 Design Approach

Sellafield Ltd. reports that fire suppression systems are used when there is a need identified to protect nuclear safety, property protection or business continuity. Qualitative and Quantitative fire assessments are undertaken to assess the need for the systems, and this is justified and detailed in the Safety Case.

Sellafield Ltd. Design Capability sources designs from third party certified contractors as in comparison to fire alarm and detection systems, the use of suppression systems within Sellafield is smaller and used less frequently. Sellafield states that certified designers utilise British Standards and relevant good practice when designing suppression systems and the optioneering process ensures the most suitable solutions are designed and implemented.

The characteristics of suppression systems used on Sellafield Site is dependent upon the fire objective and technology selected. Sellafield Ltd. reports that the fixed fire suppression systems are designed, installed commissioned, maintained in accordance with the relevant British and European standards, relevant good practice guidance produced by manufacturers and suppliers of these systems.

E-I-3.2.2.2 Types, main characteristics and performance expectations

Sellafield Ltd. reports the following types, characteristics and performance expectations of fire suppression systems at each of the installations in scope of TPR. NB: all the statements in this section are taken literally from Sellafield Ltd.'s self-assessment report.

High Level Waste Plants Fire Suppression Systems

Waste Vitrification Plants fire safety assessment places no claims on any automatic fire suppression systems for nuclear safety. There is an Aqueous Film Forming Foam (AFFF) automatic fire suppression in the transformer pens is provided to minimise fire propagation and for loss prevention purposes only.

Magnox Reprocessing Fire Suppression Systems

Within Magnox Reprocessing, Safety related Equipment designation has been placed on the in-cell suppression systems and fire dampers.

Radiological inventories are generally located in-cell and are shielded from adjacent areas. The walls and roofs of these areas have a high inherent fire resistance such that the potential for fire spread from adjacent areas is minimised. The fire risk in-cell is adequately controlled through minimisation of combustible inventories, passive containment, ventilation systems and by fire suppression (CO₂). An In-Cell CO₂ suppression system which is used to suppress any potential fire occurring in the Cells. To maintain the inert atmosphere in the cell to which the suppression has been deployed, on initiation of the suppression the inlet dampers are closed and following deployment of the CO₂ available, the outlet dampers are closed. The system itself has been assessed in a separate nuclear fire analysis to assess the available volumes in the CO₂ system and assesses whether these volumes are able to reduce the oxygen concentration to below 10% (assuming homogeneous mixing) in each of the cells it feeds. The assessment concludes that there is sufficient volume of CO₂ available to extinguish a fire in each cell.

BEPPS-DIF Fire Suppression Systems

There is a suppression system in the engine bay within BEPPS-DIF transporters to mitigate the consequences of a vehicle fire. This system is designated as safety related Equipment. It is therefore considered that the potential for any fire to develop into full involvement of all the combustibles on the transporter is very low.

The design performance requirements are the In-vehicle automatic fire suppression (Proprietary Plant and Equipment from FireTrace™) which uses a pressurised linear heat detection pipe system within the Tug engine bay.

A review regarding the omission of fire suppression in the vaults was undertaken and concluded that the circumstances under which a fire suppression system would provide any significant risk reduction are extremely limited, and therefore fire suppression was not required.

The Sellafield Packages containing the nuclear inventory are robust against a vehicle fire, and will maintain bulk shielding, along with no significant loss of containment, even during a fully developed fire, which further supports this argument.

Encapsulation Plants

The Encapsulation Plants nuclear fire safety assessment places no claims on any automatic fire suppression systems for nuclear safety. There is an automatic fire suppression system using an AFFF agent within the transformer pens within one of the Encapsulation Plants, operating a 'double knock' system, whereby the agent is only released if two detectors in the same locality are activated. This system is in place for loss prevention purposes and to prevent fire escalation should one initiate in a transformer.

Pile 1 and SPRS

There are no fire suppression systems in Pile 1 or SPRS therefore no nuclear safety claims and associated designations.

E-I-3.2.2.3 Management of harmful effects and consequential hazards

Sellafield Ltd. reports that hazards identified in the Internal and External Hazard Assessments such as flooding, and aircraft crashes are assessed for each facility. Criticality assessments also consider fire and firefighting when assessing the risk of criticality within the facility. Sellafield Ltd. states that standards are complied with where reasonably practicable, supported by appropriate collaborative ALARP justification as necessary for any relaxations against them.

E-I-3.2.2.4 Alternative/temporary provisions

Sellafield Ltd. reports that if activities or experiments were undertaken that required additional fire suppression or other fire protection features not usually utilised within the facility, this would be assessed on a case-by-case basis and additional controls would be identified through the task risk-assessment process and implemented accordingly. For example, additional suppression or other water supplies may be provided to the facility if there was a heightened risk of fire due to hot work activities.

E-I-3.2.3 Administrative and organisational fire protection issues

E-I-3.2.3.1 Overview of firefighting strategies, administrative arrangements and assurance

Sellafield Ltd.'s Fire Safety Strategies (FSS) are overarching documents that set out building function with respect to fire safety. They are a new approach adopted by Sellafield Ltd. following a pilot assessment in Financial Year 2018-2019. Previously Sellafield Ltd. covered the topic by the conventional fire analyses in the Nuclear Safety Case, however, Sellafield acknowledges that this was generally focused on life safety. Sellafield Ltd. reports that FSSs now cover all holistic fire objectives: nuclear safety, life safety, property protection and how these are addressed. Sellafield develops FSSs by identifying the fire safety objectives specific to each facility and stipulating the measures (both physical and managerial) in place to ensure that these objectives are met, and therefore that people, property and nuclear safety are suitably protected from the effects of fire.

The FSS identifies the nuclear fire safety objectives, standards, guidance and relevant good practice adopted, it provides a high-level summary of the nuclear fire issues and ultimately references out to the detailed nuclear fire analysis that is found in the Nuclear Safety Case for the nuclear facility in question.

Sellafield Ltd. intends the FSS to be used by building management throughout the life of the building to ensure that the fire safety provisions are understood and remain in place and functional. The document includes Requirements and Managerial controls which are intended to highlight key components of the fire safety strategy requiring increased focus by plant management during the Fire Risk Assessment review/audit process and these are explicitly and conspicuously identified. Sellafield Ltd. considers this particularly useful in buildings that are historic on the Sellafield Site and may not meet current design standards;

it allows buildings to be upgraded to modern standards where proportionate and prioritises areas that may require these upgrades.

Sellafield Ltd. acknowledges that FSS are not currently available for all nuclear facilities, however, it has a programme of work recently established for their production and they are being produced using a prioritised risk-based approach. Key nuclear facilities are high priority on the list to be completed. For the plants in the scope of TPR 2, there is a FSS for Encapsulation Plants and Waste Vitrification Plants Lines 1&2 with the FSS for WVP Line 3 currently in development. The strategies undergo scrutiny and review within internal committees and forums to ensure factual accuracy. Sellafield Ltd. reports that the plants have live, maintained analyses for Conventional Fire, Nuclear Fire, Internal Hazards, External Hazards, Process Fire and DSEAR. The remaining plants in scope of TPR 2 are on Sellafield's programme of future FSSs to be produced.

E-I-3.2.3.2 Firefighting capabilities, responsibilities, organisation and documentation onsite and offsite

Procedures

Sellafield Ltd. has seconded a Fire Officer from Cumbria Fire & Rescue service to create a new suite of operational response documents which are subject to a review process. These documents are created in the same format as local authority fire service documents. Sellafield Fire & Rescue Service (SF&RS) have an electronic competence management and recording system where SF&RS personnel manage any training records.

Sellafield Ltd. reports that SF&RS have an emergency response document governance group that reviews any changes to any emergency response documents. The documents are version controlled and subject to a periodic review process. Any documents relating to Fire Safety within the Sellafield Ltd. Management System, including a suite of documents owned by Fire Protection, go through a thorough review and scrutiny process ensuring stakeholders affected by the processes are consulted.

Sellafield Ltd. reports that Tactical Information Plans (TIPs) and Site-Specific Risk Information (SSRI) are owned by SF&RS and ensures they have a clear understanding and familiarisation with the facilities on the site. It also states that there is a rolling programme to ensure these are updated and familiarisation visits with the fire crews take place to maintain competence.

Drills and Exercises

The Emergency Management capability within Sellafield's Security and Resilience department has produced a drill and exercise manual, relevant for all parts of the organisation. The document includes accountabilities, types of drills and exercises, planning requirements and implementation. Sellafield reports the following main considerations associated to drills and exercises. NB. They are reproduced literally from Sellafield Ltd.'s self-assessment report:

- SF&RS have an Officer aligned to the site drills and exercise group with the reference to facilitate SF&RS involvement in site exercises and training events. Emergency Planners

are aligned to the Value Streams and plan drills and exercises in accordance with the hazards associated with the facilities within those Value Streams. There are varying levels of exercise from plant level training to full site emergency exercises. There is a five year rolling drills & exercises programme, coordinated with the Sellafield Executive and ONR have an input to this.

- Evaluation of drills and exercises are conducted using objective performance criteria and involves assessment of each participant/function/organisation's ability to demonstrate its identified objectives and capabilities during the drill/exercise. A formal report is written to document any good practices, deficiencies that require corrective action and any other noteworthy issues. These reports are kept for three years then destroyed.
- Fire evacuation exercises are carried out every 12 months in every facility. Building Managers act as the Competent Person to arrange and facilitate the unannounced exercises. Objectives of the drill are to provide staff with practical training, test management procedures, identify any strengths or weaknesses in the procedures and rehearse joint action with SF&RS.
- Any exercises that fail the requirements below, require a condition report to be raised to make the findings visible and the building will be re-tested.
 - Not all persons evacuated from building
 - Personnel re-entering building while alarms still sounding
 - Roll call exceeds 10 minutes when undertaken
 - Excessive evacuation time

Sellafield Ltd. runs two ONR witnessed level one exercises per year, one is a safety related exercise and the other a security related exercise. There are a range of topics covered during the emergency exercises such as loss of steam, cyber attack and fire.

Sellafield Ltd.'s Unified Command and Control framework is underpinned by the principles outlined in the UK Joint Emergency Services Interoperability Programme. Sellafield has both an on-site command and control facility and an off-site location, either of which can be manned during in an emergency or an exercise scenario. Emergency duty teams operate on a rota utilising stakeholders from a wide range of disciplines and technical experts within the business to enable Sellafield to respond to an accident or incident. The Emergency Duty teams are subject to exercises on a regular basis.

EMIT schedules and activities

For operational equipment, EMI&T Schedules are set by a pre-ops team who will evaluate schedules based on the manufacturers' maintenance requirement for the equipment and the statutory inspection requirements for equipment that is subject to external verifications such as Lifting Regulations.

There is a site Computerised Maintenance Management System (CMMS) where all EMI&T jobs are managed across the site. Assets within the system are all tagged to allow the system to be navigated by asset or building. SF&RS also use an internal periodic inspection process for their own routine operational equipment checks and inventory inspections.

Licence Condition 28 of Sellafield Ltd. Site Licence is 'Examination, Inspection, Maintenance & Testing' and states that a Plant Maintenance Schedule (PMS) must be in place for each plant. CMMS schedules jobs and tracks completion, requiring the person completing the maintenance to record any findings and confirm the job has been completed. Failure to comply with the PMS is reportable to the ONR.

Sellafield reports that maintenance Instructions are in place, and they are usually plant-specific for fire protection assets within a building. For example, Encapsulation Plants have a specific Maintenance Instruction for maintenance of the Fire Alarm & Detection System. This instruction details the frequency, requirements and recording process for all maintenance of the fire alarm system in this building.

Fire Safety-related maintenance records are requested during Fire Risk Assessment reviews and any overdue maintenance is queried by the Fire Risk Assessor, particularly if the fire safety system is in place for Nuclear Safety or Life Safety reasons e.g. Fire Dampers that have not been maintained. If any issues are found, this is raised as an action and responded to appropriately.

Statutory maintenance is recorded via the sites Computerised Maintenance Management System (CMMS) that schedules and records all maintenance activities centrally. All assets are recorded on a parent and child protocol flowing down from Operating Units, to buildings, individual capabilities and individual items. Each individual asset is given an identifying TAG number. The CMMS data base contains the data that is used to record maintenance and statistics for equipment to ensure compliance.

The work week managers for the Operating Unit will schedule the EMIT activity for an asset and issue a prompt card to the relevant area, the EMIT work is either completed, non-delivered if the asset or service provider isn't available or if defects are found a further work order prompt is generated to rectify the fault.

Sellafield Ltd. states that a sitewide dashboard is in development to track fire protection system EMIT activities and address any overdue maintenance.

Onsite firefighting capability and interface with off-site/local fire services.

Sellafield Ltd. reports that SF&RS have a modern professional fire service permanently based on site with an overall operational staffing level of 86 personnel. This Operates on a shift basis covering 24 hours a day. There is a Chief Fire Officer for the Fire Service. All SF&RS Officers receive training and certification in incident command. Officers with more responsibilities such as Watch Manager or Station Managers carry out additional training.

Firefighters training portfolio includes mandatory training across a range of subjects and disciplines, as the firefighters also form part of the medical response teams within Sellafield.

Sellafield Ltd. states that SF&RS respond to most issues on the Sellafield Site, where additional resources are required, they may request support from the local authorities. There is a response plan for requesting Cumbria Fire and Rescue Service response and resources to the Sellafield Site. The SF&RS Station Manager acts as Incident Commander and has authority to request a number of appliances, depending on the nature and size of the incident. The regional Fire Control centre action this request. Communications between SF&RS and CF&RS continue as the event progresses.

SF&RS and CF&RS have an ongoing joint interoperability programme. This programme consists of quarterly liaison meetings between management within both organisations. In addition to this formal meeting, regular communications between the two services are ongoing, to ensure the services are kept up to date with issues that could impact either party. For joint training, an annual program based on both organisations maintenance of skills program is run on one evening per week on site. CF&RS crews undertake practical and familiarisation training on the Sellafield Site, this includes joint Breathing Apparatus, equipment drills and high-risk building visits including fixed firefighting installations.

CF&RS have their own tactical response plans for responding to fires on the Sellafield Site. CF&RS have access to all SF&RS TIPs and SSRIs for Sellafield Ltd. and Sellafield Ltd. states that they are considered industry leading.

Safety culture and staff training

Sellafield Ltd. states that improving and maintaining a good safety culture is a key priority and a constant topic cascaded through the organisation from the executive team. Any issues, events or equipment/system failures are captured on the sites ATLAS learning system as individual Condition Reports, each report is evaluated and either recorded for trending or escalated for investigation or actioned for rectification. Safety Shares are often used at the beginning of meetings to highlight a topic or recent event where learning can be shared. Observations can also be raised on the ATLAS system including, Peer to Peer assessment tools where employees can report instances of when they have observed a peer and found positive or negative findings.

Sellafield Ltd. has initiated a series of sprint events. The first of these was a focus on pride in the workplace and litter picks across the business. Good housekeeping has a direct correlation with good fire protection measures and culture. Sellafield Ltd. also has Safety Pauses which consist of a day focused on safety to encourage learning and sharing of information within the business. Safety conferences are also held on site which again, demonstrate relevant good practice.

Training covers a broad spectrum reflecting the complex nature of the day-to-day activities undertaken onsite. For all training activities, a training needs analysis is undertaken and completed to identify what training requirements were to then subsequently identify any gaps in the training provision provided. Where gaps in training provision were identified, suitable training provision was identified and sourced be it via an external, or internal route.

There is a Conduct of Training Manual which details 'The systematic approach to training' (SAT) to ensure it is fit for purpose and is undertaken at a frequency which allows operational crews to maintain competence.

Any external training events and internally Sellafield Ltd. course events are recorded and tracked as per site requirements so that it can be demonstrated that staff are competent to deploy or not.

E-I-3.2.3.3 Specific provisions, e.g. loss of access

Sellafield Ltd. reports that proposed road closures on site for any maintenance works or other scenarios follow an approval process where SF&RS are consulted and can evaluate any restrictions for access to buildings. If special access arrangements would be required, this is highlighted and shared with the Sellafield Site Shift Manager who would liaise with SF&RS. Joint communications with the Security Guards and on-site constabulary also take place.

Sellafield Ltd. considers that with its internal firefighting capability, it means that Sellafield is not immediately at risk, should the roads around the site be blocked or not accessible. Emergency arrangements for these scenarios are in place, should these issues become apparent.

E-I-3.2.4 Licensee's experience of the implementation of the active fire protection

E-I-3.2.4.1 Overview of strengths and weaknesses

Sellafield Ltd. has identified strengths relating to active fire protection in the preceding subsections, including:

- Provision of a modern professional fire service permanently based on site.
- Low reliance placed on active suppression systems to deliver nuclear safety.
- Utilisation of new technologies to enable rapid deployment of wireless systems to replace ageing fire alarm systems.

Sellafield Ltd. has also identified weaknesses including:

- Holistic FSSs are not currently available for all nuclear facilities.

Sellafield Ltd. has identified how FSSs would benefit facilities. A sitewide FSS development plan has identified the priority buildings that require a FSS. The programme is being completed but due to the complexity and size of the Sellafield Site and its nuclear facilities, this process will take significant time. Sellafield Ltd. states that each Safety Case still has a valid Conventional Fire Hazard Analysis which provides confidence that conventional fire safety is appropriately controlled and managed. This ultimately provides defence in depth for the nuclear fire safety aspects.

In addition, as part of the Sellafield Ltd. Safety Case Process and Methods improvement plan tranche 3 there is a project to update the Fire Safety Strategy Process Technical Guidance.

E-I-3.2.4.2 Lessons learned from events, reviews fire safety related missions, etc.

ONR conducts Life Fire Safety inspections under the Regulatory Reform (Fire Safety) Order [20]. ONR also conducts Nuclear Fire-themed System Based Inspections which focus on systems that we rely on such as fire alarm systems. A system-based inspection of Sellafield Ltd.'s First Generation Magnox Storage Pond (FGMSP) led to a regulatory issue around the obsolete fire alarm system in 2021, the impact of this halted operations at the facility until a replacement fire alarm system was installed.

Recent life fire safety and system-based inspections by ONR have identified further issues in facilities on Sellafield Site including fire alarm system obsolescence and challenges related to fire damper maintenance. Sellafield Ltd. has carried out extent of condition reviews and determined that these issues are localised. Whilst Sellafield Ltd. does not claim the systems affected in the nuclear fire safety cases, the systems provide life and property protection and therefore required resolution. Regulatory engagement between ONR and Sellafield Ltd. is ongoing on these aspects and Sellafield Ltd. has established a wireless fire alarm working group to determine how the business adapts to the growing need for rapidly deployable systems. ONR is satisfied that work is also ongoing to improve the efficiency of progressing fire alarm systems from initial design to install as it has been recognised that this process is often much longer than the licensee would prefer.

E-I-3.2.4.3 Overview of actions and implementation status

Sellafield Ltd. has responded to the issues highlighted in section E-I-3.2.4.2 by committing to a high-level review within Fire Protection and Engineering, as well as developing an improvement programme to address the root causes of these issues. Sellafield Ltd. has committed to improving visibility of Fire Protection metrics at both tactical and strategic levels. The tactical levels will improve the facilities' awareness of the status of any maintenance, obsolescence and operability of systems and the strategic level will ensure appropriate oversight is in place, to mitigate and address any concerns that could implicate Fire Safety.

Sellafield Ltd. has states that there is a programme of work recently established for the production of fire strategies and they are being produced using a prioritised risk-based approach. Key nuclear facilities are high priority on the list to be completed.

E-I-3.2.5 Regulator's assessment of the active fire protection

E-I-3.2.5.1 Overview of strengths and weaknesses in the active fire protection

ONR has considered the information provided by Sellafield Ltd. against WENRA SRLs and IAEA guidance as well as the ONR SAPs [15] and internal hazards TAG [16].

Sellafield Ltd. has described in section E-I-3.2.1 how fire alarm and detection systems are identified as Safety Related to ensure EIM&T is prioritised but are generally not relied upon in safety cases. This meets the expectations of the internal hazards TAG [16] and SRL SV 6.11 regarding EIM&T as well as ONR expectations on the hierarchy of controls in SAPs as described in para 155 [15]. While ONR is satisfied that maintenance of nuclear classified systems at Sellafield is adequate, there have been recent instances of fire protections

systems without a nuclear claim not being maintained. This is expanded upon in Section 3.5.1.2.

Sellafield Ltd. has demonstrated a capability for rapid deployment of temporary fire detection and alarm systems where the permanent system has been found to be inadequate by ONR or Sellafield Ltd. ONR judges this to be a positive and necessary capability given the age and status of many facilities at the site.

Fire alarm and detection systems at Sellafield are designed in accordance with RGP, which in the UK is BS5836. Sellafield has stated compliance with this standard for all facilities within the sample and ONR understands this is the design intent across the Sellafield estate. The licensee has also described how the Nuclear Fire Hazard Analyses assess the risk associated with nuclear fire and identify the requirements for designation of any fire protection systems for nuclear safety for inclusion in the Engineering Schedule. This meets expectations of SAP EHA.16 and SRL SV 6.8 that the fire detection, alarm and extinguishing systems provided should be commensurate with the fire hazard scenarios stipulated in the safety case and should be appropriately categorised and classified.

Sellafield Ltd. places limited claims on fire suppression in the candidate facilities (and across the estate). This approach is in accordance with ONR expectations on the hierarchy of safety measures.

Section E-I-3.2.3 describes the SF&RS provision on site. ONR judges this to be a strength of the Sellafield Ltd. assessment. While fire service intervention is not credited in the fire hazard analyses, the demonstration of robust arrangements for onsite firefighting and coordination with CF&RS provides defence in depth. ONR judges this to meet the expectations of SRL SV 6.12, 6.13 and 6.14. In addition, the expectations of IAEA SSR-4 for fuel cycle facilities that “specific training and drills for operating personnel, internal and external firefighters and other personnel relevant for emergency response shall be provided relevant to their assigned response functions in the event of a fire or explosion at the facility” are shown to be met [19].

Finally, the licensee has described the process of developing fire safety strategies across the site. These are holistic cases considering all aspects of fire safety. ONR has raised this as a point of good practice at inspections of facilities with a strategy in place.

E-I-3.2.5.2 Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

A 2021 inspection of the First Generation Magnox Storage Pond (FGMSP), a nuclear waste facility not within the candidate installation list, revealed obsolescence and functionality issues with the fire alarm system. These issues led to ONR serving an enforcement notice on the facility in 2022. Sellafield Ltd. committed to a full system replacement and in the interim period successfully completed the rapid deployment of a temporary, wireless system in the facility.

Obsolescence of and functionality of aging fire protection systems is a focus area for ONR at Sellafield. Sellafield Ltd. faces ageing management challenges due to the age and complexity of some of its legacy and other facilities. ONR has identified through life fire

safety inspections at the site several facilities with current or imminent obsolescence issues. ONR has raised regulatory issues to track these findings to resolution.

The identification of the above fire safety issues as part of ONR's regulatory activity at Sellafield has led to a Level 2 (second highest level) regulatory issue being raised with an expected closure date of end 2023. Sellafield Ltd. has committed to develop and implement a strategic fire safety improvement plan at the site and this is tracked by ONR through the regulatory issue.

F Facilities under decommissioning

The text in the Sections below has been prepared by Dounreay Site Restoration Ltd. Background information on the site and the range of installations considered in the scope of the assessment is provided in Sections 1.1.2 and 1.1.3.

F-I Dounreay

F-I-3.2.1 Fire detection and alarm provisions

Dounreay assesses faults and classifies the preventative and mitigatory controls on the basis of the consequences. Dounreay reports that the PFR fire alarm and detection system is a SSSC Class 4 and that the safety function and performance requirements of the SSSC are identified in the Engineering Schedule.

The main features of fire detection and alarm provision at PFR provided by Dounreay, reproduced literally from Dounreay's self-assessment, are as follows:

- Automatic smoke detection is provided in parts of most of the buildings in the PFR complex; however, the coverage of detection does not extend throughout all areas of the buildings. The automatic fire detection initiates the fire alarm in the building automatically and concurrently raises an alarm at the site fire station control room. The PFR fire alarm panel is repeated in the fire station control room, enabling the Fire Service to identify the zone in which the fire is located prior to attending the building, if required the DFARS can determine the specific detector head that has initiated. The device level resolution is also repeated in the fire station.
- Manual fire call points are located throughout the facility, initiation of any of these will also raise the alarm at the site fire station. There are no automatic fire suppression systems at PFR.
- Should a smoke detector or a manual call point be activated, the building fire alarm will annunciate. This will prompt the simultaneous evacuation of all occupants of the PFR complex. The fire alarm system is claimed within the radiological hazard analysis as the means to prompt evacuation of personnel from the plant. No claim is made on site fire service intervention. In regard to alkali metal fires, the visibility and the effects of caustic smoke are assessed and identified as a means that provokes evacuation. All personnel are trained in fire safety and PFR personnel are made aware of alkali metal hazards.

Dounreay considers the above meets WENRA SV 6.8.

F-I-3.2.1.1 Design Approach

PFR is a large building with different areas and Dounreay considers that the fire alarm system has been designed to accommodate this.

The design characteristics provided by Dounreay, reproduced literally from Dounreay's self-assessment, are as follows:

- The fire alarm system at PFR consists of multiple fire panels and Graphix PCs all interconnected at PFR. The system includes panels located at PFR and remote from the facility. All panels speak to each other, and all alarms come up on all PCs.
- The fire panels are located around PFR to ensure adequate coverage of the different areas e.g. Reactor Hall, ETP, Cable basement. Within each panel there are different zones that cover sub areas within the larger area e.g., the different floor levels are each on a different zone.
- The system was installed to give the best coverage of the plant whilst letting the fire service and plant personnel identify the exact location of the fire before entry to the building. The components within the system are self-testing and if a fault occurs this will be notified and then be rectified. There are no alternative technologies used.
- Heat and smoke detectors are utilised throughout the facility. They are routinely maintained and tested to ensure that operate as per requirements. Detector locations are reviewed and advised by the on-site Fire Advisor.
- The fire alarm and detection system does not actuate protection measures, its primary function is to detect a fire and to provide an alarm to personnel.

F-I-3.2.1.2 Types, main characteristics and performance expectations

Dounreay reports that the fire alarm and detection system can report the temperature and how clean each detector head is. This information can be found at each panel. The PFR system gives the details of which detector head has gone into alarm and the location.

The on-site Fire Service Control Room (known as the fire station) has a repeater panel of the fire detection and control system. Should a fire be detected, the panel will sound and indicate fire which alerts the Fire Service Control Room operator who will mobilise the on-site fire crews.

Key features of the panel are, combined text and graphics that display on a single screen, comprehensive system wide event and status logging, management and query system, touch screen operation, single operator controls (no mouse or keyboard required), event and report printing capability, monitored connection to the network.

The fire detection and alarm system has been designed to operate on an on-demand basis. To support this functionality the fire detection and alarm system is supported by battery back-up power supplies which operate until the GID system is initiated after 30 – 60 seconds. Two diesel generators external to the facility provide back-up power to the PFR.

The rating of the cable is Pyro cable that is rated from fire alarm systems. Dounreay reports that all components would have been installed to meet BS 5839-1:2017 [179] and BS 5839-6:2019 [182] for the design, installation and maintenance of fire detection and fire alarm systems.

F-I-3.2.1.3 Alternative/temporary provisions

Dounreay reports that the need for alternative or temporary provisions has been identified as necessary when the system is under maintenance or repair. It states that the fire alarm system is maintained annually by a specialist contractor, and plant operators carry out weekly fire alarm tests on a 3-monthly rotation to capture all points. A tannoy is relayed advising personnel of tests to be undertaken and the Fire Service Control Room are informed.

F-I-3.2.2 Fire suppression provisions

F-I-3.2.2.1 Design Approach

There are no suppression systems installed within the PFR facility.

F-I-3.2.2.2 Types, main characteristics and performance expectations

Not applicable.

F-I-3.2.2.3 Management of harmful effects and consequential hazards

Not applicable.

F-I-3.2.2.4 Alternative/temporary provisions

Dounreay states that the requirement for alternative or temporary fire protection measures for experiments or temporary activities would be determined in the safety case for that activity.

F-I-3.2.3 Administrative and organisational fire protection issues

F-I-3.2.3.1 Overview of firefighting strategies, administrative arrangements and assurance

Dounreay reports that the strategy used on site is to ensure an adequate provision of fire safety measures and systems in the workplace to enable all persons in or near those workplaces to escape safely from a fire, to prevent fire occurring, and to mitigate the effects of any fire to meet its obligations under the Fire (Scotland) Act 2005 (FSA) and associated legislation. These general fire precaution measures include both the physical protective measures and also the management arrangements to ensure they are effectively used and maintained. Dounreay requires the production of building fire risk assessments. Dounreay considers this aligns with WENRA SV6.11: *In order to ensure the operability of the fire protection measures, procedures shall be established and implemented. They shall include examination, inspection, maintenance and testing of fire barriers, fire detection, alarm features and extinguishing systems.*

F-I-3.2.3.2 Firefighting capabilities, responsibilities, organisation and documentation onsite and offsite

Dounreay reports that the responsibilities for personnel located within PFR are communicated through:

- PFR Emergency Operational Instruction
- Their initial plant induction, pre job briefs, outcomes from work scope hazard reviews, recommendations recorded from sub work permits e.g., Hot works permit, and lessons learnt from previous incidents
- Fire induction on employment and thereafter every 3 years
- 6-monthly building fire evacuation exercises
- DFARS response to a fire call from PFR is covered in Station Standing Instructions. Crews also receive building specific hazard training from the subject matter expert(s).

Training of onsite, facility-based personnel

Dounreay reports that to ensure compliance with the Fire Safety Scotland Regulations 2005 section 20, evacuation procedures are scheduled for all occupied buildings. Dounreay states the main considerations as follows:

- Evacuation procedures are tested at least annually to ensure personnel can react and respond correctly to a fire alarm sounding. A person is identified and asked to carry out their actions in response to a fire within their area. A specific form is used to ensure commonality of exercising. Part of the procedure is for the person to sound the alarm so building personnel can evacuate and attend the assembly point where a roll call is taken. Evacuation testing and exercising is managed through the site maintenance system with work orders generated for each occupied building at least annually.
- Fire hazard awareness and response training provided to personnel, covers the relevant aspects relating to the nature of fire, signage, housekeeping, emergency procedures, selection and use of fire extinguishers. This mandatory training is given on induction and thereafter every 3 years.
- For those personnel that carry out the role of a fire watcher an additional short presentation is given to them and is followed up with completion of a practical exercise, where under controlled conditions, they are shown and asked to operate an extinguisher to extinguish a fire.

Dounreay consider the arrangements align with WENRA SV 5.10: *Adequate organisational arrangements, including minimum staffing levels, equipment, fitness for duty, skills and training, and procedures shall be in place to ensure safety, as identified by the hazard assessment.*

Integration of learning from experience

Dounreay reports that the safety culture initiatives on site are managed by the Professionalism Team and communicated to staff through Learning from Experience (LFE) broadcasts. These can encompass fire safety related issues not only on site but those from other Nuclear and Industrial organisations including the Health & Safety Executive (HSE). The site reports that it delivers regular roadshows to personnel, which cover various topics including fire safety.

Maintenance of fire protection systems

Dounreay reports that fire protection systems such as fire alarm systems, emergency lighting, fire extinguishers and fire doors are managed through the site maintenance system. It also states that statutory maintenance and testing is carried out in accordance with the relevant British Standard. Should any faults occur during testing or are identified out with a test period then a work order is raised to rectify. All results are recorded and held within the site maintenance system. Dounreay's planned maintenance is held and managed through the sites Computerised Maintenance Management System (CMMS). Dounreay considers the arrangements align with WENRA SV 5.10.

Access to and integration of support from the offsite local Fire Service

At Dounreay, the criteria for contacting the offsite local fire services are where a situation arises that is out with the capability of the onsite fire service, such as a fire that is of a magnitude beyond their resources, an incident requiring a large number of breathing apparatus wearers or more than one simultaneous incident occurs on site. This is covered in Dounreay Fire, Ambulance & Rescue Service working instructions and the Scottish Fire Service (SFS) Site Specific Operational Plan.

The responsibility for coordinating the response initially lies with the Fire Service Incident Commander who will liaise with the SFS and provide guidance on the facility specific hazards and risks. As the situation develops the responsibility will be transferred to the Site Incident Controller for overall incident management.

The on-site fire service carries out regular facility familiarisation visits to ensure the team are kept up to date with the hazards and associated firefighting limitations related to the facility.

Dounreay reports that the documentation available to responding local fire services are the building specific-hazard files, which show the type of material held and the quantities these also give the relevant Hazchem codes. Building plans showing location of fire break walls and specifically for PFR, also available are Alkali Metal Fire Pre-Fighting Plans. Given on arrival are the appropriate rendezvous points (RV) relevant to the facility.

Emergency Preparedness

The Nuclear Installations Act 1965 (as amended) (NIA65) [103] requires ONR to attach conditions to nuclear site licences. Site Licence Condition 11 refers to Emergency Arrangements; the purpose is to ensure that the site has adequate arrangements in place to respond effectively to any incident or accident. This includes preparing and updating a Site Emergency Plan and conducting emergency exercises. Dounreay reports its key priorities as follows:

- Compliance: with legislation
- Preparedness: ensuring an emergency response capability (people and equipment) is maintained
- Response: to events and exercises

- Recovery: from incidents and events

In order to test the emergency arrangements, Dounreay has a requirement to hold regular emergency exercises. Exercise scenarios are sent to ONR for comment or information and include an annual level 1 safety demonstration exercise, a level 2 safety demonstration exercise (typically held every three years in collaboration with the Highland Council) and an annual Regulatory Evaluated Demonstration Exercise (REDE).

F-I-3.2.3.3 Specific provisions, e.g. loss of access

There are several access routes to the PFR facility. Dounreay reports that if the main access route is unavailable, then additional access routes can be made available by liaising with the CNC. With regards to offsite access routes, there are two main roads to site that approach from different directions with network of interlinking roads in between.

F-I-3.2.4 Licensee's experience of the implementation of the active fire protection

F-I-3.2.4.1 Overview of strengths and weaknesses

Dounreay reports that the PFR Fire Detection and Alarm system was recently upgraded as there were concerns about obsolescence. Dounreay states that it selected a reputable supplier with a long history of delivery of fire protection systems. It has engaged the same supplier in maintaining the system, to ensure continuity of knowledge and to minimise potential obsolescence.

F-I-3.2.4.2 Lessons learned from events, reviews fire safety related missions, etc.

No specific active fire protection missions have been recorded. Lessons learned from fire events which have occurred at the PFR facility are recorded in Section I-2.6.6.2.

F-I-3.2.4.3 Overview of actions and implementation status

No specific actions have been identified by the licensee related to active fire protection. An ongoing regulatory issue related to EMIT activities of the PFR Fire Alarm and Detection System has recently been closed. Additionally, Dounreay is continuing to report to ONR on future plans associated with replacement of fire related systems as part of normal regulatory business.

F-I-3.2.5 Regulator's assessment of the active fire protection

F-I-3.2.5.1 Overview of strengths and weaknesses in the active fire protection

Strengths

Fire Alarm & Detection Capability: Dounreay has identified that the PFR facility does not place significant claims on any active fire protection systems. Indeed, there are no fire suppression or smoke control features present within the facility and the claim placed on the fire alarm and detection system is based primarily around assuring prompt evacuation of personal from potential risk areas. This is generally aligned with the expectations of the ONR Technical Assessment Guide for Internal Hazards [16] which outlines that limiting the

consequences of hazards should be ensured by good plant layout principles and passive hazards protection measures.

Dounreay has made a significant investment to replace the alarm and detection system at PFR which provides device level resolution to the Dounreay site fire control room. This is aligned with the expectation of the ONR Technical Assessment Guide for Internal Hazards which states “the fire detection, alarm and extinguishing systems provided should be commensurate with the fire hazard scenarios stipulated in the safety case”. The fire alarm system is provided with battery back-up as stipulated by the British Standard for Fire Alarm System Design BS5839-1 [179]. ONR therefore judges that the system meets the expectations of WENRA Safety Reference Level S 4.1 [1].

Onsite Response Capability: Dounreay has identified that the Dounreay Fire Ambulance and Rescue Service (DFARS) provides a 24-hour firefighting capability onsite. DFARS are familiar with the onsite hazards and are consulted on building design and modification. Dounreay also noted that DFARS can be backed up by the Scottish Fire and Rescue Service should a fully developed fire break out on site. The enhanced provision of firefighting capability on site is reflective of the site’s remote location and a target response time of 3 minutes is applied for fire events across site. Whilst no formal claims are made on firefighting response within the PFR safety case the provision offered by DFARS is a strong defence in depth measure and ONR judges this to be a point of strength in Dounreay’s overall fire protection concept.

Weaknesses

No specific weaknesses have been identified relevant to this section of the NAR however, relevant issues identified during inspection are described in Section F-I-3.2.5.2.

F-I-3.2.5.2 Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

ONR carried out a targeted inspection of the PFR Fire Alarm and Detection system in February 2023 including sampling of maintenance and inspection records. ONR also observed the site fire control room and the PFR repeater panel display. ONR raised a level 4 regulatory issue (lowest level) for Dounreay to ensure completeness and accuracy of maintenance records. This issue has since been closed. The alarm system was found to be in a good, maintained condition with the level of resolution and information provided by the PFR system back to the control room recognised as a strength.

3.3 Passive fire protection

A Nuclear power plants

The text in the Sections below has been prepared by EDF NGL and NNB GenCo with minimal editing by ONR. Background information on the sites and the range of installations considered in the scope of the assessment is provided in Section 1.1.3.

A-I Operating facilities

A-I-3.3.1 Prevention of fire spreading (barriers)

A-I-3.3.1.1 Design approach

This Section describes EDF-NGL's approach to determining fire boundary requirements, in particular how it decides fire compartment boundary lines and it makes the decision to implement a fire compartment or fire cell approach.

General - The first generation AGRs stations (illustrated here by HNB) were designed with an active fire protection that was typical for that generation of station. In terms of the containment and fire influence approach, the older stations had a combination of the two approaches in their design against fires.

Later stations (illustrated here by HY2 and SZB) took the fire containment approach and segregated the safety trains against fire from the outset of the design.

First Generation AGRs (HNB) - For HNB it can be stated that throughout the station there is a combination of both the fire influence and fire containment approach. EDF NGL reports that, where practicable, segregation was backfitted to the original design, and the three trains of auxiliary feed that were later installed were segregated from each other and the original auxiliary feed trains. However, EDF NGL acknowledges it is much more difficult to retrospectively introduce fire barriers than design good segregation from the outset.

Second Generation AGRs (HY2) – EDF NGL considers the four safety trains at HY2 to be well segregated for fire protection purposes. Segregation by fire barriers is the basis of the design. Redundant equipment that contain significant quantities of oil are separated in the four reactor quadrants and segregated by fire barriers.

SZB - SZB was designed from the outset to segregate the four safety trains into four fire areas.

Lifetime considerations

General – EDF NGL states that the designs and safety cases have been upgraded over the life of the plant. Where practicable, EDF NGL has made changes to bring the facilities up to current standards. The current safety cases carry out assessments to modern standards. EDF NGL reports that whilst there is full fire segregation in HY2 and SZB, the older stations like HNB claim much more fire suppression within the fire safety case. This is detailed under the Fire Suppression Section A-I-3.2.

Maintenance of the fire confinement function

General – EDF NGL applies a company technical standard to manage the integrity of the fire barrier/compartments/confinement elements.

First Generation AGRs (HNB) – EDF NGL states that there are significant challenges with a facility that was originally designed with the older regulations in mind (such as HNB), and that once a nuclear facility is built to the standards of the day, then it is normally not practicable to carry out significant modifications to the structure. As stated above, for HNB fire suppression is the main means of maintaining nuclear safety with regard to fire.

EDF NGL reports that due to reliance on the active fire systems, the provisions for maintaining the claims on the barriers over the lifetime will depend upon ageing and obsolescence reviews and also the replacement strategy for these active fire systems. These are therefore considered under the PSRs until the end of operating life.

EDF NGL also states that after power generation stops, many of the oil inventories are removed, thus reducing many large fire loads. In turn this means there is a lower demand on the previous design provisions. When the nuclear fuel is also removed the nuclear challenges are also very much reduced.

Second Generation AGRs (HY2) – EDF NGL considers the HY2 fire suppression systems as generally ancillary to the passive fire protection and part of the defence in depth approach to fire hazards. EDF NGL states that further FDSS to be claimed will be as a result of the application of the ground rules developed, to be applied as part of the Fire Hazards Safety Case review and Update, as discussed in section I-2.1.2.2.

Sizewell B – EDF NGL reports that, for SZB, the primary claims are on fire segregation, and the fire suppression is provided for defence in depth. Any changes are mainly due to obsolescence issues.

Fire barrier maintenance

This Section describes EDF NGL's approach to confirmation of suitable fire barrier performance. In addition, it covers EDF NGL's approach to ensuring that the expected fire resistance and stability ratings are fulfilled and are suitable for the associated safety function e.g. calculations, testing, internal guidance.

General – EDF NGL decides fire resistance ratings upon whether the need for personnel fire safety or nuclear fire safety. EDF NGL distinguishes these based on a fire rating requirement. For personnel life fire safety, EDF NGL's general expectation is that 30 minutes fire barriers are sufficient and adequate for the staff to apply the fire escape plan and exit the building to an ultimate place of safety, where upon they will muster within minutes. The expectation is in line with the Regulatory Reform Fire Safety Order (FSO) 2005 for England and 2006 in Scotland. Therefore, the fire rating for life safety of 30 minute is all that is required to meet that criteria (note for SZB this is one hour). EDF NGL reports that each station has such fire barriers in place.

Beyond this, EDF NGL provides fire barriers of nuclear significance which are claimed accordingly to the site specific safety case. Their fire barrier resistance ratings vary

depending on challenge to the fire barrier which in the case of HNB can be 1-hour. Nuclear significant fire barriers at HY2 are typically for a 1-hour rating or a 4-hour rating. At SZB this is typically a three-hour fire barrier. The rating was adopted from the original US design.

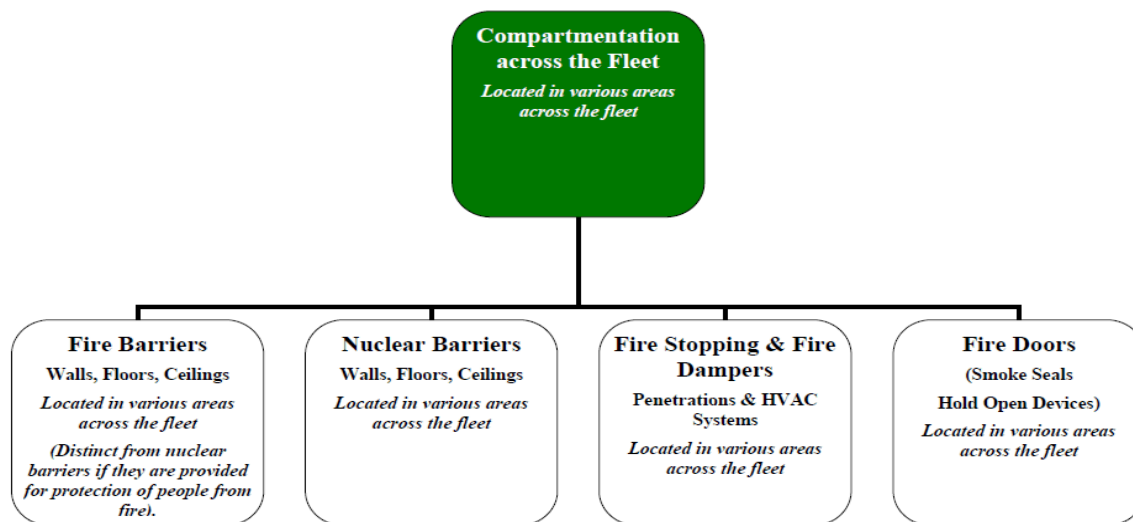
EDF NGL then uses the fire barrier ratings to determine the overall level of rebar concrete cover. EDF NGL’s civil design group specify these calculations, however, the general approach is outlined in the Loss Prevention Council Code of Practice for the Construction of Buildings ISBN 0 902167 00 – 6. 1992. EDF NGL typically uses information on the fire resistance of standard types of construction, such as brickwork of solid clay or solid concrete or sand lime bricks or reinforced concrete walls (25 mm of cover over reinforcement).

EDF NGL reports that all fire barriers are inspected, tested and maintained to the relevant EDF NGL Company Technical Standard. One of the mandatory requirements within the EDF NGL standard, as outlined in the section above on lifetime considerations, is to ensure the installation of the products, are 3rd Party Accredited products and that workmanship across the stations is carried out by 3rd Party Accredited companies which are on auditing schemes. Within the EDF NGL standard it is specified that each station is compliant to one of a number of auditing schemes. Further detail is provided in the licensee’s self-assessment report for TPR 2 [25].

A-I-3.3.1.2 Description of fire compartments and/or cells design and key features

General – EDF NGL reports that passive fire protection for all fire barriers is inspected, tested and maintained as per EDF NGL passive fire protection standards. EDF NGL’s approach for nuclear barrier compartmentation, Fire Stopping, Fire Rated Dampers and Fire Doors, are shown in Figure 7.

Figure 7: EDF NGL’s approach for nuclear barrier compartmentation



EDF NGL’s safety principle is to segregate mutually redundant trains of equipment and specific areas of plant having safety related equipment so that a fire in one train cannot affect other trains or important areas of plant. In this way, EDF NGL maintains plant safety

without making claims on active fire protection equipment. EDF NGL reflects this in the safety cases for HY2 and also in the safety case for SZB. Older AGRs such as HNB were not designed with modern concepts of fire compartmentation in mind. The original concept varies from station to station and has been upgraded where practicable.

EDF NGL reports that many types of penetration sealing are utilised throughout the fleet to ensure the fire barrier rating is maintained for the nuclear claims required. Fire and flooding seals can be installed too where needed. All of these penetration seals utilise EPRI/NFPA and British Standards as a way to ensure adequacy by regular inspections. The same applies for any item that is a penetration on any fire barrier, such as fire doors, fire dampers. All of these are inspected, tested and maintained at intervals to reflect these standards. Relevant EDF NGL documentation is given in the company standards for inspection testing and maintenance of passive fire systems and maintenance, inspection and testing of HVAC fire dampers. In terms of the installation of the products, these are third party accredited products and it is mandatory to have all the contractors carrying out workmanship across the stations to be on Third-Party Accredited auditing schemes. This is not a legal requirement but it is best practice and it is also a mandatory requirement within the relevant EDF NGL Company Technical Standard.

EDF NGL uses multi-hazard flexible bellows seals at SZB and HY2. In the case of HY2, EDF NGL reports that there are many flexible multi-hazard seals between the Turbine Hall and the Reactor Island. These have claims on fire, hot-gas, steam and blast and EDF NGL reports HY2 they have had a replacement programme and newly installed seals have a 4-hour fire rating and they are installed on both sides of the 4-hour fire barrier. Additionally, EDF regards a major fire within the Turbine Hall as 1-hour duration fire, therefore EDF NGL concluded that there is much defence in depth, even without the availability of the water spray systems working within the Turbine Hall.

Maintenance of access routes

General - EDF NGL reports that there are fire protected stairwells throughout all facilities for both personnel escape to safe area and to enable the fire services to access floor levels within each building. EDF NGL's fire safety coordinators undertake formal risk assessments for life safety. There is a legal requirement to keep these risk assessments up to date and the responsibility is for all stations. SZB has pressurised stairwells to prevent smoke ingress.

A-I-3.3.1.3 Performance assurance through lifetime

General - EDF NGL reports that fire barriers rating is kept during the operation and defueling state. EDF NGL considers that as long as there is fuel within the reactor then the claims are essentially the same for each station. EDF NGL reports that the fire ratings remain at present (during defueling). As decommissioning advances, EDF NGL reports that, in theory nuclear significant claims could be adjusted, however, it also acknowledges that it would be prudent to keep the fire barriers ratings in place as there will still be a significant amounts of lube oil, cables and other fuel sources, thus sufficient fire loading to compromise a fire barrier and cause building damage. EDF NGL states that this *is not something that it wishes to leave as its legacy to hand over to Magnox*. EDF NGL acknowledges that, beyond the transfer of responsibility point, the defueled stations are still

a commercial building, and will need to keep up with inspection testing and maintenance of the fire barriers and components (fire dampers, seals, fire doors) and continue fire barrier reinstatements. EDF NGL reiterates that the fire protection arrangements are likely remain as in the power operation state, in terms of prevention and protection of fire systems, whether active or passive. EDF NGL considers that the management of transient combustibles, lay-down areas, housekeeping, hot works etc will continue and that fire provisions would still be robust. EDF NGL finally states that a major difference for the AGRs after fuel removal is that there will be no high temperature heat source that is above the auto-ignition temperature of the combustible loads and, therefore, the likelihood of fire is reduced.

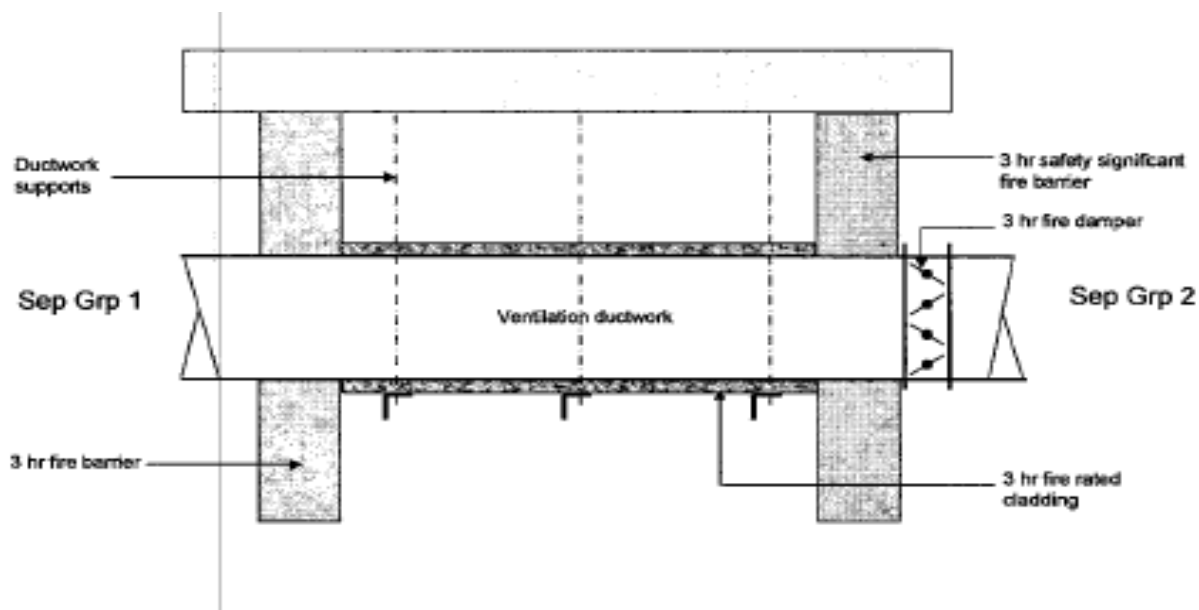
A-I-3.3.2 Ventilation systems

A-I-3.3.2.1 Ventilation system design: segregation and isolation provisions (as applicable)

General – EDF NGL reports that ventilation systems on all stations follow the same philosophy of utilising fire dampers either within the fire barriers or on the side of the fire barrier or, in the case of SZB, there are fire dampers mounted either sides of the fire barriers. EDF NGL states that, where necessary, it also uses fire cladding on the HVAC ductwork to ensure compartment fire rating where there is an HVAC duct in an area associated with another segregation area.

EDF NGL states that when the ventilation systems are maintained in any compartment, the fire service is required to enter the area for inspection purposes. It therefore has confidence that the fire dampers or cladding on ventilation ductwork are inspected, tested and maintained. EDF NGL states that the ventilation systems are protected to the same fire rating as the fire barriers within that fire compartment. Therefore, the fire safety level is the same for the ductwork as the main fire barrier.

EDF NGL notes that if cladding is not always used, it could allow a fire to potentially spread from one compartment to another by bypassing the cladded compartment if no fire damper exists. EDF NGL reports that to ensure this does not happen, it may be necessary to provide a fire damper in addition to fire cladding if there is a risk of fire travelling from one separation group to another as shown below in Figure 8. Therefore, EDF NGL considers that fire cladding is sometimes useful, rather than using the fire damper either side of the fire barrier.

Figure 8: Illustration of Fire Barrier Cladding

Protection against other hazards

General – EDF NGL states that the interface between the fire protection and ventilation systems first considers the air flow regime from the lowest to the highest contamination; C0 to C2 to C3 and the inflow and outflow balance so that flows out of the building are matched by supply and infiltration. EDF NGL's general philosophy for control of smoke and ventilation systems in radioactive areas is, in principle, in the event of a fire, to turn off the supply and keep the extract running. This maintains sub-atmospheric conditions and allows personnel to escape through thoroughfares and fire doors into an ultimate place of safety. In this way airborne contamination is kept in the highest contamination area by drawing air into the building.

EDF NGL also states that there are occasions where the sub-atmospheric conditions may hinder escape as it may not be possible to open the escape doors and personnel could be trapped inside. Whilst this maintains contamination control, it is not acceptable for life fire safety. EDF NGL reports that at SZB a compromise was met relating fire and HVAC systems which was agreed with the UK Regulator. It allows personnel to escape a fire but may cause a small amount of contamination to escape. Once all personnel have arrived at an ultimate place of safety, a controlled re-entry is carried out to go back into the contamination-controlled area. Shutting down the C2 extract means that the HVAC filters are not being clogged by smoke.

In addition, EDF NGL reports that there are smoke detectors on the inlet supply to all buildings, this is an NFPA standard. This shuts off the supply into the building on detection of smoke.

In the case of the fire dampers, EDF NGL's general rule is they all close automatically in the event of a fire. This is the primary means of detection and protection. It states that this is actuated by a control system which closes the HVAC dampers on detection of smoke, heat

or radiation. It is also possible that some fire dampers close on CO₂ detection (for example if there is a CO₂ release from a large CO₂ store). Fire dampers can, therefore, be used to protect against hazards other than fire.

EDF-NGL's secondary means of fire detection is by use of fusible links, however it considers there can be reasons not to automatically close all fire dampers protecting contaminated areas due to potential loss of contamination control.

A-I-3.3.2.2 Performance and management requirements under fire conditions

General – EDF NGL reports that fire dampers are installed in HVAC system penetrations through nuclear significant or otherwise certified, fire/safety barriers. The typical fire resistance ratings of fire dampers vary depending on the fire barrier rating which can be 1-hour at HNB and up to 4 or 3-hours at HY2 and SZB respectively.

At EDF NGL Fire dampers are assigned to one of three tiers as required in the relevant EDF NGL standard for maintenance, inspection and testing of HVAC fire dampers', i.e.:

- Tier 1 – Nuclear Significant fire dampers. (Nuclear significant dampers are those installed to maintain the integrity of nuclear safety barrier penetrations, in accordance with the requirement of the station's Fire Safety Case).
- Tier 2 – Fire dampers which are installed in HVAC systems having a nuclear significant role and maintain the integrity of barriers forming fire escape routes or compartments.
- Tier 3 – Fire dampers which maintain the integrity of barriers forming fire escape routes or compartments.

EDF NGL states that the same fire resistance rating is required across all ventilation systems. It requires any component, whether cladding or a fire damper to be the same fire rating as the fire barrier rating it penetrates.

EDF NGL has various methods of fire damper actuation. Typically there are fusible links, air compressor pneumatic actuation to open and springs to close, and also intumescent fire rated fire dampers. It states that not all HVAC systems that serve a Radiological Controlled Area (RCA) have the same response in the event of a fire. In general the confinement of the airborne radiological hazard during a fire is the same as under normal operating conditions. The normal arrangement is for potentially contaminated air to be contained in extract ductwork before it reaches HEPA filters (and in some cases charcoal filters) for filtration before discharge to atmosphere. The ductwork provides a static confinement. The filters also provide a static confinement. HEPA filters can be rated to 120°C (Type 1) or 500°C (Type 2), the latter providing greater protection in the event that the filters experience higher temperature conditions. Fire dampers may close during a fire and are therefore dynamic in their nature. They provide a physical barrier that acts as a dynamic confinement; however the fire dampers are there to prevent the spread of fire and they are not there to prevent the spread of contamination.

EDF NGL reports that it is possible that the supply fans or both the supply and extract fans will shut down during a fire. If the extract continues to run, then the air movement remains in

the direction from the least potentially contaminated area to greatest potential, minimising any reverse flow of contamination within the building, i.e. the confinement is provided by the flow of air (note that this flow of air is sometimes described as a dynamic confinement). If both the supply and extract fans are not operating then there could be reverse flow of contamination due to the loss of the dynamic confinement that was provided by the air flow. For fire damper maintenance often the ventilation system has to be turned off and people who work in the areas are not permitted access until the ventilation system is back in service. The same applies if the contaminated ventilation system is out of service for any other reason.

A-I-3.3.3 Licensee's experience of the implementation of the passive fire protection

The EDF NGL experience with the fire protection concept of containment is represented by HY2/SZB, i.e. prevent the spread of an unsuppressed fire from compartment of origin. The EDF NGL experience has been gained over a long period of operation of diverse AGR designs and has in particular been influenced by the Browns Ferry fire.

A-I-3.3.3.1 Overview of strengths and weaknesses

HY2/Sizewell B – EDF NGL reports that, at HY2 and SZB, the fire containment approach has been challenged by poor quality of the original build, e.g. linear gap seals not installed correctly originally, or through time based degradation of flexible barrier materials. EDF NGL manages the potential impairments of the containment approach by regular inspections of the plant and subsequent repairs.

EDF NGL considers that the fire-segregated four-safety train approach at HY2 and SZB provides the built-in reliability inherent in the segregation approach. EDF NGL provides these stations with fire detection and suppression for defence in depth and asset protection. EDF considers HY2 and SZB's approach of four separate safety trains with fire containment between the trains, reinforced by fire influence to be more robust than the fire influence approach alone.

A-I-3.3.3.2 Lessons learned from events, reviews fire safety related missions, etc.

Lessons learnt are addressed in Section A-I-4.3.3.1.

A-I-3.3.3.3 Overview of actions and implementation status

No actions were identified by the licensee.

A-I-3.3.4 Regulator's assessment of the passive fire protection

A-I-3.3.4.1 Overview of strengths and weaknesses in the passive fire protection

The approach described in Section A-I-3.3.1.1 details how and where EDF NGL applies fire containment via the physical separation of areas through the use of fire rated barriers, where this is applied within its facilities. Where this is applicable, this meets ONR expectations as set out in the internal hazards TAG [16] and IAEA SSG-64 [17] in addition to WENRA SRL SV 6.5. EDF NGL has set out how fire barrier designation is driven by fire

hazard analysis. This meets ONR's expectations that fire barriers should be provided to provide the fire resistance as required by the fire hazard analysis.

The three EDF NGL candidate facilities place different nuclear safety claims on passive fire protection features. At HNB, the predominant means of fire protection is active which is largely linked to the age/time of build, with compartment and ventilation design based upon the standards of the time. This does not meet the expectations of the ONR internal hazards TAG [16], which stresses the importance of segregating redundant safety measures in separate fire compartments. EDF NGL recognised the shortfalls in the HNB design and (as described in section I-2.1.1.2) added compartmentation and additional lines of protection which are physically separated from other lines such that full compartment burn out can be tolerated. In addition, HNB is now undergoing defueling, hence the nuclear risk is decreasing on the site. At HY2 (as described in section I-2.1.1.2) the fire hazard risk management is based upon passive protection by fire barrier segregation supplemented by claims in active protection in a small number of areas. ONR judges the fire barrier segregation provisions at SZB to be in line with modern standards and expectations.

ONR expects dampers to be provided in ventilation ducts that penetrate fire barriers to prevent the transmission of fire and smoke. Consideration should be given to the means of initiation and the potential for transmission of smoke and the acceptability of this should it occur. The ventilation system integrity should be maintained despite possible filter fires or any other fire or explosion hazards. These expectations are described in the ONR internal hazards TAG [16]. EDF NGL has set out its approach for ventilation systems and fire dampers (in section A-I.3.3.2.2) detailing how fire damper design meets RGP and how ductwork is protected from fire. ONR judges the licensee's provision in this area to be a strength in the EDF NGL safety case in line with standards and regulatory expectations.

A-I-3.3.4.2 Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

A 2023 inspection of the Torness power station, a facility not within the candidate installation list, revealed deficiencies regarding fire resisting compartmentation, as reported in section A-I.3.2.5.2. This led to ONR raising Regulatory Issues to track the licensee's response to the findings. ONR NGL committed to addressing the shortfalls in a timely manner. It should be noted that the compartmentation issues identified related to shortfalls in life fire safety provisions.

A-II New Build Facilities

A-II-3.3.1 Prevention of fire spreading (barriers)

A-II-3.3.1.1 Design Approach

NNB GenCo's approach to fire zoning is described in Section 4 of the HPC FAD [48]: *Preference is given in the design to passive fire protection instead of relying on active fire protection. Fire spread is limited by dividing the buildings into volumes, which use physical or spatial separation principles. Physical separation – fire compartments – is preferred to spatial separation – fire cells. Fire cells may have to be used where the design has a very large open space or has large openings that cannot be avoided.*

Each type of fire zone is created for a specific purpose, the fire zone boundaries are selected to fulfil that purpose. Fire zones can be primary fire zones or secondary fire zones which are contained within a primary fire zone. The types of fire zones are summarised in the licensee's self-assessment [49].

NNB GenCo reports that the boundary elements which have nuclear safety functions have been assigned SFRs, and that evidence will be presented of their compliance with the SFRs in substantiation reports. NNB GenCo reports that substantiation evidence will mainly rely on calculations or test evidence. It expects that once the station is operational it will follow a PSR programme similar to the existing EDF NGL fleet, including confirmation that the fire boundary requirements are still satisfied.

NNB Genco states that fire doors and hatches which form part of a boundary between fire compartments will be clearly designated and those on the boundaries of SFS/ZFS will have position monitoring that will initiate an alarm in the MCR if the door is left open (unlatched) for an extended duration. It also states that any changes to the plant which may affect the validity of the fire zoning will be assessed under the design change process or the in-service modification process depending on the stage in the life of the station. Challenges that might arise, based on OPEX from the generating stations, include modifications to pipework or cabling where additional penetrations need to be created in the boundary walls, and increases in the combustible inventory in a hazard safety volume that could increase the severity and duration of the fire and require the boundary walls to be reassessed for withstand.

A-II-3.3.1.2 Description of fire compartments and/or cells design and key features

NNB Genco states that it will provide fire compartmentation in accordance with the HPC Fire Application Document requirements ([48], Section 4.5.6); typically either 120 minute or 60 minute fire separation of escape routes, firefighting access routes, external envelopes, areas with a PFG risk, storage spaces, and areas with safety systems and or safety equipment. NNB GenCo requirements also specify whether the requirement is for load bearing capacity I, fire integrity I or thermal insulation (I). Similar requirements apply to components which form part of the boundary such as doors, penetrations, dampers, joints, envelope and cases and fire rated ducts. Cable trays are also being wrapped where required. Two categories of cable tray wrapping are being adopted, depending on the required functionality. NNB reports as follows (reproduced literally from NNB GenCo's submission):

- **Functional Cable Tray Wrapping (F-CTW):** Ensures preservation of the function of cables within a cable tray during a fire. It is predominantly used to prevent fire-induced common cause failures where it has not been possible to route the cables to avoid cables from more than one division passing through a fire HSV but may also be used where vulnerabilities to active single failure are identified. The cables must remain operational during the fire.
- **Soustraction de Charges Calorifiques –Heat Load Subtraction System (SCC):** Reduces the fire load within a fire HSV, to reduce the challenge to HSV boundaries. SCC may also be used to reduce the fire load in the vicinity of a safety target or to

suppress the PFG risk outside SFI. The cables do not need to remain functional during the fire but must not burn.

NNB GenCo concluded that the requirement for cable tray wrapping is dictated by the hazard vulnerability analysis for CCF (F-CTW) and the fire modelling studies for SCC.

A-II-3.3.1.3 Performance assurance through lifetime

NNB Genco states that the measures to prevent fire spreading have been determined based on the most onerous planned plant state or maintenance state, and any changes to operating conditions during the plant operational life will be assessed under the modification control process, which will include the potential effects on fire barriers.

A-II-3.3.2 Ventilation systems

NNB GenCo states that changes in air temperature and pressure due to a fire, or fire damage to filters and ventilation ducts, could cause uncontrolled transfers of radioactive materials around the installation and eventually to the environment. A fire could also cause smoke or harmful combustion products to spread around the facility.

A-II-3.3.2.1 Ventilation system design: segregation and isolation provisions (as applicable)

NNB GenCo states that the general principles of the Heating, Ventilation and Air Conditioning (HVAC) systems described in PCSR3 [192] and are still applicable to the current design. NNB GenCo's main objectives are:

- to maintain internal conditions within acceptable limits (air quality, temperature, humidity, and contamination) for staff and equipment,
- to protect staff and materials against specific risks arising from internal hazards and external hazards, and
- to monitor and limit radioactive discharges during normal plant operation and accident conditions (confinement function).

Rooms at risk of explosive atmosphere formation: NNB GenCo reports that the HVAC systems are designed to avoid local accumulation of explosive atmosphere (typically hydrogen) and to keep the concentration below the lower explosive limit.

Fire Containment: NNB GenCo reports that the ventilation systems are designed to provide fire containment as follows:

- Ventilation systems within each fire compartment are generally fitted with fire dampers which close if there is a fire in the compartment.
- Provision for the Single Failure Criterion (SFC): fire dampers are considered to be active elements of the protection systems so single failure must be taken into account when the fire containment function is a nuclear safety requirement. Accordingly, when required, two fire dampers are provided in series. If redundancy is not possible due to

layout constraints, alternative measures will be taken, such as fire resistance of the ductwork.

Fire restriction: NNB GenCo states that ventilation systems are designed to be shut down or isolated from a compartment containing a fire. Additional measures, including fixed firefighting systems described in earlier sections of this report, are provided for fires in iodine adsorption units.

Ventilation for protected escape and intervention routes: Ventilation systems also provide smoke control and extraction for the main staircases, lobbies, and protected corridors. Protected areas within radiologically controlled areas use pressure differential systems to ensure that radiological containment is maintained.

A-II-3.3.2.2 Performance and management requirements under fire conditions

NNB GenCo states that ventilation system components which form part of fire HSV boundaries, or which cross adjacent fire HSVs have at least the same fire rating as the barrier that they cross, on ducts crossing any fire barrier at the point of entry and/or exit to the compartment. It also noted that, in addition to the use of fire dampers, ventilation ducts crossing different fire compartments (including ones attached to another division) are protected against fire by being constructed from materials providing fire resistance equal to that of the fire compartment boundaries. In cases where ducts traverse multiple boundaries with different requirements, the rating with the greatest requirement is applied. Fire dampers close automatically in the event of fire by automatically closing these dampers when a fire is detected by the JDT system or by operation of the damper's thermal fuse(s).

Confinement for Radiologically controlled areas: NNB GenCo reports that exhaust mass flowrate is higher than the supply mass flowrate to maintain a negative pressure in the controlled area relative to outside and non-controlled areas. It also states that exhaust air is collected, filtered, and discharged to the main unit ventilation stack. An additional negative pressure is maintained in rooms housing iodine and their adjacent rooms.

NNB GenCo reports that the design takes account of the risk of spurious operation of fire dampers interfering with the radiological containment function of the ventilation system, for example if closing an exhaust damper could increase the pressure in a ventilated area which is intended to be maintained under a negative pressure with respect to its surroundings.

Other areas: NNB GenCo reports that HVAC systems can operate in recirculating mode to reduce cooling power or heating power, but a minimum fresh air rate must be maintained for acceptable indoor air quality

A-II-3.3.3 Licensee's experience of the implementation of the passive fire protection

A-II-3.3.3.1 Overview of strengths and weaknesses

NNB GenCo considers that cable tray wrapping has some implementation challenges in practice. Wrapping adds to the cost and complexity of installation and would need to be locally removed and reinstated if wrapped components need to be accessed for maintenance or repairs during the operational life of the plant. Cables generate heat from

the electrical currents that they carry, and wrapping the cables reduces the heat dissipation because it acts as a layer of thermal insulation. This means that it may be necessary to reduce the rating of the cables so that they carry less current and therefore generate less heat.

NNB GenCo also states that cable tray wrapping materials to be used in the reactor building will have to avoid generating fibrous material that could clog the filters of the pumps that would be used to circulate water for cooling in a severe accident. NNB GenCo's intention is to only wrap specific cable trays within the reactor building that are local to fixed fire initiators, and to claim low frequency of cable autoignition for other cables, and low frequency of ignition due to human action and transient combustibles due to management arrangements and low occupancy.

A-II-3.3.3.2 Lessons learned from events, reviews fire safety related missions, etc.

NNB GenCo reports that the firefighting water system has been redesigned taking into account experience from the FA3 design ([174] Section P2.3). The main design modifications concerning the fire safety functions are as follows:

- A dedicated building (HOJ) is being provided for HPC to house the entire Firefighting Water Supply System (JAC).
- Total separation of the firefighting safety functions from other safety functions that the JAC system contributes to.
- Changes in routing of the piping in the galleries and in interface with the Safeguard Auxiliary Building, within the framework of functional optimisation

A-II-3.3.3.3 Overview of actions and implementation status

No actions were identified by the licensee.

A-II-3.3.4 Regulator's assessment of the passive fire protection

A-II-3.3.4.1 Overview of strengths and weaknesses in the passive fire protection

Section A-II-3.3.1.1 details how NNB GenCo applies fire containment via the physical segregation of areas through the use of fire rated barriers. NNB GenCo has set out how fire barrier designation is driven by fire hazard analysis. This meets ONR's expectations that fire barriers should be provided to provide the fire resistance as required by the fire hazard analysis and is consistent with the ONR internal hazards TAG [16], IAEA SSG-64 [17] and WENRA SRL SV 6.5. ONR also judges the licensee's approach for ventilation systems and fire dampers meets RGP.

A-II-3.3.4.2 Lessons learned from inspection and assessment on the passive fire protection as part of its regulatory oversight

Fire inspections of the HPC site have focussed on the active life fire safety protection aspects as the site is still under construction. Assessments have been carried out at various

stages of the construction of HPC. No significant issues have been identified relating to the passive fire protection areas of the EPR design.

B Research reactors

C Fuel cycle facilities

The text in the Sections below has been prepared by Urenco UK Ltd and Springfields Fuels Ltd Background information on the sites and the range of installations considered in the scope of the assessment is provided in Sections 1.1.2 and 1.1.3.

C-I Enrichment facilities – UUK Capenhurst

C-I-3.3.1 Prevention of fire spreading (barriers)

C-I-3.3.1.1 Design approach

For new build, UUK's approach to determining fire compartment boundary lines utilises BS9999 calculations made of compartment fire loading to combine aspects of life safety and asset protection to support operational requirements/functionality.

UUK states that existing buildings are subject to fire compartmentation surveys by SQEP Fire Engineers and fire modelling and general guidance from the above referenced publication.

UUK reports the primary challenge over the lifetime of the installations as follows:

- Penetrations – cable runs, asset removal from plant, damage through weathering or material breakdown
- Ageing/asset condition of fire doors and fire dampers leading to degradation of fire resistance
- Innovation resulting in obsolescence (i.e., fire dampers with fusible link activation versus modern solenoid activated, introduction of combined fire & smoke damper units).

UUK did not identify any nuclear safety function relating to the above. In consultation with the Association for Specialist Fire Protection, review of fire test data provided through British and European standards. Third party accredited contractors and approved materials through UKAS accredited certification and schemes EN ISO 17025.

C-I-3.3.1.2 Description of fire compartments and/or cells design and key features

UUK states that it provides:

- FR30 and FR60 (30 minute and 60-minute fire resistance) compartment walls and doors, and fire dampers through ventilation systems.
- Fire stopping in penetrations using third party accredited materials, including temporary stopping arrangements during ongoing works.
- FR30 typical deployment through welfare areas for life safety and FR60 for higher risk areas to offer maximum protection for life safety e.g., segregation of plant areas from admin and the protection of means of escape (corridors/stairwells). Specific to one plant

area is a 200m fire break corridor providing emergency egress and deep penetration access for emergency service personnel.

C-I-3.3.1.3 Performance assurance through lifetime

UUK reports the following performance assurance considerations through life:

- Specific procedures detail the requirements for passive fire protection including where penetrations are needed.
- Planned work and inspection checklists detailed inspection frequencies in accordance with manufacturers recommendations.
- Lifetime quality records are maintained as part of the 'golden thread' for asset maintenance where all penetrations, remediation and product details are captured including photographic evidence prior to, and on completion of work.

C-I-3.3.2 Ventilation systems

UUK reports that general conventional safety fire provisions for life safety rather than nuclear safety have driven ventilation system design at UUK as detailed below.

C-I-3.3.2.1 Ventilation system design: segregation and isolation provisions (as applicable)

Ventilation system design at Capenhurst underwent significant review in 2018 as the site recognised that existing assets were subject to obsolescence and significant maintenance challenges.

UUK reviewed the ventilation system arrangement and design to support effective fire compartmentalisation alongside a Fire Compartment Upgrade Project. UUK's review of requirements identified that existing installations to no longer be fit for purpose and resulted in the installation of new dampers (ActionAir SmokeShield PTC 501 fire dampers). These are combined smoke and fire dampers which improve on the original fire-only dampers.

UUK's stated design objective of smoke and fire dampers, where installed across Capenhurst, is to exceed the requirements of the fire compartments in which they are installed. UUK considers that the project achieved the following:

- re-aligned the three systems back to their original functional design intent, enhancing safety for personnel on site.
- Met current regulatory requirements with regards to fire compartmentation, including the integrity of the fire compartment walls, fire dampers and fire doors.
- Provided a system for the management of penetrations (both existing and future) through fire compartmentation elements within buildings.

- Established a system to ensure that all future penetrations and fire door works are undertaken in accordance with an approved methodology and specification (BM Trada - independent inspection and training service).

C-I-3.3.2.2 Performance and management requirements under fire conditions

UUK reports that in line with the 'Construction Products Regulation (CPR) 1st July 2013, all fire dampers/smoke dampers are CE marked and must fully comply with the product standards: EN 15650:2010 Ventilation for Buildings - Fire Dampers [193] and compliance shall be verified through assessment by a "Notified Body", by the fire damper manufacturer.

UUK states that factory-fitted installation frames (IF's) are provided for masonry walls & solid floors and built in by the Principal Contractor. Where it provides dampers in dry wall systems or fire curtains it requires provision with manufacturer's installation fixing frames/clamps etc. and installs dampers in accordance with the manufacturer's recommendations.

Consequently, UUK considers that all Fire Dampers meet the following:

- External visual indication is provided to indicate their open/closed status.
- Automatic fire/smoke dampers are tested to BS EN1366-2 [194] and have a classification in accordance with BS13501-3 [195] that meets the following requirements:
 - Automatic fire/smoke dampers have an E classification at least equal to the surface in which they are mounted and, additionally, have an ES classification for a minimum of 60 minutes.
- All dampers are approved by the LPCB certification scheme.
- Thermal links operate at 68°C.
- Installation follows the manufacturer's instructions to ensure that any E or ES classifications are met.
- Ductwork access points are installed local to all damper positions for re-setting/maintenance of fusible links on both sides of the damper.

UUK reports that the automatic fire/smoke dampers are double skin spigot cases with continuously welded corners and spigot connections. Double skin stainless steel aerofoil blades are interlocked within twin trailing edges with the interlocking system providing a double metal seal to form a positive fire and smoke barrier. The blades incorporate a synthetic seal to ensure low closed blade smoke leakage at ambient temperatures. Furthermore, the dampers ensure an accurate bearing, alignment, positive cap, bar drive and blade retention to provide a slimline double skin case of high rigidity, complying to DW144 classes A, B and C. Finally, UUK states that all fusible link fire dampers are of the ActionAir Fire/Shield range. Likewise, all fire/smoke dampers are taken from ActionAir Smoke/Shield PTC rectangular or CSS circular range.

C-I-3.3.3 Licensee's experience of the implementation of the passive fire protection

Section C-I-3.3.1 describes the licensee experience and is not reiterated here for conciseness.

C-I-3.3.4 Regulator's assessment of the passive fire protection

C-I-3.3.4.1 Overview of strengths and weaknesses in the passive fire protection

Passive fire protection strengths

ONR considers the main strengths of UUK's self-assessment in the area as passive fire protection as follows:

- The licensee described a site compartmentation project supported by appropriate guidance BS9999 [71] and accredited contractors.
- The site has lifetime quality asset management arrangements for compartmentation.
- The site has implemented a fire damper upgrade project improving the original design and referencing appropriate guidance (BS15650 Ventilation for buildings) [193].

Passive fire protection weaknesses

No specific weaknesses regarding passive fire protection have been identified by the licensee.

C-I-3.3.4.2 Lessons learned from inspection and assessment on the passive fire protection as part of its regulatory oversight

Recent ONR fire safety inspections at UUK Capenhurst have not identified issues regarding passive fire protection at the site. Records of fire safety inspection may be found on the ONR website.

C-II Fuel Fabrication Facilities – Springfields Fuels Ltd

C-II-3.3.1 Prevention of fire spreading (barriers)

C-II-3.3.1.1 Design Approach

Springfields Fuels Ltd initially designates fire compartment boundaries for new builds following guidance in the Approved Document B to the England Building Regulations for life safety (maximum compartment sizes, fire service access and means of escape). Fire resistance periods will initially follow guidance given in the Approved Document B. Areas of specific high fire loading (e.g., electrical switchrooms) or potentially higher fire hazard (e.g., areas storing or using highly flammable materials) will be designated as individual fire compartments (typically 60 minutes duration unless preliminary calculations merit a higher fire resistance duration). Further compartmentation may be designated as deterministic Safety Features to protect radiological inventories from fire or to protect equipment designed to prevent a criticality incident. Springfields Fuels Ltd states that

compartmentation may be designated to separate multichannel protection systems from fire.

C-II-3.3.1.2 Description of fire compartments and/or cells design and key features

Springfields Fuels Ltd provides fire protected stairwells in multistorey buildings for fire service access. Springfields Fuels Ltd reports that where protected stairs have not been provided, buildings have been divided with compartmentation to allow firefighting access to one part of a specific level for fighting fire in the other part. Springfields Fuels Ltd reports that no specific measures are provided for running hoses through fire compartment boundaries.

Springfields Fuels Ltd reports that there are no fire cells on the Springfields site. As such fire sterile areas/cable wrapping is not used as part of a fire influence approach (separation by distance) to prevent fire spread.

C-II-3.3.1.3 Performance assurance through lifetime

Ensuring confinement function over the lifetime of the installation

Springfields Fuels Ltd reports that, as part of the COSR process, fire loads and the requirement for compartment boundaries are reviewed. Springfields Fuels Ltd reports that additional compartmentation is designated if vulnerabilities are identified e.g., protection systems are identified that could be vulnerable to common cause failure due to fire or secondary effects. Springfields Fuels Ltd reports that, similarly, compartment boundaries no longer deemed necessary e.g., due to changes in processes or changes to the fire loading may be downrated to reduce maintenance requirements. Springfields Fuels Ltd states that each change of site activity that could result in fire/smoke spread is assessed by the site PMP process and that this identifies if permanent or temporary measures are required to mitigate the risk.

Example of ensuring confinement function over the lifetime of the installation

In one of the buildings on the site the fire compartmentation scheme was developed using a fire engineering approach based on the fire loading, which was assessed as being lower than that required by Building Regulations (ADB). Springfields Fuels Ltd considered that while this was correct in many areas, there were some rooms and areas where it was established as part of COSR reviews that the fire loading would warrant additional sub-fire compartmentation and structural protection.

Springfields Fuels Ltd determined that enhanced fire compartmentation was required around the perimeter of the fire compartment containing the Central Control Room due to a stay put policy in the event of fire in any area other than the compartment containing the control room. In addition, a specific area of concern post construction was an area of the facility where no true fire separation was achieved (many of the fire compartment boundaries were a steel partition system). Springfields Fuels Ltd tested the systems and achieved a fire resistance of 71 minutes (integrity) and 12 minutes (insulation).

Springfields Fuels Ltd's approach adopted for fire safety improvements was to provide notional fire separation between two sides of the building, creating a true alternative escape

for occupants; fire compartmentation was re-designated to achieve this divide, and Iso fire compartmentation between some of the main facilities was upgraded to further complete fire boundaries.

Springfields Fuels Ltd reports the following measures taken in 2001:

- New partitioning was provided to give a notional 30-minute fire resistance.
- On all fire boundaries where there was glazing, it was upgraded to the fire resistance of the boundary.

Springfields Fuels Ltd reports that the fire compartmentation scheme was completely reviewed in 2020. Due to uncertainties over the fire resistance of the partitions used throughout the building all partitions were designated a notional 30-minute fire resistance and fire drawings were updated.

Approach to Fire Barrier Performance

Springfields Fuels Ltd uses the results of fire loading studies to confirm that the fire resistance (integrity, insulation and load bearing capacity) of the fire compartment boundaries (integrity and insulation) or main structural members (load bearing capacity) is below the calculated fire load density. Springfields Fuels Ltd reports that if fire loads are found to exceed the designated fire resistance, it typically reduces the fire loading or, if this is not practicable, applies enhancements to structural protection.

Springfields Fuels Ltd states that all penetrations are sealed typically using intumescent coated mineral wool batts and intumescent sealants. Springfields Fuels Ltd prohibits the use of expanded foam sealants in penetration sealing. Third-party accreditation of installers of both passive and active fire protection systems, materials and products is a mandatory site requirement.

Springfields Fuels Ltd reports that all fire doors are inspected on an annual basis with a report produced & all remedial works carried out are completed by third party accredited fire door installers. Relevant third-party accreditation & certification schemes in relation to the above fire safety products and services which are recognised as acceptable to Springfields Fuels Ltd, include: LPCB, FIRAS, BAFE, BWF Certifire scheme, BM TRADA Q-Mark scheme.

C-II-3.3.2 Ventilation systems

C-II-3.3.2.1 Ventilation system design: segregation and isolation provisions (as applicable)

Springfields Fuels Ltd reports the following approaches to ventilation system design for segregation and isolation:

- In accordance with Design Guide ES_0_1738, Section 19 a building will be divided into Fire Zones based on the requirements for Conventional Fire Safety. In addition, a Radiological Fire Safety assessment may lead to the allocation of additional fire zones or an increase in rating of a fire zone. Typically, radiologically controlled areas are separated from non-radiologically controlled areas by fire compartment boundaries. Fire

compartmentation may also be used to protect areas such as source stores or areas containing safe by geometry equipment (slab tanks, racking, etc.) that require protection from an external fire.

- The period of fire resistance for designated fire resisting walls and floors is typically 30 minutes or one hour to BS 476 Part 22 for conventional fire safety and one hour for radiological safety. Exceptionally two hours to BS 476 part 22 may be designed based on the calculated fire load.
- Ventilation systems are designed to keep the size and number of penetrations in these fire barriers to a minimum. In accordance with Design Guide ES_0_1738, Section 19 where ductwork passes through a fire compartment zone boundary (fire barrier), then a fire damper is fitted where it penetrates that fire barrier. The damper will have at least the same level of fire resistance as that required by the barrier through which the system passes. If the ductwork passes through a fire zone, but the duct has no opening into it, then as an alternative the ductwork can be fire rated obviating the requirement for a fire damper on one of the fire boundaries. In areas where there are low fire loads steel ductwork has been left unprotected. This typically occurs in older buildings where no fire protection was provided to the ductwork and as part of the COSR review further consideration was given to the unprotected ductwork typically by calculating the fire loading in the area where the unprotected duct passes through.

Example of how ventilation systems are arranged/designed so as not to compromise integrity of fire compartment lines.

As an example, Springfields Fuels Ltd reports that a review of a building identified that in many cases reliance would need to be placed on fire boundaries for compartment-to-compartment escape. As such the boundaries required to resist smoke as well as fire, and any dampers in the ductwork that linked either side of these boundaries and that could spread smoke from one side to the other required to be fire/smoke dampers operated by the detection system.

Springfields Fuels Ltd carried out upgrades to the ventilation system early in the life of the plant. These included the addition of fire dampers fitted at strategic locations to prevent smoke spread from one side of the facility to the other. Springfields Fuels Ltd reports that the ductwork was left unprotected as the principal requirement was for preventing smoke spread. Springfields Fuels Ltd considered that, even unprotected, the steel ductwork was capable of providing at least 30 minutes fire resistance and this was explicitly claimed. However as no specific measures were taken to protect the duct. There were two types of ductwork used in the facility, namely ducts specified in accordance with AESS 6008 Part 1 [196] and AESS 6008 Part 2 [197]. Springfields Fuels Ltd commissioned tests [198] and found that AESS 6008 Part 2 ducts achieved 120 minutes stability and integrity and 3 minutes insulation.

Springfields Fuels Ltd reports that since it undertook the upgrades it has completed a full fire loading study of the building. It also reports that in areas where ductwork is unprotected, and the dampers are not on a fire compartment boundary, it now makes reference to the calculated fire loading in the area and provides a justification where appropriate for leaving the ductwork unprotected based on the test information.

Access for Firefighting

Springfields Fuels Ltd reports the following:

- In all buildings there are typically protected stairs for fire service access to upper floor levels. In some cases, these are provided with lobbies, in other cases lobbies are not provided where there are large open areas with high ceilings.
- Any ventilation in stairs is typically for radiological containment and is not designed for firefighting purposes.
- Many stairs are not ventilated, and the design of the ventilation system does not address the availability of access routes for firefighting.

Preventing fire spread between redundant trains

Springfields Fuels Ltd reports that there are no specific trains of safety systems with redundancy so there are no nuclear fire safety barriers designated for separating trains of safety systems, although specific measures such as separation by distance may be taken to ensure multichannel protection systems are not vulnerable to a common fire. In the event of fire typically the main ventilation fans shutdown. Access into radiological areas is then restricted and re-entry cannot occur until a period typically 20 minutes has elapsed after ventilation is restored.

Springfields Fuels Ltd provided the example of the arrangements in OFC as follows:

- The layout of the building, plant and equipment within OFC has been designed around the concept of islands of activity located within an overall clean area to localise and isolate contamination.
- OFC has five distinct types of areas: Amenities Area, Operator Area, Secondary Area, Secondary Containment Area, Primary Containment Area.
- Some of the Secondary Containment Areas can form expanded Primary Areas when the primary containment is removed for maintenance/enrichment changes. The operator areas are designed to operate at a slight positive pressure while the secondary containment areas are operated at a slight negative pressure. The primary containment area was designed to operate at a slight negative pressure with respect to the secondary containment areas.
- The ventilation system provides protection for the plant operators against breathing contaminated air in general operating areas by a system of containments kept at negative pressures relative to the surrounding areas.
- Ventilation fans in OFC remain running and there is no automatic shutdown on closure of fire dampers. Shutdown of the fans occurs if the flow rate is reduced so that damage to the fans is prevented.
- The Central Control Room has a 'stay put' policy. The stay put policy for the control room is based on the Central Control Room operators staying in place for a maximum of

30 minutes in the event of fire elsewhere in the building. Evacuation is required if a fire is detected in Amenities or in the areas of Mechanical 1 that are below the control room. A dedicated air conditioning system serves the control room to provide a clean controlled working environment. The air handling units are configured to shut down on detection of smoke. Three of the dampers serving the computer room are fusible link and one is actuated. To provide assurance that smoke cannot enter these areas from elsewhere a recommendation was made to change the fusible link operated dampers to ES rated dampers.

- The Central Control Room is located within the Amenities part of the building. The ventilation systems within the Amenities part of the building are not connected in any way to the main ventilation systems of the Manufacturing Areas. As such there could be no possibility of radiological contamination of the control room in the event of fire even if all ventilation systems shutdown.
- With respect to corrosive/toxic materials the principal hazard within OFC is hydrogen fluoride (HF) in the off-gas system. A dedicated extraction system is provided for the off-gas areas. This system is of polypropylene construction and the air discharged to atmosphere via louvers at the 130m level.

A further example of the ventilation system in EURRP is provided within the Springfields Fuels Ltd self-assessment report for TPR 2 [9].

C-II-3.3.2.2 Performance and management requirements under fire conditions

Fire Resistance

Historically the ventilation and containment systems on the Springfields site were designed and constructed in accordance with Code of Practice AECF 1054 [199] (superseded by NVF/DG001 which was then superseded by ES_1738_1 Ventilation Systems for Radiological Facilities - Design Guide.) AECF 1054 [200] covered the ventilation/containment of radioactive areas and incorporated the following principal functions:

- Removal of radioactive airborne contamination.
- Removal of chemotoxic fume and dust.
- Maintaining progressive depressions in secondary areas and primary containment areas.
- Maintaining personnel comfort and provide a satisfactory working environment meeting statutory requirements.
- Removal of heat generated from machinery and equipment.
- Removal of the products of combustion from machinery and equipment.
- Minimising the discharge of radioactive materials to the environment.

Ductwork was historically designed and constructed in accordance with AESS 6008. Parts 1 and 2. Ductwork was typically left unprotected, and dampers were rated to BS476 Part 22 [201]. All new ductwork systems installed on site are designed and constructed in accordance with ES_0_1738_1_Issue 1 [200]. All new dampers are ES rated dampers to BS EN 1366-2:2015 [194].

At the time of construction, the fire dampers/fire shutters were mostly of the thermal link/frangible bulb type. These relied on the heat from a fire to activate the damper/shutter.

As a result of post construction improvements to fire compartmentation additional fire dampers/fire shutters were installed. All these additional devices were configured to be actuated from the fire detection system. Some of these result in the fire alarm going to evacuate on closure, some are configured to provide a Level 5 'Damper closed' message only.

In 2011 there were approximately 71 fire dampers in the facility with 24 fire dampers being thermal link/frangible bulb type. Since 2011 some additional dampers have been added as part of the construction of new areas in Conversion. These additional dampers are ES rated dampers to BS EN 1366-2:2015.

The minimum fire resistance rating of fire dampers is determined based on the rating of the fire compartmentation through which the ventilation system passes. This is confirmed as part of the periodic COSR reviews by undertaking fire loading studies and confirmed that the fire resistance period exceeds the calculated fire load equivalent. New design is to ES1738.

Provision for Isolation

Dynamic confinement as defined in ISO 26802: 2010 [202] is an action allowing, by maintaining a preferential air flow circulation, the limitation of back-flow between two areas or between the inside and outside of an enclosure, to prevent radioactive substances being released from a given physical volume. At the interface with the environment (i.e., external dynamic confinement), the ventilation system maintains a negative pressure within controlled areas with a high potential radioactive contamination, to avoid uncontrolled releases.

In accordance with Requirement 35 of the IAEA guide for the safety of fuel cycle facilities [19] dynamic containment systems are used to create airflow towards areas with higher levels of contamination for treatment before discharge. The static containment system consists of physical barriers between radioactive material and the personnel or the environment typically steel and glazed partitions to separate Operator areas from Secondary areas. Primary areas are typically kilns, autoclaves, hoppers, pipework etc. Secondary areas may become expanded primary areas when opening equipment during outages. The radiological designation of each area is shown in

Table 5:

Table 5: Springfields Fuels Ltd's radiological area designations

Area	Designation
Amenities	Unrestricted
Operator area	Controlled Area (Radiation)
Secondary	Controlled Area (Radiation and Contamination)
Secondary Containment	Secondary Containment
Controlled Area (Radiation and Contamination)	Controlled Area (Radiation and Contamination)

Springfields Fuels Ltd states the following considerations applied to its radiological area designations:

- The amenities area is an unrestricted area because no radioactive material is present.
- Operator areas are designated as areas within the manufacturing parts of the building but outside the primary/secondary containment and areas which are clean areas because of the higher differential pressure and all uranic material is inside a sealed enclosure (i.e., pin or drum).
- The secondary area is designated as substantially clean since it is the normal access into secondary containment.
- Secondary containment areas are cubicles and rooms which house primary containments and are substantially clean by reason of good primary containment, cleaning where necessary and confirmation by monitoring.
- Primary containments are designated as either plant items or areas in which surface and airborne contamination levels may exceed the maximum design level. Access into these areas is restricted to authorised personnel wearing protective clothing.
- Where appropriate primary containments are provided with glove ports and posting ports for operator intervention and removal of materials from the containments. On occasions when the primary containment is breached for maintenance, the associated secondary containment is re-classified temporarily as an expanded primary containment with access via a vestibule. On completion of the operations the areas are cleaned and monitored. On achieving satisfactory results, the areas are re-classified to a secondary containment.

In the event of fire ventilation fans in OFC remain running and there is no automatic shutdown on closure of fire dampers. Shutdown of the fans occurs if the flow rate is reduced so that damage to the fans is prevented. The shutdown for the Amenities block fans can be undertaken manually from a panel in the front entrance.

The only interface with the fire detection and alarm system is the air handling units in the computer/control room that shutdown on detection fire. Specific controls available on the fireman's control panel related to ventilation are described in [9].

C-II-3.3.3 Licensee's experience of the implementation of the passive fire protection

C-II-3.3.3.1 Overview of strengths and weaknesses

Examples of enhancements and programmes or review relevant to passive and fire protection measures are described in Section C-II-3.3.3.2.

C-II-3.3.3.2 Lessons learned from events, reviews fire safety related missions, etc.

Examples of passive protection review and improvement projects include:

- Full fire damper survey of OFC considering and justifying which fusible link operated dampers could be retained, which dampers could be safely declared redundant and permanently left in an open position and which required to be operated by smoke detection and alarm systems.
- A full ratification of the fire compartment scheme for OFC and production of amended fire compartment drawings.
- Replacement of all dampers and a full upgrade of the fire detection and alarm system in the laboratory building.

C-II-3.3.3.3 Overview of actions and implementation status

No specific open actions relevant to passive fire protection have been identified by the licensee.

C-II-3.3.4 Regulator's assessment of the passive fire protection

C-II-3.3.4.1 Overview of strengths and weaknesses in the passive fire protection

Strengths

Passive Fire Protection Upgrades

Springfields Fuels Ltd has identified several examples where proactive upgrades and studies have been made to passive fire protection measures. These include reviews of fire compartment data, enhancement of fire compartmentation where identified, upgrades to glazing to meet the resistance standard of the barrier within which it is housed and implementation of fire resisting shutters. The prioritisation of passive safety measures is aligned with SAP EKP.5 [15] which outlines a preferred hierarchy of safety measures with passive measures being at the top of that hierarchy. This approach also meets the expectations of IAEA guidance SSG-77 [18] which identifies passive measures as a key aspect of defence in depth, particularly against fire hazards.

Weaknesses

No specific weaknesses have been identified with respect to passive fire protection. Springfields have provided a significant number of examples of how passive fire protection is considered within their nuclear safety case and how proactive works continue to ensure the safety function of these measures.

C-II-3.3.4.2 Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

ONR's arrangements for regulating the Springfields site are described in Section II-2.3.7.2.

ONR has undertaken fire safety focussed inspections or assessments at the Springfields site in line with risk focussed inspection planning. Several life fire safety inspections have been undertaken (2021, 2019, 2017, 2016) which consider as part of their scope the methodology for deriving fire compartmentation requirements and the material condition of passive fire barriers. ONR did not raise any regulatory issues related to passive safety measures.

D Dedicated spent fuel storage facilities

Spent fuel storage facilities associated with reactor sites are reported under Section A - Nuclear power plants. Spent fuel management facilities at Sellafield are reported under Section E - Waste storage facilities.

E Waste storage facilities

E-I Sellafield facilities

The text in this section (bar the regulator's assessment subsections) of the report has been prepared by Sellafield Ltd, with only minor changes for clarity and conciseness. For avoidance of duplication, all Sellafield Ltd. facilities, including waste processing facilities are reported in this section.

E-I-3.3.1 Prevention of fire spreading (barriers)

E-I-3.3.1.1 Design Approach

Sellafield Ltd. reports that its fire containment approach uses effective compartmentation to achieve the following:

- Segregation of nuclear inventory from the effects of fire; and
- Segregation of multiple protection channels.

Fire compartmentation is the physical separation of areas through the use of fire rated barriers (i.e. walls, doorsets, fire dampers etc.) which are capable of withstanding the complete combustion of the contents without allowing the fire (or its products) to spread outside the compartment. Sellafield Ltd. states that it undertakes an appropriate level of analysis when applying this approach to confirm the required level of fire resistance to be provided by the fire barriers and their location. Sellafield Ltd. evaluates this as part of the Nuclear Fire Collaborative Review Meeting and Nuclear Fire Hazard Analysis as required

by the Safety Case. Sellafield Ltd.'s process is detailed in Safety Case Process and Methods Technical Guidance [100]. The process identifies the SSCs and nuclear inventory that requires fire barriers. There are a variety of fire engineering calculations that are used within the Nuclear Fire Hazard Analysis to confirm the required level of fire resistance and to substantiate those barriers.

Sellafield Ltd. reports the following main considerations:

- Sellafield Ltd.'s Conventional Fire Hazard Analysis/Fire Safety Strategy ensures the plant design is in accordance with Building Regulations ADB for life safety and ADB plus Insurers requirements for property protection. This legislation requires fire compartmentation commensurate with the fire risk. This helps determine the fire compartment requirements as a minimum.
- The fire load assessments and Nuclear Fire Collaborative Review identifies where barriers should be provided, and these assessments are maintained throughout the lifecycle of the plant to ensure the barriers are suitable and sufficient for the fire load and fire risk.
- The approach ensures that all fire compartments and fire barriers are provided to limit the spread and propagation of fire and smoke. Fire compartments are provided fundamentally to isolate areas of medium and high fire loads such as providing fire resisting barriers commensurate with the fire load for example, electrical rooms and vehicle import/export bays and to provide passive fire protection for SSCs important for nuclear safety.
- The fire compartments and barriers are identified in the fire analyses and detailed on the fire compartmentation and fire incident drawings for the nuclear facilities. The nuclear fire barriers are identified within the engineering schedule of the safety case. This details the Safety Function Class (SFC) and level of importance, performance and maintenance requirements that must be implemented for nuclear safety.
- These are regularly reviewed and substantiated by engineering undertaking calculations and testing as appropriate as part of the Safety Case Processes and Methods. Any shortfalls are documented and rectified. In addition, the Building Manager and dutyholder usually the Safety Case Manager is responsible for ensuring the fire stopping is maintained in accordance with the fire requirements identified on the drawings and within the Safety Case Analyses.
- It is mandatory on Sellafield Site to use third party accredited fire stopping products, designers, installers and maintainers to ensure that the fire barriers are built and maintained as required by the fire analyses.
- Visual nonintrusive fire inspections carried out by the onsite fire protection advisors also review the condition of the barriers in line with the frequency of the fire risk assessment that is required to comply with the Regulatory Reform Fire Safety Order.

BEPPS-DIF is a recent example where the quantified fire load assessment identified the fire compartments and fire barriers for life safety and property protection. Sellafield Ltd.

provides this to limit and contain the fire/smoke propagation and spread. This provides defence in depth mitigation for fire containment approach. Sellafield Ltd. reports that the NFSA did not identify the need for nuclear fire barriers and provided fire engineering calculations as described earlier to demonstrate that the worst-case fire scenario would not affect nuclear safety.

E-I-3.3.1.2 Description of fire compartments and/or cells design and key features

Sellafield Ltd. assesses penetrations to fire barriers on a case-by-case basis. It reports that, where applicable, fire stopping is applied to ensure the fire barrier remains in place. Third party certification of fire stopping is a method Sellafield Ltd. utilises to ensure reliability of fire barriers. Civil asset inspections identify any breaches to fire compartmentation and fire barriers, and this is actioned accordingly. Building Manager inspections and Fire Risk Assessment reviews further inspect these areas and identify any shortfalls and associated remedial action

Firefighting access routes are required to be fire sterile and within fire resisting structures as required by mandatory legislation. At Sellafield Ltd, this requirement is managed by the dutyholder specifically the Building Manager and Safety Case Manager to ensure implementation of these requirements as specified in the fire analyses.

E-I-3.3.1.3 Performance assurance through lifetime

Sellafield Ltd. considers that any changes to plant that are likely to impact fire barriers are identified through the Plant Modification Process which requires a fire safety endorsement from a Fire Protection Advisor. It reports that any breaches to fire stopping, defective fire doors or other fire barriers can be highlighted by any occupant of the building, to the building manager who will action this to be repaired. It also reports that assurance is also carried out during the Fire Risk Assessment review.

E-I-3.3.2 Ventilation systems

E-I-3.3.2.1 Ventilation system design: segregation and isolation provisions (as applicable)

In building ventilation systems, fire dampers are installed in ductwork where fire compartment boundaries are crossed. The fire dampers comply with BS EN 15650 and bear the UKCA marking. It stands for 'UK Conformity Assessed' and means that products that hold this mark have met health and safety standards in Great Britain. The fire dampers meet the Integrity criteria (classification (E)) specified in BS EN 1366 Part 2 [194] for a period of 2 hours; and all fire dampers are classified as E 120 as a minimum in accordance with BS EN 13501 Part 3 [203].

In ventilation systems which extract potentially radiologically contaminated air or gases from within radiologically classified containments, such as vessels, cells and glove boxes, the extract ductwork will not incorporate fire dampers where fire boundaries are crossed. Reasons for this include the risk that spurious closure could lead to a loss of radiological containment and potentially result in a radiological release within a facility. Such a release could result in a plant operator receiving a radiological dose and could potentially challenge the external containment of the building if the ventilation system flows were not restored

expediently. It is also not recognised good practice to install maintainable plant items, such as fire dampers, in potentially contaminated extract air streams. In lieu of fire dampers on these systems, the high integrity, very low leakage ductwork which is held at a negative pressure, can be enhanced where required to provide a fire resistance of 120 minutes stability and integrity, measured external to the furnace, if subjected to an internal fire exposure test (duct B) in accordance with BS 476 Part 24 [204].

Access corridors in radiologically controlled facilities are segregated as separate fire compartments from adjoining rooms; and any building ventilation ductwork crossing these fire compartment boundaries are fitted with fire dampers which meet the maximum smoke leakage limits given in BS EN 13501 Part 3 for Integrity E [203].

On most modern facilities the building ventilation systems are shut down and all fire dampers closed in the event of a fire being detected in any area of the building. As mentioned earlier, these systems can be activated when the fire alarm sounds to prevent the spread of fire.

Examination, inspection, maintenance & testing of fire dampers

Fire dampers are used to prevent fire and reduce smoke and toxic products spreading from one fire compartment to another through the air ductwork systems, which may penetrate fire compartments. Fire dampers normally form part of the building ventilation system and can be linked to the building fire alarm system, which causes the dampers to close automatically. Fire dampers may also be independent dampers operated by the activation of fusible links contained within the fire damper and ventilation ducting. The Building Manager shall ensure that a Fire Damper Asset register is maintained for all buildings where such devices are installed. Building Managers shall ensure all fire dampers are maintained in accordance with the British Standard requirements BS EN 15650. Records of maintenance shall be recorded in the CMMS.

Any fire dampers installed for life or property protection reasons are maintained in accordance with Sellafield Ltd. EMI&T procedures. There is no requirement for these to be designated as SRE as they are not claimed within the nuclear fire assessment.

Waste Vitrification Plants and SPRS fire assessments state that the fire dampers in nuclear fire compartment boundaries are designated as Safety Related Equipment. There are no nuclear fire dampers in Encapsulation Plants, BEPPS-DIF or Pile 1.

E-I-3.3.2.2 Performance and management requirements under fire conditions

Fire compartments are isolated using fire dampers as described above. Fire rated ductwork is sometimes installed on building ventilation systems to BS 476 Part 24 [204] and/or BS EN-1366 Part 1 [205] to minimise the installation of fire dampers where a duct passes through several fire compartments without duct openings (grilles) within those fire compartments.

Fire rated ductwork is provided certified to provide fire resistance of 120 minutes stability and integrity to BS 476 Part 20-22 [112] [113] [201] and associated BS ENs.

To comply with BS EN 15650, fire dampers are fitted with a thermal release mechanism and will close automatically on activation of this thermal release. In addition, the fire dampers are closed automatically on receipt of a signal initiated from a smoke detector.

A building specific hazard assessment may determine that a ventilation system serving a radiological confinement zone needs to continue to operate in the case of a fire. In these circumstances the integrity of the ductwork on that system will be assessed and fire rated ductwork installed in areas where applicable.

The NFSA identifies the safety designation's function, class and fire performance and maintenance requirements associated with fire and smoke dampers. This information is detailed in the Safety Case Engineering Schedule. As a minimum life safety requires fire/smoke dampers to be tested annually to comply with recommendations from the Regulatory Reform (Fire Safety) Order [20] and British Standard 9999 [71].

E-I-3.3.3 Licensee's experience of the implementation of the passive fire protection

E-I-3.3.3.1 Overview of strengths and weaknesses

Sellafield Ltd. has identified strengths in the implementation of passive fire protection in the preceding sections including:

- Provision of passive fire protection for SSCs important for nuclear safety.
- Mandating of mandatory the use of third-party accredited fire stopping products, designers, installers and maintainers to ensure that the fire barriers are built and maintained as required by the fire analyses.
- A Fire Damper Asset register is maintained for all buildings where such devices are installed.

Sellafield Ltd. has identified weaknesses relating to fire damper maintenance at the Encapsulation Plant facilities. A management investigation highlighted the lack of dedicated fire systems engineering resource in the facility as a contributing factor. Sellafield Ltd. fire engineering team are currently engaged to undertake a review and rationalisation of the fire compartmentation and fire damper system. Fire Protection/Engineering capability are providing support and advice to plant management/stakeholders to ensure regular safe maintenance in accordance with the legislation and standards as a matter of urgency. Work is ongoing as part of a wider engineering review, to account for capability issues and how the business chooses to prioritise this going forward to ensure a sustainable capability is available to carry out routine maintenance.

E-I-3.3.3.2 Lessons learned from events, reviews, fire safety related missions, etc.

Recent life fire safety and system-based inspections by ONR have identified issues in facilities on Sellafield Site including challenges in maintaining fire dampers. Whilst these systems are not claimed in the nuclear fire safety case, they provide life and property protection which if compromised, could impact on defence in depth within the facility.

E-I-3.3.3.3 Overview of actions and implementation status

Sellafield Ltd. has committed to undertaking a high-level review within Fire Protection and Engineering, as well as developing an improvement programme to address some of the root causes of the issues described in section E-I.3.3.2 above. Sellafield Ltd. has committed to improving visibility of Fire Protection metrics at both tactical and strategic levels. The tactical levels will improve the facilities' awareness of the status of any maintenance, obsolescence and operability of systems and the strategic level will ensure appropriate oversight is in place, to mitigate and address any concerns that could implicate Fire Safety.

E-I-3.3.4 Regulator's assessment of the passive fire protection

E-I-3.3.4.1 Overview of strengths and weaknesses in the passive fire protection

The approach described in section C-II-3.3.1 details how Sellafield Ltd. applies fire containment via the physical separation of areas using fire rated barriers. This meets ONR expectations as set out in the internal hazards TAG [16] and IAEA SSG-64 [17] in addition to SRL SV 6.5. Sellafield Ltd. has set out how fire barrier designation is driven by fire hazard analysis and nuclear fire collaborative reviews. This meets ONR's expectation that fire barriers should be designed to provide the fire resistance as required by the fire analysis.

ONR expects fire dampers to be provided in ventilation ducts that penetrate fire barriers to prevent the transmission of fire and smoke. Consideration should be given to the means of initiation and the potential for the transmission of smoke and the acceptability of this should it occur. The ventilation system integrity should be maintained despite possible filter fires or any other fire or explosion hazards. These expectations are described in the ONR internal hazards TAG. Sellafield Ltd. has set out its approach for ventilation systems and fire dampers, detailing how fire damper design meets RGP and how ductwork is protected from fire as required. ONR judges the licensee's provision in this area to be adequate.

E-I-3.3.4.2 Lessons learned from inspection and assessment on the active fire protection as part of its regulatory oversight

ONR inspected nuclear fire at SPRS under LC23 in July 2021. The intervention identified that nuclear fire safety assessments and compliance checklists had been adequately completed and that fire safety systems and assets such as nuclear fire barriers and dampers had appropriate examination, inspection, and testing. The inspection was rated as "*Green*" (no formal action).

Life fire inspections at BEPPS-DIF in 2022 and 2023 found that a significant element of the life fire strategy for this facility relies on the fire compartmentation. ONR witnessed a high standard of control of the penetrations within compartment walls. All penetrations were individually registered and assigned a unique reference code so that they can be identified and inspected for any signs of degradation over their lifetime. The same approach has been applied to the fire dampers separating different fire zones. ONR judge this to represent good practice.

An investigation into fire damper issues reported at the Encapsulation Plants in 2022 identified that a significant number of fire dampers had not been maintained in accordance with relevant good practice (such as BS 9999 [71]) and were found to be non-functional upon testing. ONR raised a level 4 regulatory issue related to this topic and have placed several actions on the licensee. This is expected to be closed out in late 2023. The dampers identified as failed in the initial incident do not have nuclear classification, however the full condition of dampers across the facility was unclear. Sellafield Ltd. is progressing actions to access and test all dampers in addition to confirming the purpose of all dampers in the facility (life safety/nuclear safety/property protection). ONR is tracking this activity via the regulatory issue.

ONR has also found issues with dampers not being designed for ease of maintenance in other facilities at Sellafield, with accessibility issues in new build facilities as well as legacy buildings. Level 4 regulatory issues have been raised on this topic as a result and are currently being monitored by ONR.

ONR is content that Sellafield Ltd. recognises the above as an ongoing issue and that work is ongoing to ensure fire safety systems are maintainable when designed and installed. Sellafield Ltd. has committed to place increased oversight on this process going forward and ONR is monitoring progress through the regulatory issues raised.

F Facilities under decommissioning

The text in the Sections below has been prepared by Dounreay Site Restoration Ltd. Background information on the site and the range of installations considered in the scope of the assessment is provided in Sections 1.1.2 and 1.1.3.

F-I Dounreay

F-I-3.3.1 Prevention of fire spreading (barriers)

F-I-3.3.1.1 Design approach

PFR facilities are more than 50 years old and were designed to meet the design requirements of the day. The buildings are largely open plan and there are limited fire boundaries. With the exception of the fire detection and alarm system, no claims pertaining to fire barriers are made within the safety case, which required substantiation.

F-I-3.3.1.2 Description of fire compartments and/or cells design and key features

Due to the open plan nature of the main processing areas of the PFR complex, there are only a small number of fire barriers located in the building though these were not installed as fire barriers.

- A 60-minute fire barrier separates the Reactor Hall and Decontamination Hall from the adjacent SGB and Surveillance Centre/Admin Building.
- A number of 30-minute fire barriers are located in the Caesium Removal Plant (CRP) and the SDP.
- A 60-minute fire barrier separates the Turbine Hall from the Diesel Generator building.
- A number of stairways are also protected in various areas of the building.

The IFC is essentially a concrete vault of thickness greater than 1m. Dounreay considers such construction to be very robust to the effects of fire.

Access routes are maintained by utilising delineated markings. These markings lead personnel to exits, from which they can progress through compartmentation to another building.

F-I-3.3.1.3 Performance assurance through lifetime

Modifications to the facility or to its operational activities are subject to the Dounreay Modification Report (DMR) process. Implications for fire safety are considered as part of this process. Dounreay reports that any change requiring a Fire Risk Assessment under the Fire (Scotland) Act 2005 and any changes to emergency plant, equipment, systems or services defined within the Dounreay Emergency Plan, Emergency Manual and local Emergency Manuals at PFR are automatically assessed as a modification.

The Dounreay due process outlines the measures that should be taken when progressing such a modification, i.e. requirement to consult with Fire Safety Advisor with regards to matters relating to Fire Safety and implement accordingly the fire risk assessment requirements; measures to reduce the risk of fire and the spread of fire; measures in relation to the means of escape; the means of detecting fires and giving warning in the event of fire; firefighting measures; testing and maintenance of all fire protection and control equipment; seeking advice from the Fire Safety Advisor or engineers (when used) on planning, construction or alteration of buildings under their control.

In addition, Planned Maintenance Instructions and Building Inspection report forms include the requirement to identify and record performance assurance.

F-I-3.3.2 Ventilation systems

The ventilation systems at PFR have largely been in operation for almost 50 years and were installed to meet the standards at that time.

F-I-3.3.2.1 Ventilation system design: segregation and isolation provisions (as applicable)

As previously discussed, the buildings are mostly open plan in nature. No claims are made against the ventilation systems in regard to segregation and isolation provisions.

F-I-3.3.2.2 Performance and management requirements under fire conditions

No fire resistance ratings are claimed, and none have been substantiated against fire performance requirements, e.g., dampers or filters.

F-I-3.3.3 Licensee's experience of the implementation of the passive fire protection

No specific passive fire protection features are claimed within the PFR nuclear safety case or have been implemented since the start of operations.

F-I-3.3.3.1 Overview of strengths and weaknesses

No specific passive fire protection features are claimed within the PFR nuclear safety case or have been implemented since the start of operations.

F-I-3.3.3.2 Lessons learned from events, reviews fire safety related missions, etc.

No specific passive fire protection missions have been recorded. Lessons learned from fire events which have occurred at the PFR facility are recorded in Section I-2.6.6.2.

F-I-3.3.3.3 Overview of actions and implementation status

No specific actions related to passive fire protection have been identified by the licensee.

F-I-3.3.4 Regulator's assessment of the passive fire protection

F-I-3.3.4.1 Overview of strengths and weaknesses in the passive fire protection

Strengths

Dounreay does not place any specific claims on passive fire protection features for nuclear safety and the extent of passive fire protection is limited across PFR. Therefore no specific strengths have been identified in this section of PFR.

Weaknesses

Dounreay has identified that the PFR facility does not place any nuclear safety claims on passive fire protection features. This is largely due to the age of the facility with compartment and ventilation design being based on the standards of the time. This does not meet the expectations of the ONR Technical Assessment Guide on Internal Hazards which states, with respect to limiting hazard consequences, “an important example is by arranging redundant safety measures in fully segregated fire compartments. This is referred to as the fire containment approach; the preferred approach to fire protection”. Similarly fire barriers and the fire compartment concept are identified as good practice within both the WENRA Safety Reference Levels (SV 6.5, S 2.3), IAEA SSG-77 [18] and IAEA SSG-64 [17].

ONR notes that the PFR facility is in the advanced stages of decommissioning which was initially constructed in the late 1960s. The primary focus of SSG-64 and SSG-77 is operating or new build power reactors. Additionally, concrete structures are present within PFR which, although not explicitly fire rated, would offer significant fire resistance e.g., the boundary of the IFC.

ONR therefore considers the lack of passive fire safety measures to be acceptable subject to robust fire safety management, the control of combustibles and the continuing reduction of nuclear safety risk at the facility.

F-I-3.3.4.2 Lessons learned from inspection and assessment on the passive fire protection as part of its regulatory oversight

As stated above there are limited passive fire safety features contained within PFR. ONR attended site in July 2022 [160] and noted that services appeared to have been passed through a compartment wall within the Sodium Tank Farm (which forms part of PFR) but fire stopping had not been reinstated. Dounreay committed to rectify this shortfall and the fire stopping was observed to have been reinstated during a follow-up inspection in February 2023 [128].

3.4 Licensee experience of the implementation of the fire protection concept

To avoid duplication, licensee experiences of the implementation of the fire protection concept are not repeated in this section. This information can be found for each licensee in turn as follows:

- EDF NGL; sections A-I-3.1.3, A-I-3.2.4 and A-I-3.3.3.
- NNB GenCo; sections A-II-3.1.3, A-II-3.2.3 and A-II-3.3.3
- UUK; sections C-I-3.1.3, C-I-3.2.4 and C-I-3.3.3.

- Springfields Ltd; sections C-II-3.1.3, C-II-3.2.4 and C-I-3.3.3.
- Sellafield Ltd; sections E-I-3.1.3, E-I-3.2.4 and E-I-3.3.3; and
- Dounreay; sections F-I-3.1.3, F-I-3.2.4 and F-I-3.3.3.

3.5 Regulator's assessment of the fire protection concept and conclusions

To avoid duplication, the regulator's assessment of the implementation of the fire protection concept is not repeated in this section. This information can be found for each licensee in turn as follows:

- EDF NGL; sections A-I-3.1.4, A-I-3.2.5 and A-I-3.3.4.
- NNB GenCo; sections A-II-3.1.4, A-II-3.2.4 and A-II-3.3.4
- UUK; sections C-I-3.1.4, C-I-3.2.5 and C-I-3.3.4.
- Springfields Ltd; sections C-II-3.1.4, C-II-3.2.5 and C-II-3.3.4.
- Sellafield Ltd; sections E-I-3.1.4, E-I-3.2.5 and E-I-3.3.4; and
- Dounreay; sections F-I-3.1.4, F-I-3.2.5 and F-I-3.3.4.

4. Overall assessment and general conclusions

The scope of this National Assessment Report is 14 installations from six GB licensees, covering a wide range of nuclear installations. It includes the nuclear power reactors owned by EDF Nuclear Generation Limited (EDF NGL), represented by Heysham 2, Hunterston B, Sizewell B and its dry spent fuel store. It also includes the twin reactors currently under construction at Hinkley Point C, owned by EDF Nuclear New Build Generation Company (NNB GenCo), Dounreay's Prototype Fast Reactor Complex (including the Irradiated Fuel Cave), Urenco UK Ltd.'s Enrichment facilities at Capenhurst works, Springfields Fuels Ltd.'s fuel fabrication, and Sellafield Ltd.'s Magnox reprocessing plant.

A selection of Sellafield Ltd.'s waste treatment and storage installations, namely: the High Level Waste Plant, Waste Vitrification Plant and Encapsulation Plants, Sellafield Product and Residues Store (SPRS), the Box Encapsulation Plant Product Store - Direct Import Facility (BEPPS-DIF) and Pile 1 are also included.

The overall assessment and general conclusions are presented per installation type and licensee in turn below. Findings and recommendations from this review for future follow up are numbered and highlighted in boxes for traceability.

Nuclear power reactors owned by EDF NGL: Heysham 2, Hunterston B, and Sizewell B (including its dry spent fuel store)

EDF NGL operating reactors were commissioned between 1976 and 1995 and the licensee has long-established processes for fire safety analysis and implementation of the fire protection concept. In the assessment of EDF-NGL's fire safety analysis, ONR concluded that the licensee has developed and applied processes which implement relevant IAEA guidance and made improvements to fire detection and alarms, fire suppression and compartmentation over the life of the plants.

1. ONR's assessment of EDF NGL's fire safety analysis has identified one area in which further review would be beneficial and proportionate, the licensee's consideration of fire hazards in combination with other hazards, to meet expectations in new IAEA guides SSG-77 and SSG-64 that the approach is comprehensive and systematic.

ONR will assess the adequacy of EDF NGL's combined hazards methodologies and assessments in SZB's PSR3 and HY2's Justification for Continued Operations (JCO) relating to a turbine disintegration event due in 2024.

The nature of the recommendation and licensees ongoing assessment does not indicate that there is a generic issue with EDF NGL's fire safety analysis or the consideration of hazard combinations. The identification of further hazard combinations through the licensee's PSRs process indicates that its processes are identifying opportunities for improvement across its installations and, therefore, ONR does not consider that a broader

review of the EDF NGL fleet over and above the reviews undertaken in this exercise and the PSRs would be warranted.

ONR's assessment of the licensee's implementation of the fire protection concept concluded that fire prevention, active fire protection and passive fire protection provisions have been implemented adequately and upgraded over the life of the plant to meet IAEA guidance expectations, subject to reasonable practicability. No issues of concern for nuclear safety were found, and life fire safety inspections indicate transferable learning on matters of life and asset protection.

NNB GenCo's twin reactors under construction at HPC

For NNB GenCo, ONR is content that the licensee has shown that it is developing and implementing nuclear fire hazard analysis in close alignment with national and international standards and guides such as IAEA SSG-64.

2. ONR's assessment of NNB GenCo's fire safety analysis has identified one area in which further review would be beneficial and proportionate; the effects of combined hazards on the selection, design and performance expectations for active fire protective systems, on the capacity for firefighting and on how the firefighting system may contribute to combined hazards.

ONR is following the gap to resolution through regulatory engagement with NNB GenCo, and will be subject to ONR's permissioning assessment prior to release of Hold Point for SSCD#3 – the safety case for bringing fuel to the HPC site.

NNB GenCo's identifies fire load accounting and management as an area of focus for future operational procedures. The licensee's proposed provision of a fire and rescue service on the HPC site is also subject to further development commensurate with the stage of the build. No significant issues have been identified relating to the planned passive fire protection provision of the EPR design.

While Fire Safety inspections of the HPC construction site are not per se representative of the future operation of the site from a nuclear safety perspective, ONR has raised regulatory issues to ensure adequate management of combustibles and ignition sources, emergency lighting, fire points and exit signage. ONR considers the integrated regulation of fire safety for life protection with nuclear safety as a strength of the regulatory regime, reinforcing a culture for fire safety from the early stages of new build.

Urenco UK Limited enrichment facilities

Based on this review, ONR has judged that UUK has a fire safety programme commensurate with its radiological risks from fire, noting that the dominant fire hazard is to building structures. UUK has recognised a need to update its safety case arrangements and guidance for consideration of nuclear fire safety in light of new IAEA guides e.g. SSG-64 in so far they are transferable to fuel cycle facilities, applying a graded approach. Through this review and ONR inspections, UUK also recognised an opportunity to make secondary improvements to document fire safety action follow up, closure and linkage with safety cases. ONR therefore raises a recommendation as follows:

3. UUK reviews and makes any necessary improvements to its safety case arrangements and guidance in relation to the consideration of fire in light of new IAEA guides e.g. SSG-64 in so far they are transferable to fuel cycle facilities, applying a graded approach. Closure date – March 2025.

A combined nuclear fire safety and life fire safety inspection is planned at the Capenhurst site for early 2024 which will examine the linkage between the nuclear fire safety case and implementation of fire safety measures, in line with RGP, including any identified hazard combinations. Any outstanding actions required to address TPR2 findings will be tracked through regulatory issues.

ONR's assessment of the licensee's implementation of the fire protection concept judged that fire prevention and passive fire protection provisions are adequate and fire detection and alarm system obsolescence is being managed adequately following regulatory interventions.

Springfields Fuels Limited fuel fabrication facilities

Springfields' approach to fire safety analysis relies on engineering judgement and hand calculations, while assessing fire loadings quantitatively based on surveys undertaken on a compartment-by-compartment basis. ONR judges that Springfield's approach is commensurate with the facilities' radiological hazards and risks and aligned with ONR expectations in the Internal Hazards TAG, which implement IAEA requirements in SSR-4 and IAEA guide SSG-64.

Springfields described the consideration of fire hazards in combination with flooding and with seismic events, and how consequential fires or hazards consequential to fire are considered in its nuclear fire analysis and LTPRs. ONR welcomes that this consideration implements in part expectations in IAEA guidance SSG-64 applicable to nuclear power plants. ONR's assessment has identified an area where further consideration would be appropriate; formalising a proportionate yet systematic methodology for assessment of combined hazards, including fire. The nature of this identified improvement does not indicate that there is a general issue with the sites' resilience to fire or fire hazards in combination, nevertheless it offers the opportunity to systematically demonstrate resilience. This is a recommendation which applies to several other licensees is documented in point 4.

Springfields Fuels Ltd identified a wide range of fire prevention measures for site-specific risks. It has also undertaken reviews and installation of a new fire detection systems in OFC. Active fire protection and passive fire protection meets ONR expectations as described in ONR Internal Hazards TAG.

Sellafield Ltd.

ONR has judged that Sellafield's fire safety analysis broadly meet ONR expectations in the Internal Hazards TAG, which implements IAEA requirements in SSR-4 and IAEA guide SSG-64. In the area of combined hazards, ONR has found that the licensee could make beneficial and proportionate improvements to its fire safety guidance for assessment of hazard combinations. Sellafield Ltd. is currently updating the NFSHA Safety Case Process and Methods Technical Guidance methodology. The nature of this identified improvement

does not indicate that there is a general issue with the sites' resilience to fire or fire hazards in combination, nevertheless it offers the opportunity to systematically demonstrate resilience. This is a recommendation which applies to several other licensees and is documented in point 5.

Several nuclear fire safety inspections are planned at the Sellafield site for 2024/25 which will give specific opportunities for ONR to assess progress against this item. Any outstanding actions required to address TPR2 findings will be tracked through regulatory issues.

ONR life fire safety and system-based inspections at the site identified fire detection and alarm system obsolescence at First Generation Magnox Storage Pond (FGMSP), a facility not in the list for TPR 2. Sellafield Ltd. committed to a full system replacement and in the interim period successfully completed the rapid deployment of a temporary, wireless system in the facility.

Sellafield Ltd. is also addressing shortfalls in maintenance relating to fire dampers provided for life and property protection at the Encapsulation Plants as identified in 2022. Furthermore, as identified through ONR's life fire safety inspections at the site, ONR judges that obsolescence of fire protection systems is a focus area for Sellafield Ltd. and ONR raised a Level 2 regulatory issue to track Sellafield Ltd.'s implementation of strategic fire safety improvements in this area. This has an expected closure date end of 2023. While these issues did not impact nuclear safety directly, they offer insights into fire system challenges which should be highlighted to ensure that high levels of defence in depth are consistently maintained.

ONR considers the integrated regulation of fire safety for life protection as providing valuable insights to ensure that the licensee implements and maintains high standards of fire safety generally, and not only for nuclear safety.

Dounreay's PFR Complex

ONR has assessed Dounreay's fire safety analysis approach and the implementation of the fire protection concept. These have been supplemented by evidence gathered during onsite inspections. ONR judges that the current arrangements for fire safety analysis and fire protection implementation align with ONR expectations and are commensurate with installations in advanced stages of decommissioning. ONR's assessment has identified two secondary areas where further consideration would be appropriate in the areas of fire prevention and fire safety analysis:

4. Fire Prevention: Dounreay should implement a proportionate approach to link the day-to-day management of fire loading with the assessment of fire loadings in the nuclear safety case, to aid consistency in adherence to combustible inventory controls. Closure date – December 2024

5. For fuel cycle facilities and facilities undergoing decommissioning, the licensees should develop a proportionate yet systematic approach for the consideration of hazard combinations including fire to systematically demonstrate resilience. Closure Date – March 2025

With respect to Recommendation 4 a life fire safety based inspection is planned at the Dounreay site for January 2024. This will include consideration of TPR2 findings and the approach taken to suitably close these out. It is intended that a representative from Magnox's central fire team will also attend to provide clarity on Dounreay's ongoing resource profile for fire safety. Any outstanding actions required to address TPR2 findings will be tracked through regulatory issues.

With respect to fuel cycle facilities captured under Recommendation 5, combined nuclear fire safety and life fire safety inspections are planned at both the Capenhurst and Springfields sites for early 2024 which will examine the linkage between the nuclear fire safety case and implementation of fire safety measures, including any identified hazard combinations. ONR will instigate licensee cooperation in the development and implementation of proportionate yet systematic approaches, and outstanding actions required to address TPR2 findings will be tracked through regulatory issues.

The nature of the above improvements does not indicate that there is a general issue with the sites fire prevention approach or consideration of fire hazards in combination with other hazards, nevertheless, they offer the opportunity for Dounreay to systematically demonstrate resilience.

4.1 Overall conclusions

ONR's assessment has found that the UK installations reporting in this second topical peer review have adequate fire safety analysis and fire protection arrangements commensurate with their radiological risks from fire, the potential for fire to impact nuclear safety systems and the stages that each installation is in its lifecycle. Nevertheless, beneficial improvements have been found in a number of areas, namely, the implementation of methodologies for proportionate but systematic screening and analysis of hazards combinations, including fire, and the enhancement of linkages between the extant management of fire loading for life protection and the nuclear safety arrangements in decommissioning facilities. ONR has consequently raised actions for the licensees to implement improvements, formally tracked to completion through ONR regulatory issues and regulatory interventions.

ONR also concludes that the integrated consideration of fire safety for life protection in the report has enabled the sharing of valuable transferable learning in two additional areas, fire damper maintainability issues and fire detection and alarm system obsolescence. The issues are the subject of formal regulatory follow up through ONR regulatory issues. While they did not impact nuclear safety, they offer insights into fire system challenges which should be highlighted to ensure that high levels of defence in depth are consistently maintained.

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Appendices to the NAR

A Development of the national selection of installations

Table 6: Qualifying installations for the purposes of the NAR.

Nuclear power plant units	Number	Qualifying Installations	Licensee	Type & Status (as of 30 th June 2022)	Sampling rationale (highlighting installations selected for TPR)
units in operation (or undergoing de-fuelling) <i>Each AGR has two units, Sizewell B (PWR) is one unit only</i>	15	Hartlepool Heysham 1 Heysham 2 Hinkley B Torness	EDF Energy Nuclear Generation Ltd	AGRs in operation	Heysham 2 included as a second generation AGR in operation. All EDF NGL stations are under the same management arrangements for nuclear fire safety.
		Hunterston B	EDF Energy Nuclear Generation Ltd	AGR shutdown and defueling by TPR start	Hunterston B included as a first generation AGR, undergoing de-fuelling. All EDF NGL stations are under the same management arrangements for nuclear fire safety.
		Dungeness B	EDF Energy Nuclear Generation Ltd	AGR permanently shutdown (prior to commencement of defueling)	Transferability of insights from Heysham 2 (AGR in operation) and Hunterston B (AGR undergoing de-fuelling) documented in the report, as well as Dungeness B fire-related events.
		Sizewell B (incl. dry fuel store)	EDF Energy Nuclear Generation Ltd	PWR in operation	Sizewell B (incl. dry fuel store) ; included as the only PWR unit in operation in GB and to include dry storage of spent fuel
units in construction	2	Hinkley Point C – EPR PWR	Nuclear New Build Generation Company (NNB GenCo), a subsidiary created by EDF Energy	PWR units in construction	Hinkley Point C (incl. spent fuel storage pond and waste storage and management facilities) as the only NPP under construction in GB. Representative of modern standards of fire safety analysis and design in GB New Reactors.
units in decommissioning	29	4 units at Calder Hall NPP	Sellafield Ltd	Defueled – defueling completed in 2019	Nuclear Fire Safety Arrangements and standards represented by sample of waste storage facilities at the Sellafield Licensed site.
		1 unit - Windscale Advanced Gas Reactor (WAGR)	Sellafield Ltd	Defueled and largely decommissioned (reactor has been decommissioned, only the bioshield, the external clad sphere and some ancillary plant remain)	Nuclear Fire Safety Arrangements and standards represented by sample of waste storage facilities at the Sellafield Licensed site.
		2 Windscale Piles	Sellafield Ltd	Reactors have been defueled with the exception of the fire affected zone of Pile 1 (which suffered a fire in 1957). Plant supporting the reactors has been removed or disconnected. The demolition of the remaining ventilation chimney for Pile 1 has been progressed.	Pile 1 included, as a graphite-moderated, air-cooled nuclear in a state of care and maintenance, sharing a boundary with the Pile chimney, which is undergoing decommissioning (height reduction)
		2 units at Berkeley 2 at Bradwell 4 at Chapelcross 2 at Dungeness A 2 at HNA 2 at Oldbury 2 at Sizewell A 2 at Trawsfynydd 2 at Wylfa	Magnox Ltd.	The Magnox stations are de-fuelled and under the control of the same licensee. Berkeley has completed a number of key activities, including disposing of its 310 tonne boilers and entering both reactors into a safe - store state. Priorities for the site include removing all legacy wastes and emptying the active waste vaults.	Magnox stations are all de-fuelled and do not attract Detailed Emergency Planning Zones, based on the remaining radiological risks quantified in Consequence Reports to meet the requirements of the Radiation (Emergency Preparedness and Public Information) Regulations 2019. Transferable insights from installations selected for TPR.

Decommissioning (former research) reactors	Number	Installations	Licensee (as of 30 th June 2022)	Type & Status (as of 30 th June 2022)	Sampling rationale (highlighting installations selected for TPR)
in operation	0	N/A	N/A	N/A	N/A
in construction	0	N/A	N/A	N/A	N/A
in decommissioning	9	1 Imperial College Research Reactor at Ascot	Imperial College	The nuclear fuel was removed from site in 2014. Decommissioning the reactor commenced in 2015. The reactor has now been demolished and the site cleared of all radioactive waste. Imperial College applied to have the site licence revoked to free the land for re-use.	Not appropriate – reactor demolished and site cleared, site delicensed by ONR in 2022.
		3 at the UK's former centre of fast reactor research and development – Dounreay, the Materials Test Reactor (MTR); Dounreay Fast Breeder Reactor (DFR); and the Prototype Fast Reactor (PFR))	Dounreay Site Restoration Limited (DSRL). NB. Dounreay joined Magnox Limited on April 1 st , 2023	Dounreay Fast Breeder Reactor (DFR). Destruction of the bulk liquid metal coolant from the primary circuit was completed in 2012. Complete delivery of all fuels from DFR to Sellafield expected in 2023. Dounreay Material Test Reactor Structures to be demolished by 2023 (NDA Draft Business Plan 2020 to 2023 (publishing.service.gov.uk))	Prototype Fast Reactor (PFR) complex. Focus on PFR is based on radiological risk from irradiated fuel, distinct fire hazards and technology, and overall site complexity. The PFR complex includes the Irradiated Fuel Cave (waste storage).
		2 at Winfrith	Magnox Ltd.* *Inutec Ltd is the licensee for B4 and A50 plots	Only 2 out of the 9 research reactors at Winfrith (the prototype high gas cooled reactor, DRAGON, and the SGHWR, Steam Generating Heavy Water Reactor) remain on site but are under decommissioning. The interim end state is expected to be reached after demolition of the remaining reactors in 2023.	Decommissioning in advanced stages. Demolition of the remaining reactors (SGHWR and Dragon) expected to complete in 2023 [NDA 2021 strategy Land & Property Management publishing.service.gov.uk]. The site does not attract an offsite emergency planning zone.
		3 at Harwell	Magnox Ltd.	Two of the five reactors have been completely removed: <ul style="list-style-type: none"> Low-energy graphite reactor – fully decommissioned. Graphite core incinerated at an off-site facility; Experimental graphite reactor, materials testing reactors and PIE concrete-shielded cells all in storage; All fuel has been removed from the remaining three which are now in decommissioning. ILW retrieval and packaging operations are underway; nuclear materials are being transferred off-site.	Decommissioning in advanced stages. All fuel has been removed. ILW retrieval and packaging operations are underway; nuclear materials are being transferred off-site. Site does not attract an offsite emergency planning zone.
Spent fuel storage facilities	Number	Installations	Licensee (as of 30 th June 2022)	Type & Status (as of 30 th June 2022)	Sampling rationale (highlighting installations selected for TPR)
<i>in operation</i>	7*	Dry store at Sizewell B	EDF Energy Nuclear Generation Ltd	In operation	Included as part of Sizewell B's
		2 at Dounreay, the Irradiated Fuel Store and Shielded cave	Dounreay Site Restoration Limited (DSRL).	Remaining PFR fuel is currently dry stored in the Irradiated Fuel Cave. The remainder of the irradiated fuel is stored in a shielded cave that was previously used for the examination of irradiated fuel.	Irradiated Fuel Cave included as part of Dounreay's report on the PFR complex
		4 at Sellafield: FGOSP (First Generation Magnox Storage Pond), FHP (Fuel Handling Pond) TRSP (THORP Receipt and Storage Pond) FGASP (First Generation AGR Storage Pond)	Sellafield Ltd.	FGOSP was used between around 1968 and 2004 for the receipt and storage of spent oxide fuel, including fuel to be reprocessed in THORP. The pond is still operational but with limited fuel inventory. FHP has been used since 1984 to store and cool spent Magnox and AGR fuel and to remove the fuel cladding. Spent Magnox fuel which has not been reprocessed is stored in the pond pending a future decision on its disposition. AGR fuel is subsequently transferred to the THORP Receipt and Storage Pond. THORP Receipt and Storage Pond used since 1988 as a short-term buffer store for spent AGR fuel prior to reprocessing in THORP. Since the cessation of reprocessing in THORP in 2018, TRSP is now used as an interim store for spent AGR fuel pending a decision on its disposition. FGASP; this pond has been used since 1982 for the temporary storage of dismantled AGR fuel from FHP before subsequent dispatch to the Thermal Oxide Reprocessing Plant (THORP) Receipt and Storage (TR&S) for processing through THORP. The pond is still operational and is a key operational part of the AGR flask moves.	Spent Fuel Ponds in AGR stations included in UK sample. Nuclear Fire Safety Arrangements and standards in these Sellafield facilities represented by the sample of waste storage facilities at the Sellafield Licensed site (operated under the same licensee arrangements)
<i>in construction</i>	0	N/A	N/A	N/A	N/A

<i>in decommissioning</i>	3	Dounreay DFR's Irradiated fuel in the vessel	Dounreay Site Restoration Limited (DSRL).	Breeder fuel elements are currently located in the DFR vessel and are being retrieved for reprocessing at Sellafield.	Nuclear Fire Safety Arrangements and standards represented by Dounreay's sample e.g. the Irradiated Fuel Cave in the PFR complex
		2 at Sellafield: PFSP (Pile Fuel Storage Pond) FGMSP (First Generation Magnox Storage Pond)	Sellafield Ltd.	Nuclear fuel has been removed from PFSP and is now stored in modern engineered storage facilities. Pond sludge is being retrieved and encapsulated in the Waste Encapsulation Plant FGMSP - transfer of sludge-to-sludge buffer tanks continues (2021 JCR). Since fuel exports began in 2016 nearly a quarter of the fuel has been removed.	Nuclear Fire Safety Arrangements and standards in High Hazard and Risk Reduction (HHRR) Facilities represented by sample of HHRR waste storage facilities at the Sellafield Licensed site.
*Each AGR site has one fuel storage pond (these are not included in the numbers for this section. Sizewell' dry store is included in this list. Three facilities at Dounreay (DFR vessel, Irradiated Fuel Cave and shielded cave). As per joint convention report, DFR held fuel is being retrieved. Sellafield: PFSP (bulk fuel removed), FGMSP (fuel being removed) + FGOSP in ops, FHP (in ops), TRSP, FGASP					
Fuel cycle facilities	Number	Installations	Licensee	Type & Status (as of 30 th June 2022)	Sampling rationale (highlighting installations selected for TPR)
Enrichment plant					
<i>in operation</i>	1	Capenhurst works	Urenco UK Ltd	Site contains three enrichment plants. It also contains cylinder storage raft, cylinder storage, residues stores and Tails Management Facility.	Capenhurst works included as the UK's only enrichment facility and in line with the expectation to provide a reasonable cover of the fuel cycle in the sample/ all facility types covered by the Nuclear Safety Directive.
<i>in construction</i>	0	N/A	N/A	N/A	N/A
<i>in decommissioning</i>	0	N/A	N/A	N/A	N/A
Nuclear fuel fabrication plants					
<i>in operation</i>	1	Springfields	Springfield Fuels Limited (SFL)	In operation, manufacture of oxide fuels for Advanced Gas-cooled and Light Water Reactors, intermediate fuel products, such as powders, granules and pellets, uranium recovery services and decommissioning and demolition of redundant plants and buildings.	Springfields Fuels Limited (SFL) included as the UK's only operational fuel fabrication facility and in line with the expectation to provide a reasonable cover of the fuel cycle in the sample/ all facility types covered by the Nuclear Safety Directive.
<i>in construction</i>	0	N/A	N/A	N/A	N/A
<i>in decommissioning</i>	3*	Sellafield's Fast reactor fuel plant, MOX fuel demonstration plant and the plutonium purification plants	Sellafield Ltd.	Advanced stages of decommissioning – most equipment has been removed. Some buildings have been removed	Not included, facilities and equipment largely removed. Nuclear Fire Safety Arrangements and standards at the licensee represented by sample of Sellafield Ltd. waste storage facilities below.
*MTR fuel fabrication facility at Dounreay already decommissioned and demolished therefore not counted					
Reprocessing plants					
<i>in operation</i>	1	Magnox reprocessing plant	Sellafield Ltd.	Operations expected to complete in 2022 – likely to be in decommissioning by TPR start	Magnox reprocessing plant included as UK's only reprocessing plant in operation by 30 th June 2022, to include all facility types covered by the Nuclear Safety Directive. The facility ceased operations and entered clean-up and decommissioning phases in 2022.
<i>in construction</i>	0	N/A	N/A	N/A	
<i>in decommissioning</i>	4	Reprocessing at Thorp	Sellafield Ltd.	entering post operational clean out (POCO) stage	Nuclear Fire Safety Arrangements and standards and facility type represented by Magnox reprocessing plant at the same licensee site above.
		Dounreay MTR reprocessing, Dounreay Fast Reactor Fuel Reprocessing Plant, Dounreay's Enriched Uranium processing facility	Dounreay Site Restoration Limited (DSRL).	Dounreay MTR reprocessing – partially decommissioned. Dounreay Fast Reactor Fuel Reprocessing Plant – POCO stage Dounreay's Enriched Uranium Processing facility – partially decommissioned	Nuclear Fire Safety Arrangements and standards represented by Dounreay's reporting on the PFR complex including the Irradiated Fuel Cave.

Waste Storage / Management Facilities*	Number	Installations	Licensee	Type & Status (as of 30 th June 2022)	Sampling rationale (highlighting installations selected for TPR)
		The Sellafield site comprises more than 250 nuclear facilities and over 1000 buildings, with a wide diversity in radiological inventories and plant designs. Sellafield's main waste processing and storage facilities are ~22 facilities including: Waste Monitoring and Compaction Plant (WAMAC); Waste Treatment Complex (WTC); Magnox Encapsulation Plant (MEP); Waste Encapsulation Plant (WEP); Waste Processing and Encapsulation Plant (WPEP); Liquid Effluent Treatment Plants; series of facilities for engineered storage for conditioned wastes. Interim PCM drum storage (unconditioned); Magnox Swarf Storage Silo (MSSS), Intermediate Level Waste (ILW) tanks, Miscellaneous Beta Gamma Waste (MBGW) store, High Level Waste Plants and vitrification; Active Handling Facility; Windscale Advanced Gas Cooled Reactor (WAGR) Packaging Plant and Box Store; Floc storage tanks, Magnox sludge settling facility.	Sellafield Ltd	Wide range of facilities and lifecycle stages. TPR focus on High Hazard and Risk and significance of nuclear fire safety considerations in design and operations.	<p>High Level Waste Plant, Waste Vitrification Plant and Encapsulation Plants representative of waste storage facilities and fire safety standards. Significance of fire considerations in design and operations e.g. redundant and diverse safety systems such as power supplies, control systems, and HVAC.</p> <p>Sellafield Product and Residues Store (SPRS) representative of alpha facilities</p> <p>Box Encapsulation Plant Product Store – Direct Import Facility (BEPPS-DIF) High Hazard and Risk Reduction (HHRR) enabler, modern facility under construction and commissioning by the start of TPR.</p>

* Other waste storage/management facilities at GB licensed sites in this table:

- Low-Level Waste Repository (LLWR) incl. trenches, vaults 8 and 9; Grouting Facility; PCM assay facility.
- Waste management facilities at Magnox sites: encapsulation facilities at Berkeley, Chapelcross, Harwell, Hinkley Point A, Hunterston A, Trawsfynydd & Winfrith; vacuum drying plants at Berkeley, Bradwell, Chapelcross, Dungeness A, Hinkley Point A, Oldbury, Sizewell A; interim ILW stores at Berkeley, Bradwell, Chapelcross, Harwell, Hinkley Point A, Hunterston A, Trawsfynydd, Wylfa
- Tradebe Inutec Ltd at Winfrith
- Dounreay's waste management: cementation plant, low level liquid effluent treatment plant, Low Level Waste (LLW) receipt characterisation and super compaction facility
- Dounreay's waste storage facilities: waste wet silo, shaft, 2x Stores for unconditioned solid remote and contact handled ILW drums, store for conditioned ILW 500L drums and raw solid remote handleable intermediate level waste (RHILW) 200L drums; liquid ILW storage facility; solvents and oil storage facility; Dounreay LLW Disposal Facility

B NNB GenCo's Internal Fire Hazard Analysis process using EPRESSI studies and FRA

Internal Fire EPRESSI Studies – Fires Inside buildings

NNB GenCo carries out EPRESSI studies room-by-room for fires inside buildings so are very extensive in their scope. A single bounding fire scenario is defined for each room. The methodology follows the principles of ISO 18195.

The fire risk within a room is categorised as (in order of highest fire risk to lowest):

- PFG – which indicates the 'Possibility of a Generalised Fire'.
- PFL – which indicates the 'Possibility of a Localised Fire'.
- nPFGnPFL for rooms which are 'neither PFG nor PFL', which indicates that a developed fire will not occur.

The fire scenario is also categorised according to fuel type: combustible liquid/cable/solid materials/electromechanical equipment. The fire scenario can then be characterised according to both the fire risk and the fuel type. For example, a room may be 'PFG Liquid' or 'PFL Cable'.

The rules associated with determining the presence of PFG or PFL fire risks according to the amount of fuel type present and its configuration are detailed in the EPRESSI methodology [57] and the Fire Application Document (FAD) [48].

The principle is that the most onerous fire scenario that could occur in each room is studied. A PFG scenario is adopted in preference to a PFL scenario. The hierarchy associated with fuel type is (from highest threat to lowest): combustible liquid/cable/solid materials/electromechanical equipment.

The methodology considers the layout configuration of the fuel in assessing the fire risk. For cable trays this includes the number of cable trays in a stack, their orientation, their length, and the mass of cables present. This leads to the identification of a high fire risk where there are multiple heavily loaded cables trays in a particular location but does not always identify a high fire risk where the fire load is more evenly distributed.

In order to ensure that such fire risks are not missed, if a room is initially designated as nPFGnPFL then an additional criterion is checked which assesses the total fire load within the room in relation to the room surface area (walls/ceiling/floor). In this way, even if the layout configuration does not meet the PFG or PFL criteria, a PFL risk is still identified. Additionally, according to the methodology, if the fire analysis indicates that the hot gas layer temperature reaches 350° C then the room must be designated as PFG (it is assumed that the fire will spread).

The results of the analysis influence the fire zone designation of the room or area.

NNB GenCo's Internal Fire Risk Analysis – Fires Inside Buildings

Both the EPRESSI and Fire Risk Analysis approach classify fire sources which could impact a target as either close fire sources (within the target room) or distant fire sources (outside of the target room). The nPFGnPFL rooms are not assessed within the EPRESSI study whereas they are assessed within the FRA (the nPFGnPFL risk must be treated as a PFL risk).

According to the FRA methodology, NNB GenCO uses several filters for screening purposes to either discount the risk or confirm the risk. Potential fire sources which are in the proximity of a safety target may not be considered as fire initiators (they may be screened out) according to different criteria, note that they are still assessed as combustible materials which could be ignited by another fire source. Fire sources may be discounted if self-ignition is not possible however the potential for ignition through human action or the presence of transient combustibles must be considered. Fire sources may also be discounted on either an energy (minimal amount) or configuration criteria (sealed units with no air supply). This is detailed within Section 5.2.3.3 of the FRA methodology [59]. The screening describes the filters used to discount or confirm the failure of the target for both close and distant fire sources and is summarised in Table 2 of the licensee's submission [49].

Scenario selection is detailed in Section 6.3 of the FRA methodology. For close fire sources, the methodology allows the user to study each fire source individually, to select several fire sources to group together, or to group all fire sources within the room together as a single fire source. For grouping of multiple fire sources, the fire power and fire loading of the individual fire sources are added together. Then the most onerous fire growth rate and fire location must be selected considering the individual fire sources being grouped together.

For distant fire sources, the user can select a penalising fire source based on the firepower, the size and position of openings, room volumes, and the potential for a PFG to occur. The choice of a penalising scenario must be justified.

Internal Fires Inside Buildings – NNB GenCo's Reactor Building Methodology

The reactor building methodology [206] is based on the steps of the Fire Risk Analysis methodology described previously but with the following amendments to take account of the layout features and large internal volumes in the reactor building:

The MAGIC fire zone modelling tool cannot be used for volumes inside the reactor building that exceed the volume sizes for which the software has been validated.

In the standard EPRESSI approach, the performance curve of a fire zoning elements is compared to the temperature curve of the room corresponding to the hot gas layer temperature. In the large volumes, this is no longer relevant, since there is no formation of a hot gas layer. The temperature curve used for comparison against the performance curve is consequently based on localized temperatures (that could be significantly high): this approach is conservative.

The concept of "close" and "distant" fire sources is not fully applicable to HR because of the large high volumes in the building with no hot layer formation and large openings between

the volumes. All fire sources are therefore treated as close fire sources, and a separate assessment category has been developed for large cable fire sources.

NNB GenCo's Internal Fires Outside Buildings

Most of the fire scenarios for HPC originate inside buildings, but some fires could also originate inside the site boundary but outside a building. The internal fire hazard assessment also needs to consider fires spreading between buildings. These are not all explicitly covered by the fire risk assessment methodology, so additional methodologies and assessments are being developed.

A study of fire domino effects has been carried out for CI/Balance of Plant (BoP) buildings [48] which considered thermal/radiative effects and smoke effects of a fire spreading between buildings. The methodology screened buildings based on their combustible inventories and PFG risk, mitigating measures such as fire-resistant external walls, openings through which fire could spread, building separation and boundary distance based on the enclosing rectangle method in BR187 [207] and heat flux. The scenarios studied for smoke propagation were identified based on a high-level review of the site layout and operations with potential fire hazards and their location relative to building Heating, Ventilation and Air Conditioning (HVAC) openings.

Propagation of hot gas or smoke into the HVAC systems of NI buildings was also assessed [50] to determine whether fire could affect SSCs claimed for nuclear safety, and included the following scenarios:

- Diesel tanker impact accidents or fire;
- Ignition of materials temporarily stored outside buildings;
- Fire in turbine hall or diesel generator buildings;
- Accidents during diesel generator refuelling;
- Transformer fire.

A separate work stream has been initiated in 2022 to ensure studies of fire outside buildings are sufficiently robust and cover additional aspects such as fire induced sparks, fire spread in roof materials, and fire spread from car parks.

C EDF NGL's fire protection approach for fire areas containing safety-related plant performing the same safety function

C-I C.1 INTRODUCTION

This appendix provides EDF-NGL's approach for locations where it relies on fire protection systems to protect adjacent redundant safety systems. EDF-NGL considers the majority of such situations involve cabling where is not reasonably practicable to achieve segregation by locating fire barriers or re-cabling and so guidance here is restricted to this case. However, the philosophy of the guidelines is readily applicable to plant other than cabling when assessing fire protection requirements.

C-II C.2 FIRE PROTECTION REQUIREMENTS

EDF-NGL's approach to the fire protection of cables is developed from a report issued by the United States Electric Power Research Institute. EDF-NGL's aim is to specify levels of protection graded according to the perceived consequences of fire, as determined from a fire hazard analysis (see Appendix B). One of three requirements could arise from the fire hazards analyses:

- (a) To detect and extinguish a fire before an electrical fault results.
- (b) To limit damage to a single cable tray.
- (c) To limit damage to a single cable group.

By way of guidance, EDF-NGL's considers that the following fire protection measures would meet these requirements:

C.2.1 For case a):

A fast acting detection system monitoring the identified at risk cables and operating an automatic water sprinkler/deluge/spray system designed to discharge water from directional nozzles directly onto the cables².

C.2.2 For case b):

A fast acting detection system monitoring the identified cable tray and operating an automatic water sprinkler/deluge/spray system designed to discharge water from directional nozzles directly onto the cable tray².

C.2.3 For case c):

² It is EDF NGL practice for all alarms and suppression systems covering nuclear safety related plant to be monitored in the Control Room.

A fast acting detection system monitoring the identified cable group and operating an automatic water sprinkler/deluge/spray system designed to discharge water from directional nozzles directly onto the cable group².

C.2.4 For all cases:

A fast-acting detection system monitoring all remaining cables and operating an automatic water sprinkler/deluge/spray system. A smoke detection system operating an alarm in the Control Room².

D NNB GenCo's fire detection measures – Special risks

Item	Detection
Oil Cooled Transformers	Internal heat detection
Diesel generators	Smoke detection, flame detection
Diesel driven pumps	Smoke detection
Turbine bearings	Linear smoke detection
Cable spreading rooms	Point type detection, with smoke or linear heat detection in reactor annulus to protect cable trays
Server and I&C cabinet rooms	<p>Point type detection to the room, ceiling voids and floor voids in accordance with BS 5839-1 and BS 6266.</p> <p>Depending on the associated risk and criticality of the equipment, aspirating detection to the airflow path upstream of any cooling unit when local cooling units are provided, or throughout the room.</p>
Cable galleries	Smoke detection
Electrical switchrooms	Smoke detection and/or aspirating detection
Combustible and flammable liquid storage	Detection measures will be based on the combustible/flammable liquid stored and fire hazard analysis to determine the appropriate fire detection. Examples of appropriate detection types: Smoke detection, flame detection
Charcoal filters	Thermal sensors
Outside areas with a hydrogen risk	Hydrogen flame detection, IR detection
Internal areas with a hydrogen risk	Point type detection, IR detection, Hydrogen leak detection

E NNB GenCo's list of regulations, codes and standards

The list of regulations, codes and standards is from the most recent issue of the HPC Fire Strategy document [130], which was approved in 2021. NB some of the documents listed below have been updated since the HPC Fire Strategy was published and NNB GenCo will capture relevant updates in the next revision of the HPC Fire Strategy.

Number	Standard
1.	Building and Buildings, England and Wales, The Building Regulations 2010. No. 2214. Statutory Instruments. 2010.
2.	Health and Safety at Work etc. Act 1974.
3.	The Regulatory Reform (Fire Safety) Order 2005. No. 1541. Statutory Instruments. 2005.
4.	The Health and Safety (Safety Signs and Signals) Regulations 1996. Statutory Instruments. 1996.
5.	European Mutual Association for Nuclear Insurance Loss Control Standards. EMANI. 2009.
6.	Approved Document B. Volume 2 – Buildings other than Dwellings HM Government. 2006 incorporating 2013 amendments.
7.	Approved Document M. Access to and use of buildings. HM Government. 2004 edition incorporating 2010 and 2013 amendments.
8.	International Guidelines for the Fire Protection of Nuclear Power Plants. Nuclear Pools Forum. 4th Edition. 2006.
9.	Construction (Design and Management) Regulations 2015. Statutory Instruments. ISBN 978 0 7176 6626 32015.
10.	BS 476-22 1987: Fire tests on building materials and structures — Part 22: Methods for determination of the fire resistance of non-loadbearing elements of construction. British Standards Institute. 1987.
11.	BS 8519: Selection and installation of fire-resistant power and control cable systems for life safety and firefighting applications – Code of practice. British Standards Institute. 2010
12.	BS 9999: 2008 Code of Practice for fire safety in the design, management, and use of buildings. British Standards Institute. 2008.
13.	BS 9999: 2017 Fire safety in the design, management, and use of buildings – Code of practice. British Standard Institute. 2017
14.	BS 5839-1:2013 Fire detection and fire alarm systems for buildings – Part 1: Code of practice for design, installation, commissioning, and maintenance of systems in non-domestic premises. British Standards Institute. 2013
15.	BS 5839-8:2013 Fire detection and fire alarm systems for buildings – Part 8: Code of practice for the design, installation, commissioning, and maintenance of voice alarm systems. British Standards Institute. 2013.
16.	BS 5839-9:2011 Fire Detection and fire alarm systems for buildings – Part 9: Code of Practice for the design, installation, commissioning, and maintenance of emergency voice communication systems. British Standards Institute. 2011
17.	BS EN 10255: Non-alloy steel tubes suitable for welding and threading – Technical delivery conditions. British Standards Institute. 2004.
18.	BS EN 12101-6 Smoke and heat control systems – Part 6: Specification for pressure differential systems – Kits. British Standards Institute. 2005
19.	BS EN 12101-8 Smoke and heat control systems – Part 8 Smoke Control Dampers. British Standards Institute. 2011.
20.	BS EN 12101-10 Smoke and heat control systems – Part 10: Power Supplies. British Standards Institute. 2005.
21.	BS EN 12259-2 Fixed firefighting systems – components for sprinkler and water spray systems – Part 2: Wet alarm valve assemblies. British Standards Institute. 1999.
22.	BS EN 12259-3 Fixed firefighting systems – components for sprinkler and water spray systems – Part 3: Dry alarm valve assemblies. British Standards Institute. 2000.

Number	Standard
23.	BS EN 12845: 2004+A2:2009 Fixed firefighting systems – Automatic sprinkler systems – Design, installation, and maintenance. British Standards Institute. 2004.
24.	BS EN 13565-2 Fixed firefighting systems – Foam systems – Part 2: Design, construction, and maintenance. British Standards Institute. 2018.
25.	BS EN 50200 Method of test for resistance of fire of unprotected small cables for use in emergency circuits. British Standards Institute. 2015.
26.	BS EN 50362 Method of test for resistance to fire of larger unprotected power and control cables for use in emergency circuits. British Standards Institute. 2003.
27.	BS EN 50267-2-3 Common test methods for cables under fire conditions. Tests on gases evolved during combustion of materials from cables. Procedures. Determination of degree of acidity of gases for cables by determination of the weighted average of pH and conductivity. Determination of degree of acidity of gases for cables by determination of the weighted average of pH and conductivity. British Standards Institute. 1999.
28.	BS EN 50575 Power control and communication cables – Cables for general applications in construction works subject to reaction to fire requirements. British Standards Institute. 2016.
29.	BS EN 61034-2 Measurement of smoke density of cables burning under defined conditions- Part 2: Test procedure and requirements. British Standards Institute. 2005.
30.	BS 5266 Emergency lighting – Part 1: Code of practice for the emergency escape lighting premises. British Standards Institute. 2011.
31.	BS EN 13501-1 Fire classification of construction products and building elements – Part 1: Classification using data from reaction to fire tests. British Standards Institute. 2007 + A1:2009.
32.	BS EN 13501-6 Fire classification of construction products and building elements – Part 6: Classification using data from reaction to fire tests on power, control, and communication cables. British Standards Institute. 2018.
33.	BS 5306-1 Code of practice for fire extinguishing installations and equipment on premises – Part 1: Hose reels and foam inlets. British Standards; 2006.
34.	BS 5306-3 Fire extinguishing installation and equipment on premises – Part 3: Commissioning and maintenance of portable fire extinguishers – Code of practice. British Standards Institute. 2009
35.	BS 5306-8 Fire extinguishing installation and equipment on premises – Part 8: Selection and positioning of portable fire extinguishers – Code of practice. British Standards Institute. 2012.
36.	BS 6266 Fire protection for electronic equipment installations – Code of practice. British Standards Institute. 2011.
37.	BS 7176 Specification for resistance to ignition of upholstered furniture for non-domestic seating by testing composites. British Standards Institute. 2007 + A1:2011.
38.	BS 7273-3 Code of practice for the operation of fire protection measures – Part 3: Electrical actuation of pre-action watermist and sprinkler systems. British Standards Institute. 2008.
39.	BS 7273-4 Code of practice for the operation of fire protection measures – Part 4: Actuation of release mechanisms for doors. British Standards Institute. 2007
40.	BS 7671 - Requirements for Electrical Installations. IET Wiring Regulations. British Standards Institute. 2018.
41.	BS 8489 – Fixed fire protection systems – Industrial and commercial watermist systems Part 1: Code of practice for design and installation. British Standards Institute. 2016.
42.	BS EN 15004-1 Fixed firefighting systems – Gas extinguishing systems – Part 1: Design, installation, and maintenance. British Standards Institute. 2019.
43.	BS EN 81-72 Safety rules for the construction and installation of lifts – Particular applications for passenger and goods passenger lifts – Part 72: Firefighters lifts. British Standards Institute. 2003
44.	BS EN 81-73 Safety rules for the construction and installation of lifts – Particular applications for passenger and goods passenger lifts – Part 73: Behaviour of lifts in the event of fire. British Standards Institute. 2003.
45.	BS EN ISO 14122-4 Safety of machinery – Permanent means of access to machinery – Part 4: Fixed ladders. British Standards Institute
46.	BS EN 50172 BS 5266-8 Emergency Escape lighting systems. British Standards Institute. 2004.

Number	Standard
47.	BS EN 50265-2-1 Common test methods for cables under fire conditions – Test for resistance to vertical flame propagation for a single insulated conductor or cable – Part 2-1 – 1 kW pre-mixed flame. British Standards Institute. 1999.
48.	BS EN 60079-29-2 Explosive Atmospheres Part 29-2/Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen. British Standards Institute. 2015.
49.	BS 9990 Non-automatic firefighting systems in buildings – Code of practice. British Standards Institute. 2015.
50.	BS 1838/BS 5266-7 Lighting applications – Emergency Lighting. British Standards Institute. 1999
51.	BS ISO 3864-1 Graphical symbols – Safety colours and safety signs – Part 1: Design principles for safety signs and safety markings. British Standards Institute. 2002
52.	BS 5499-1 Graphical symbols and signs – Safety signs, including fire safety signs – Part 1: Specification for geometric shapes, colours, and layout. British Standards Institute. 2002.
53.	BS 5499-4 Safety signs, including Fire Safety Signs – Part 4: Code of Practice for Escape Route Signing – CORR 12082. British Standards Institute. 2000.
54.	NFPA 13 Standard for the Installation of Sprinkler Systems. NFPA. 2013.
55.	NFPA 15 Standard for Water Spray Fixed Systems for Fire Protection. NFPA. 2012.
56.	NFPA 20 Standard for the Installation of Stationary Pumps for Fire Protection. NFPA. 2016.
57.	NFPA 24 Standard for the Installation of Private Fire Service Mains and Their Appurtenances. NFPA 2013.
58.	NFPA 72 National Fire Alarm and Signalling Code. NFPA 2019.
59.	NFPA 804 Standard for Fire Protection for Advanced Light Water Reactor Electric Generating Plants. NFPA. 2010.
60.	Protection against Internal Fires and Explosions in the Design of Nuclear Power Plants. No. NS-G-1.7. IAEA. 2004. Now superseded by IAEA SSG-64
61.	PD ISO/TR 26368 Environmental damage limitation from firefighting water run-off. British Standards Institute. 2012.
62.	External fire spread: building separation and boundary distances. BR 187. Building Research Establishment. 1991
63.	NF C 32070 Classification tests on conductors and cables with regard to fire behaviour. 2001.
64.	RCC-E 2012 Design and Construction Rules for Electrical Equipment of Nuclear Island. AFCEN
65.	The Dangerous Substances and Explosive Atmospheres Regulations 2002. No. 2776. Statutory Instruments. 2002.
66.	The Application of DSEAR (for ATEX risk) for UK EPR Design & Modification. UKX-UK1421-U0-ALL-GUI-200149. EDVANCE. Revision D, BPE.
67.	Code of Practice Dangerous Substances and Explosive Atmospheres. BEG/SPEC/SHE/COP/014 NNB GenCo. Revision 005.
68.	Control of Major Accident Hazards Regulations 2015. No. 483. Statutory Instruments. 2015.

F Abbreviations

Acronym	Meaning
ADB	(Building Regulations) Approved Document B
AECP	Atomic Energy Code of Practice
AESS	Atomic Energy Standard Specifications
AFCEN	French Association for Design, Construction and Surveillance Rules of Nuclear Power
AFFF	Aqueous Film Forming Foam
AFI	Area For Improvement
AGR	Advanced Gas Reactor
ALARP	As low as reasonably practicable
AML	Alkali Metal Laboratory
AMS	Asset Management System
ANSI	American National Standards Institute
ARC	Alarm Receiving Centre
ATEX	Atmosphères Explosives
ATLAS	Analysing, Trending, Learning And Safety
AV	Assurance of validity
BAFE	British Association of Fire Equipment
BCDG	Battery Charging Diesel Generators
BCGA	British Compressed Gas Association Guidance
BDHPS	Basic Design Hazard Protection Schedule
BEPPS-DIF	Box Encapsulation Plant Product Store - Direct Import Facility
BFNP	Building Fire Nominated Persons
BIM	Building Information Models/Modelling
BNFL	British Nuclear Fuels Ltd
BR(E)	Building Research (Establishment)
BS	British Standards
BSM	Basket Safety Measure
BUCS	Back-Up Cooling System
BWF	British Woodworking Federation
CAP	Corrective Action Programme
CCF	Common Cause Failure
CCH	Combined and Consequential Hazards
CCR	Central Control Room
CCTV	Closed-circuit Television
CDM	Construction (Design and Management) Regulations 2015
CE&I	Control, Electrical & Instrumentation
CEGB	Central Electricity Generating Board
CESC	Central Emergency Support Centre
CF&RS	Cumbria Fire & Rescue Services

Acronym	Meaning
CFAST	Consolidated Model of Fire And Smoke Transport
CFD	Computational Fluid Dynamics
CFNP	Core Fire Nominated Persons
CFR	Code of Federal Regulations
CGF	Civilian Guard Force
CHF	Concentrated Hydrofluoric Acid
CHILW	Contact Handled Intermediate Level Waste
CHP	Combined Heat and Power Plant
CI	Conventional Islands
CIE	Control and Indicating Equipment
CLP	Classification, Labelling and Packaging
CMMS	Computerised Maintenance Management System
CNC	Civil Nuclear Constabulary
COMAH	Control of Major Accident Hazards Regulations 2015
CompEX	Competency in Explosive Atmospheres
COP	Code of Practice
COSC	Continued Operations Safety Case
COSER	Continued Operations Safety and Environmental Reports
COSHH	Control of Substances Hazardous to Health
COSR	Continued Operations Safety Report
CPNI	Centre for the Protection of National Infrastructure
CPR	Construction Products Regulation
CR	Contractor's Report
CRP	Caesium Removal Plant
CSS	Circular Smoke & Fire Damper
DA	Design Authority
DAP	Duly Authorised Person
DAS	Diesel Alternator Set / Distributed Antenna System
DBA	Design Basis Accident
DBAA	Design Basis Accident Analysis
DBHL	Design Basis Hazard Level
DBIF	Design Basis Initiating Faults
DBIH	Design Basis Internal Hazard
DBSM	Design Basis Safety Measures
DCP	Dounreay Cementation Plant
DSEAR	Dangerous Substances and Explosives Atmospheres Regulations
DF	Decontamination Factors
DFARS	Dounreay Fire Ambulance and Rescue Service
DFR	Dounreay Fast (Breeder) Reactor
DFRA	Deterministic Fire Risk Assessment
DFS	Dry Fuel Store

Acronym	Meaning
DFSB	Dry Fuel Store Building
DMR	Dounreay Modification Report
DNB	Dungeness B
DNV	Det Norske Veritas
DPVCW	Diverse Pressure Vessel Cooling Water
DSC	Decommissioning Safety Case
DSEAR	Dangerous Substances & Explosive Atmospheres Regulations
DSRL	Dounreay Site Restoration Limited
DU	Depleted Uranium
EC	Engineering Change / European Regulation
ECC	Emergency Control Centre
EDF	Electricité de France
EDP	Electronic Data Processing
EHA	Internal and External Hazards
EHS	Environment Health and Safety
EIM&T	Examination, Inspection Maintenance and Testing
EKP	Engineering Key Principles
EMANI	European Mutual Association for Nuclear Insurance Loss Control Standards
EMIT	Engineering, Maintenance, Inspection & Testing
EN	European Normative
ENSREG	European Nuclear Safety Regulators Group
EPCC	Emergency Preparedness Consultative Committee
EPR	European Pressurised Water Reactor
EPRESSI	Evaluation des Performances Réelles des Eléments de Sectorisation Sous Incendie [Assessment of the real performance of partitioning elements in the event of fire]
EPRI	Electric Power Research Institute
ER	Equipment Reliability
ES	Engineering Schedule
ESBWR	Economic Simplified Boiling Water Reactor
ESF	Essential Safety Function
ESLG	Emergency Services Liaison Group
ETA	Ethanolamine
ETBFPS	Effluent Treatment Building Fire Protection System
ETC	EPR Technical Code
ETP	Effluent Treatment Plant
EUR	European Utility Requirements
EURATOM	European Atomic Energy Community
EURRP	Enriched Uranium Residues Recovery Plant
EX	Explosion
FA	Fault Analysis

Acronym	Meaning
FACP	Fire Alarm Control Panels
FAD	Fire Application Document
FAIR	Fire Risk Assessment through Innovative Research
FARP	Fire Alarm Repeater Panels
FCA	Fuel Cycle Area
F-CTW	Functional Cable Tray Wrapping
FDS	Fire Dynamics Simulator
FDSS	Fire Detection and Suppression Systems
FEA	Failure Effects Analysis
FEC	Fire Event Code
FFF	Fixed Firefighting
FGASP	First Generation AGR Storage Pond
FGMSP	First Generation Magnox Storage Pond
FGOSP	First Generation Magnox Storage Pond
FHP	Fuel Handling Pond
FIRE	Fire Incidents Records Exchange
FIVE	fire-induced vulnerability evaluation
FLD	fire load density
FM	Factory Mutual
FNP	Fire Nominated Person
FPA	Fire Protection Association
FPAS	Fire Protection Alert System
FPASS	Fire Protection Alarm Supervisory System
FPS	Fire Protection System
FRA	Fire Risk Analysis
FREC	First Response Emergency Care
FRS	Fire and Rescue Service
FSA	Fire (Scotland) Act 2005
FSB	Fuel Storage Building
FSM	Fire Safety Manager
FSO	Regulatory Reform (Fire Safety) Order 2005
FSP	Fire Sector Panel
FSS	Fire Safety Strategies
GB	Great Britain
GDA	Generic Design Assessment
GEST	Generic Emergency Scheme Training
GTH	Generator Transformer House
GUI	Graphical User Interface
HA	Highly Active
HAC	Hazardous Area Classification
HAL	Highly Active Liquor

Acronym	Meaning
HAZAN	Hazard Analysis
HAZID	Hazard Identification
HAZOP	Hazard and Operability
HBN	Hunterston B
HBS	Hunterston B Simulator
HBX	Operational Service Centre Building
HDU	Emergency Response Energy Centre
HEG	National Grid 400 kV Sub-station
HEPA	Highly Efficient Particulate
HF	Hydrogen Fluoride
HFSA	Hazard Functional Safety Analysis
HGE	Hinkley Point C Technical Gallery Designation
HHK	Interim Spent Fuel Store
HHRR	High Hazard and Risk Reduction
HIE	Hazard Initiating Event
HK	Fuel Building
HM	Turbine Hall
HMS	Hazard Management Strategies
HNA	Hunterston A
HNB	Hunterston B
HOJ	Fire-fighting Water Building
HP	Cooling Water Pump House
HPA	Service Water Pump Building
HPB	Hinkley Point B
HPC	Hinkley Point C
HR	Reactor Building
HRA	Hartlepool A
HRR	Heat Release Rate
HSE	Health and Safety Executive
HSG	Health and Safety Executive Guidance
HSSE	Health, Safety, Security and Environment
HSV	Hazard Safety Volume
HUM	Emergency Response Centre
HVA	Hazard Vulnerability Analysis
HVAC	Heating, Ventilation and Air Conditioning
HWFRA	Hot Work Fire Risk Assessment
HYA	Heysham 1
HYB	Heysham 2
IAEA	International Atomic Energy Agency
ICP	Integrated Company Practice
ICRP	International Commission Radiological Protection

Acronym	Meaning
ID	Identification
IDR	Integrated Dry Route
IEC	International Electrotechnical Commission
IEF	Initiating Event Frequency
IET	Institution of Engineering and Technology
IFBS	Irradiated Fuel Buffer Store
IFC	Irradiated Fuel Cave
IFD	Irradiated Fuel Disposal
IFS	Irradiated Fuel Store
ILW	Intermediate Level Waste
ILWSRF	Intermediate Level Waste Size Reduction Facility
IMC	Industry Management Committee
INA	Independent Nuclear Assessment
IOF	Irradiated Oxide Fuel
IOSH	Institute of Occupational Safety and Health
IP	Ingress Protection
IR	Intervention Record
IRS	Incident Response Service
ISBN	International Standard Book Number
ISO	International Organization for Standardization
IV	Independent Verification
JAC	Firefighting Water Supply System
JCO	Justification for Continued Operations
JCR	Joint Convention Report
JDT	Fire Detection System
JESIP	Joint Emergency Services Interoperability Principles
JPD	Firefighting System for Conventional Island
JPH	Turbine Hall Oil Tank Firefighting system
JPI	Nuclear Island Protection and Firefighting Water Distribution system
JPS	Distribution of Firefighting Water
JPT	Transformer Fire Protection System
JPV	Diesel Fire Protection System
KPI	Key Performance Indicator
KTA	Kerntechnischer Ausschuss
LA	Low Active
LC	Licence Condition
LCC	Lancashire County Council
LCM	Low Consequence Methodology
LF&RS	Lancashire Fire and Rescue Service
LFE	Learning from Experience
LHDC	Liner Heat Detection Cable

Acronym	Meaning
LLSF	Lower Level Safety Functions
LLW	Low Level Waste
LLWR	Low-Level Waste Repository
LOPA	Layers of Protection Analysis
LPCB	Loss Prevention Certification Board
LPG	Liquefied Petroleum Gas
LPS	Loss Prevention Scheme
LSS	License Summary Statements
LWR	Light Water Reactor
MA	Medium Active
MAH	Major Accident Hazard
MBGW	Miscellaneous Beta Gamma Waste
MCR	Main Control Room
MDT	Mobile Data Terminal
MEH	Mechanical, Electrical and HVAC works (heating, ventilation and air conditioning)
MEP	Magnox Encapsulation Plant
MER	Magnox East River
MICC	Mineral Insulated Copper Covered
MJ	Megajoules
MOD	Ministry of Defence
MOX	Mixed Oxide Fuel
MR	Main Review
MS	Management for Safety
MSC	Management Safety Committee
MSF	Main Safety Functions
MSSS	Magnox Swarf Storage Silo
MTR	Materials Test Reactor
MW	Megawatts
NAR	National Assessment Report
NDA	Nuclear Decommissioning Authority
NEPS	New Enriched Powder Store
NF	Norme Française
NFCC	National Fire Chiefs Council
NFCR	Nuclear Fire Collaborative Review
NFPA	National Fire Protection Association
NFSA	Nuclear Fire Safety Analysis
NFSHA	Nuclear Fire Safety Hazard Analysis
NGL	Nuclear Generation Limited
NHSS	Non-Hazardous Stable State
NI	Nuclear Island

Acronym	Meaning
NI&IO	Nuclear Intelligence and Independent Oversight
NIA	Nuclear Installations Act 1965
NIFPS	Nuclear Island Protection and Firefighting Water Distribution system
NIFSCC	Nuclear Industry Fire Safety Coordinating Committee
NII	Nuclear Installations Inspectorate
NIST	National Institute for Standards and Technology
NNB	Nuclear New Build
NNL	National Nuclear Laboratory
NP	Normal plant
NPP	Nuclear Power Plant
NS	Nuclear Safety
NSC	Nuclear Safety Committee
NSD	Nuclear Safety Directive
NUREG	Nuclear Regulatory Commission Regulation
NVF	Nuclear Ventilation Forum
OA	Operating Assumption
OE	Operational Experience
OECD	Organisation for Economic Co-operation and Development
OFC	Oxide Fuels Complex
OHD	Occupational Health Department
ONR	Office for Nuclear Regulation
OPEX	Operational Experience
ORQ	Operating Requirement
PAT	Portable Appliance Testing
PC	Personal Computer
PCM	Plutonium Contaminated Material
PDA	Pre-Determined Attendance
PFB	Principal Fire Barrier
PFG	Possibility of a Generalised Fire
PFL	Possibility of a Localised Fire
PFR	Prototype Fast Reactor
PFSP	Pile Fuel Storage Pond
PHAST	Process Hazard Analysis Software Tool
PIE	Post-irradiation Examination
PLSF	Plant Level Safety Functions
PMP	Plant Modification Procedure
PMS	Plant Maintenance Schedule
PO&C	Performance Objectives and Criteria
POCO	Post Operational Clean Out
PPE	Personal Protective Equipment
PPEF	Powder and Pellet Export Facility

Acronym	Meaning
PPP	Programme Project Partners
PRISME	Propagation d'un incendie pour des scénarios multi-locaux élémentaires (fire propagation in elementary, multi-room scenarios)
PSA	Probabilistic Safety Assessment
PSR	Preliminary / Periodic Safety Report
PVCS	Pressure Vessel Cooling. System
PVCW	Pressure Vessel Cooling Water
PWR	Pressurised Water Reactor
QA	Quality Assurance
RAG	Red Amber Green
RB	Reactor Building
RC	Reference Configuration
RCA	Radiological Controlled Area
RCD	Residual Current Device
REDE	Regulatory Evaluated Demonstration Exercise
REPPIR	Radiation (Emergency Preparedness and Public Information) Regulations 2019
RFDB	Release Fraction Database
RFT	Reserve Feedwater Tank
RGP	Relevant Good Practice
RHILW	Remote Handled Intermediate Level Waste
RHM	Reactor Hall Mortuary
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013
RIS	Safety Injection
RPE	Respiratory Protective Equipment
RPG	Role Proficiency Graphs
RPS	Reactor Protection System
RRA	Residual Heat Removal System
RSA	Radioactive Substances Act 1993
RSS	Remote Shutdown Station
RV	Reactor Vessel
RVP	Rendezvous Points
RWVN	Reactor Vessel Water Vapour Nitrogen
SAG	Severe Accident Guideline
SAH	Safety Assessment Handbook
SAP	Safety Assessment Principle
SAT	Systematic Approach to Training
SBI	System Based Inspection
SCADA	Supervisory Control and Data Acquisition
SCALF	Steam Clean Active Liquor Filter
SCB	Secondary Containment Building

Acronym	Meaning
SCC	Soustraction de Charges Calorifiques (Heat Load Subtraction System)
SCM	Safety Case Manual
SDF	Safety Directors Forum
SDO	Safety Design Objective
SDP	Sodium Disposal Plant
SECC	Site Emergency Control Centre
SEHSC	Springfields Environment Health and Safety Committee
SF	Safety Features
SF&RS	Sellafield Fire & Rescue Service
SFA	Spent Fuel Assemblies
SFAIRP	So Far As Is Reasonably Practicable
SFC	Single Failure Criterion / Class
SFG	Safety Feature Groups
SFI	Intervention Fire Compartment
SFL	Springfield Fuels Limited
SFP	Spent Fuel Pond
SFPE	Society of Fire Protection Engineers
SFS/ZFS	Nuclear Fire Safety Compartment / Nuclear Fire Safety Cell
SGHWR	Steam Generating Heavy Water Reactor
SHE	Safety Health and Environment
SID	Sodium Inventory Disposal
SLMS	Sellafield Ltd Management System
SM	Safety Mechanism
SME	Subject Matter Expert
SPRS	Sellafield Product and Residues Store
SQEP	Suitably Qualified and Experienced Person
SR	Safety related
SRE	Safety-related Equipment
SRF	Size Reduction Facility
SRI	Safety Related Instrumentation
SRL	Safety Reference Levels
SSC	Structures, Systems and Components
SSG	Specific Safety Guide
SSI	Site Safety Instructions
SSR	Specific Safety Requirements
SSRI	Site-Specific Risk Information
SSS	Safe Shutdown State
SSSC	Safety Systems, Structures and Components
STF	Sodium Tank Farm
SWP	Sea Wall Structures
SZB	Sizewell B

Acronym	Meaning
SZC	Sizewell C
TAG	Technical Assessment Guide
TBC	To be confirmed
TBP/OK	Tri-n-butyl phosphate/Odourless kerosene
TH	Turbine Hall
THORP	Thermal Oxide Reprocessing Plant
TMF	Tails Management Facility
TOR	Torness
TPR	Topical Peer Review
TR&S	THORP Receipt and Storage
TRSP	THORP Receipt and Storage Pond
TSC	Technical Support Centre
UCP	Urenco ChemPlants
UD	Urenco Deutschland
UDG	Ultimate Diesel Generator
UHF	Ultra-high Frequency
UK	United Kingdom
UKAS	United Kingdom Accreditation Service
UKCA	UK Conformity Assessed
UNL	Urenco Nederland
UNOR	Unusual Occurrence Report
UNS	Urenco Nuclear Stewardship
UPS	Uninterruptible Power Supply
US	United States
US NRC	United States Nuclear Regulatory Commission
UUK	Urenco United Kingdom
VDU	Visual Display Unit
VHF	Very High Frequency
VLLW	Very Low-Level Waste
VRLA	Valve Regulated Lead Acid
VTT	VTT Technical Research Centre of Finland
WAC	Waste Acceptance Criteria
WAGR	Windscale Advanced Gas Cooled Reactor
WAMAC	Waste Monitoring and Compaction Plant
WANO	World Association of Nuclear Operators
WASRF	Wet Area Size Reduction Facility
WEM	West End Mortuary
WENRA	Western European Nuclear Regulators' Association
WEP	Waste Encapsulation Plant
WAGR	Windscale Advanced Gas Reactor
WPEP	Waste Processing and Encapsulation Plant

Acronym	Meaning
WTC	Waste Treatment Complex
WVP	Waste Vitrification Plant
XLPE	cross-linked polyethylene