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| ONR Assessment Report  Generic Design Assessment of the Rolls-Royce SMR – Step 2 assessment of Life Fire Safety |



ONR Assessment Report

**Project Name**: Generic Design Assessment of the Rolls-Royce SMR

**Report Title**: Step 2 assessment of Life Fire Safety

**Authored by**: [Redacted]

**Report Issue No**: 1

**Document ID**: ONRW-2126615823-3608

**Publication Date**: Jun-24

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# Executive Summary

This report presents the outcomes of my life fire safety assessment of the Rolls-Royce Small Modular Reactor (SMR) as part of Step 2 of the Office for Nuclear Regulation (ONR) Generic Design Assessment (GDA). This assessment is based upon the information presented in version 2 of Rolls-Royce SMR Limited’s Environmental, Safety, Security and Safeguards (E3S) case chapters and supporting documentation.

ONR’s GDA process calls for a step-wise assessment, which increase in detail as the project progresses. The focus of my assessment in this step was towards the fundamental adequacy of the Rolls-Royce SMR design and safety case, and the suitability of the methodologies, approaches, codes, standards and philosophies which form the building blocks for the design and generic safety and security cases.

I targeted my assessment, in accordance with my assessment plan, at the content of most relevance to life fire safety against the expectations of ONR’s Technical Assessment Guides (TAGs) and other guidance which ONR regards as relevant good practice.

I targeted the following aspects in my assessment of the Rolls-Royce SMR E3S case:

* Compliance with chosen fire safety design codes.
* Adequacy of generic fire safety information in top level safety case.
* Adequacy of methodologies and approach for LFS design and analysis.
* Adequacy of plant layout for fire safety.
* Impacts of modularisation on fire safety design.
* Demonstration of ALARP.

Based upon my assessment, I have concluded the following:

* The RP has identified adequate fire safety design principles to support the construction and operation of its design.
* The RP has identified suitable design codes and standards to support the construction and operation of its design.
* The RP has not yet adequately demonstrated that the generic design meets the requirements of the codes and standards it has selected, nor has it comprehensively identified departures from these codes and standards and their mitigations and/or justifications, this activity falls into the scope of Step 3. As such, it has not yet demonstrated risk reduction to ALARP, which is expected to be comprehensively addressed in Step 3.
* The DRP1 concept plant layout submitted by the RP is an adequate basis for future design development. While there are multiple areas where significant design development is needed to meet standards and requirements, I have not identified at this stage any fundamental issues that would preclude progress to subsequent stages of design development and eventual construction in GB. I note that the RP has primarily presented the reactor island with limited information relating to the remainder of the generic design and so I can only make a judgment on the adequacy of the reactor island design..
* The modularisation approach submitted by the RP does not present any fundamental fire safety concerns. My judgement in this area is predicated on the fact that the RP has identified requirements for a high degree of structural fire performance for all modular elements. In Step 3 the RP must present evidence that these requirements are, or can be, substantiated.
* The E3S case for fire safety, comprising the top tier chapter and the underlying documents, is adequate for this stage of the design. However, there are several shortfalls regarding internal consistency and design iteration. The fire strategies are not consistent with the layout reference design at this point. The layout has also not been fully reviewed against the fire requirements. In Step 3, I expect the RP to present a fully aligned E3S case, with suitable evidence presented in support of claims and requirements.

Overall, based on my assessment to date, and subject to the provision and assessment of suitable and sufficient supporting evidence, I have not identified any fundamental safety shortfalls that could prevent ONR’s future permissioning of the construction of a power station based on the generic Rolls-Royce SMR design.

# List of Abbreviations

ADB Approved Document B

ALARP As low as is reasonably practicable

BOP Balance of Plant

BSL Basic Safety level (in SAPs)

BSO Basic Safety Objective (in SAPs)

BoD Basis of Design

CDM Construction Design and Management Regulations

CKoP Civil Kit of Parts

CNS Civil Nuclear Security (ONR)

CAE Claim Argument Evidence

DAC Design Acceptance Confirmation

DRP Design Reference Point

DOORS Dynamic Object Oriented Requirements System

EC&I Electrical, Controls and Instrumentation

E3S Environment, Safety, Security and Safeguards

EUR European Utility Requirements

GDA Generic Design Assessment

HSE Health and Safety Executive

HF Human Factors

IAEA International Atomic Energy Agency

LC Licence Condition

LFS Life Fire Safety

LWR Light Water Reactor

MCR Main Control Room

MKoP Modular Kit of Parts

NRW Natural Resources Wales

NPP Nuclear Power Plant

ONR Office for Nuclear Regulation

HOW2 ONR’s Management System internal online portal

PCER Pre-construction Environment Report

PCSR Pre-construction Safety Report

PWR Pressurised Water Reactor

PSA Probabilistic Safety Assessment

RCA Radiologically Controlled Area

RCP Reactor Coolant Pump

RI Reactor Island

RPV Reactor Pressure Vessel

RD Reference Design

RGP Relevant Good Practice

RP Requesting Party

RRFSO Regulatory Reform (Fire Safety) Order 2005

SAP Safety Assessment Principle(s)

SMR Small Modular Reactor

SFAIRP So far as is reasonably practicable

SG Steam Generator

SSC Structure, System and Component

SCR Supplementary Control Room

TAG Technical Assessment Guide(s) (ONR)

TSC Technical Support Contractor

TI Turbine Island

WENRA Western European Nuclear Regulators’ Association

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# Introduction

1. This report presents the outcomes of my life fire safety assessment of the Rolls-Royce Small Modular Reactor (SMR) as part of Step 2 of the Office for Nuclear Regulation (ONR) Generic Design Assessment (GDA). This assessment is based upon the information presented in version 2 of Rolls-Royce SMR Limited’s Environmental, Safety, Security and Safeguards (E3S) case chapters (refs [1], [2], [3], [4], [5] and [6]) and supporting documentation.
2. Assessment was undertaken in accordance with the requirements of the Office for Nuclear Regulation (ONR) Management System and follows ONR’s guidance on the mechanics of assessment, NS-TAST-GD-096 (ref. [7]).
3. This is a Major report (refer to NS-TAST-GD-108 (ref. [8])).

## Background

1. The ONR’s GDA process (ref. [9]) calls for a step-wise assessment of the Requesting Party's (RP) submissions with the assessments increasing in detail as the project progresses. Rolls-Royce SMR Limited is the RP for the GDA of the Rolls-Royce SMR design.
2. In April 2022, ONR, together with the Environment Agency and Natural Resources Wales (NRW), began Step 1 of the GDA for the generic Rolls-Royce SMR design. Step 1, which is the preparatory part of the design assessment process and mainly associated with initiation of the project and preparation for technical assessment in later steps, was successfully completed in 12 months.
3. Step 2 commenced in April 2023. This is the first substantive technical assessment step. The focus of ONR’s assessments in this step is towards the fundamental adequacy of the design and safety and security cases, and the suitability of the methodologies, approaches, codes, standards and philosophies which form the building blocks for the design and generic safety and security cases. The objective is to undertake an assessment of the design against regulatory expectations to identify any fundamental safety or security shortfalls that could prevent ONR permissioning the construction of a power station based on the design.
4. Prior to the start of Step 2, I prepared a detailed assessment plan for life fire safety (ref. [10]). This has formed the basis of this assessment and was also shared with the RP for openness and transparency.
5. This report is one of a series of assessments which support ONR’s overall judgements at the end of Step 2 which are recorded in the Step 2 Summary Report (ref. [11]).

## Scope

1. The assessment documented in this report is based upon the E3S case for the Rolls-Royce SMR as summarised in the E3S case chapters and supporting documentation.
2. The overall scope of the Rolls-Royce SMR GDA is described in (ref. [12]). Rolls-Royce SMR Limited has indicated that it intends to complete a three step GDA, with the objective of receiving a Design Acceptance Confirmation (DAC) from ONR and has aligned its GDA scope with this objective. The GDA scope defines the generic plant and layout and includes all systems, structures and components that are identified as being important to safety, security and safeguards, all modes of operation, and all stages of the plant lifecycle.
3. However, given the step-wise assessment during GDA, information has not been submitted for all aspects within the GDA Scope during Step 2. The following aspects of the E3S case are therefore out of scope of this assessment:

* Balance of Plant (BOP) building level fire strategies
* Turbine Island (TI) building level fire strategies (removed from scope by the RP during Step 2)
* Layout of external plant
* The cooling water island, site factory and manufacturing factory
* Fire safety during the construction phase is considered under the RP’s Construction (Design and Management) Regulations (CDM) arrangements and as such does not form part of my assessment.

1. My assessment has considered the following aspects:

* Compliance with chosen fire safety design codes
* Adequacy of generic fire safety information in top level safety case
* Adequacy of methodologies and approach for LFS design and analysis
* Adequacy of plant layout for fire safety
* Impacts of modularisation on fire safety design
* Demonstration of ALARP

1. This is further discussed in Section ‎4.1.

# Assessment standards and interfaces

1. For ONR, the primary goal of the GDA Step 2 assessment is to reach an independent and informed judgment on the adequacy of a preliminary safety, security and safeguards case for the reactor technology being assessed.
2. ONR has a range of internal guidance to enable inspectors to undertake a proportionate and consistent assessment of such cases. This section identifies the standards which have been considered in this assessment.
3. This section also identifies the key interfaces with other technical topic areas.

## Standards

1. For life fire safety, the bases for ONR assessment are described below.

* The Health and Safety at Work Act 1974 (ref. [13]) which requires that employers provide a safe environment for their employees and that risks are reduced to ALARP. The act also requires that employers ensure, so far as is reasonably practicable, that persons not in their employment who may be affected are not exposed to risks to their health or safety.
* The Regulatory Reform (Fire Safety) Order 2005 (RRFSO) (ref. [14]) which requires fire precautions to be put in place where necessary and to the extent that it is reasonably practicable to do so.
* The Building Regulations 2010 (ref. [15]) which set out functional requirements for fire safety. While the majority of the site is likely to be exempt from these regulations, it is accepted UK practice to use the functional requirements as a benchmark for fire safety.

1. The RP’s case is judged against the overarching GB legal requirement of reducing risk to ALARP and the regulatory principle of Relevant Good Practice (RGP). RGP is a generic term for those control measures, standards, policies and other practices which are relevant to a situation and that, if implemented, would usually be considered to meet a goal-setting obligation or expectation.This includes the goal-setting aspects of the RRFSO such as the duty to take such general fire precautions as will ensure, so far as is reasonably practicable, the safety of any of employees.
2. I have identified various items of RGP and have assessed the RP’s generic design against these items for this Step 2 assessment.

### Safety Assessment Principles (SAPs)

1. The principles presented in the ONR SAPs are relevant to nuclear safety, radiation protection and radioactive waste management. Conventional hazards associated with a nuclear facility are excluded from consideration in the SAPs, except where they have a direct effect on nuclear safety or radioactive waste management.
2. Fire hazards with a nuclear safety impact are addressed within ONR’s internal hazards assessment report (ref. [16])
3. As such the SAPs are not referred to within this assessment.

### Technical Assessment Guides (TAGs)

1. The following TAGs have been used as part of this assessment:

* NS-TAST-GD-096 - Guidance on mechanics of assessment (ref. [7])
* NS-TAST-GD-005 - Regulating duties to reduce risks to ALARP (ref. [17]).
* NS-TAST-GD-014 – Internal hazards (ref. [18]).
* NS-TAST-GD-051, The purpose, scope, and content of safety cases (ref. [19]).

### National and international standards and guidance

1. The following national and international standards and guidance have been used as part of this assessment:

* BS 9999 Fire Safety in the Design, Management and Use of Buildings – Code of Practice, 2017 (ref. [20])
* IAEA SSG-64 Protection Against Internal Hazards In The Design Of Nuclear Power Plants (ref. [21])

This document sets out expectations for evacuation provision from containment and has been referred to in this context.

* IAEA Tecdoc 1944, Fire Protection in Nuclear Power Plants (2021). (ref. [22])

This document provides guidance on general control methods for combustible material and guidance on provision of water supplies for nuclear facilities and has been referred to in this context.

## Integration with other assessment topics

1. I have worked closely with other topics as part of my life fire safety assessment. Similarly, other assessors sought input from my assessment. These interactions are key to the success of GDA to prevent or mitigate any gaps, duplications or inconsistencies in ONR’s assessment.
2. The key interactions with other topic areas were:

* Internal hazards – including requirements for fire protection systems, claims on barriers for fire separation, location and access to the Main Control Room (MCR) and fire performance of structural modules.
* Human factors – including target audience description.
* Civil engineering – including seismic raft and access implications and fire performance of structural modules.
* Mechanical engineering – including provision of mechanical ventilation systems.

## Use of technical support contractors

1. During Step 2 I have not engaged Technical Support Contractors (TSCs) to support my assessment of the life fire safety aspects of the Rolls-Royce SMR.

# Requesting party’s submission

1. Rolls-Royce SMR Limited submitted a series of E3S chapters, or summary reports, and other supporting references, which outline the E3S case for the generic Rolls-Royce SMR design. This section presents a summary of the RP’s safety case for life fire safety. It also identifies the documents submitted by the RP which have formed the basis of my life fire safety assessment of the generic Rolls-Royce SMR design.

## Summary of the Rolls-Royce SMR design

1. The generic Rolls-Royce SMR design is a three loop Pressurised Water Reactor (PWR) with a target electrical power output of 470 MWe (from a thermal power of 1,358 MWth) and a design life of 60 years for non-replaceable components.
2. The Rolls-Royce SMR design has been developed by the RP based upon well-established PWR technology, in use all over the world. Innovation comes in the form of its modular approach to construction which would see the majority of the power station built in factory conditions and assembled on site.
3. The reactor is of a typical PWR design, including a steel Reactor Pressure Vessel (RPV) holding fuel assemblies, Steam Generators (SG), Reactor Coolant Pumps (RCP) and piping, all held within a steel containment vessel. The reactor is equipped with a number of supporting systems for normal operations and a range of safety measures are present in the design to provide cooling, control criticality and contain radioactivity under fault conditions. Passive safety features are preferred to active components, reflecting the RP’s design philosophy.
4. Importantly for life fire safety, the design is intended to be compact, with the bulk of the process structures provided by a modular lattice. This approach is novel to the UK nuclear industry and has implications for fire compartmentation, access and egress and structural fire performance.

## E3S case approach and structure

1. Rolls-Royce SMR Limited has chosen to develop its cases in a holistic manner, as an Environment, Safety, Security and Safeguards (E3S) case. The overall objective for the E3S case is to demonstrate that the design will ‘protect people and the environment from harm’.
2. This means that, although the case made for each of the E3S purposes (i.e. environment, safety, security and safeguards) will inevitably be different at the top level, it will draw upon common evidence outputs (as well as other non-common outputs) to substantiate each of the purposes. This is claimed to offer benefits in terms of clarity, integration and understanding impacts from any changes to the case.
3. The E3S case is being developed using a three tier hierarchy and incorporating a Claim, Argument and Evidence (CAE) structure with the highest-level claims being derived from the RP’s own E3S principles. The highest level of the three tiers is the RP’s Tier 1 E3S chapters, with the lower tiers providing more detailed arguments and evidence. This is illustrated in Figure 1.

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**Figure 1: Claim, Argument and Evidence (CAE) structure within the E3S hierarchy** (ref. [1])

1. The structure of the E3S case largely aligns with the IAEA guidance for safety cases, SSG-61 (ref. [23]), supplemented to include UK specific expectations and expanded to include the other E3S purposes.

## Summary of the requesting party’s E3S case for life fire safety

1. The aspects covered by the Rolls-Royce SMR safety case in the area of life fire safety can be broadly grouped under four headings which are summarised as follows.

### Sitewide fire strategy aspects

1. The RP makes the claim that (ref. [6]):

* Conventional safety and fire safety requirements for the design are complete and correct.

1. In support of this claim, the RP argues that:

* Generic conventional fire requirements are identified and are derived from applicable codes, standards, RGP, and OPEX.
* Conventional fire safety requirements for fire protection & extinguishing systems are identified and are derived from applicable codes, standards, RGP, and OPEX.

1. The RP presents a sitewide fire strategy that aims to establish the applicable fire safety related legislation, guidance and technical standards which apply to the generic Rolls-Royce SMR site, buildings and systems and to define and describe the fire safety principles which apply to the generic Rolls-Royce SMR site, buildings and systems (ref. [24]).
2. This is supported by a basis of design (BoD) for fire protection which aims to establish the appropriate standards and fire safety requirements applicable to the fire protection and extinguishing systems which are generally applicable and / or communal to the generic Rolls-Royce SMR design (ref. [25]).

### Building specific fire strategy and layout aspects

1. The RP makes claims that (ref. [6]):

* Overall layout of Reactor Island (RI) is designed to minimise conventional safety and fire risks to ALARP.
* Layout of safety systems is designed to minimise conventional safety and fire risks to ALARP.
* Layout of fuelling systems is designed to minimise conventional safety and fire risks to ALARP.
* Layout of containment systems and Interspace is designed to minimise conventional safety and fire risks to ALARP.
* Layout of waste systems is designed to minimise conventional safety and fire risks to ALARP.

1. The RP makes additional building or area specific claims in the E3S case, but these are not supported at Step 2 and so are excluded from the scope of this assessment as per Section ‎1.2.
2. The claims are supported by the argument that:

* Driving principles for the layout and system design include conventional and fire requirements.

1. The RP has submitted a Reactor Island Fire Strategy Document which aims to establish legislation and guidance applicable to the design and define fire safety principles specifically for the reactor island building. This fire strategy also seeks to make an assessment of risk and fire hazards in the building and to define the technical requirements to achieve an appropriate level of life fire safety (ref. [26]).
2. The RP has also submitted a series of layout reports that summarise the high-level layout principles and assessments relevant to the E3S case (refs. [27], [28], [29], [30], [31] and [32]).

### Modularisation aspects

1. Given the RP’s intention to utilise a highly modular design, the characteristics of the modular structure also form part of the life fire case. The RP has produced documents describing the preliminary concept definition of the Modular Kit of Parts (MKoP) for Primary Structures and for barriers (refs. [33], [34], [35]).

### ALARP

1. At this stage of the design and safety case development, evidence to demonstrate risks are reduced ALARP in regards to life fire safety is limited.
2. The RP has produced an overall ALARP report, although this contains limited information of specific relevance to life fire safety (ref. [36]). Some evidence of optioneering and design decision making has been included in the RP’s case for specific examples, such as the site ring main (ref. [24]).

## Basis of assessment: requesting party’s documentation

1. The principal documents that have formed the basis of my life fire safety assessment of the E3S case are:

* Reactor Island Fire Strategy (ref. [26]), which primarily establishes the fire safety related legislation, guidance and technical standards which the RP considered applicable to the reactor island building and defines and describes the fire safety principles which apply to reactor island. Secondarily, the strategy identifies potential departures from guidance.
* Site Fire Strategy Document (ref. [24]). This document details the site fire strategy for the Rolls-Royce Small Modular Reactor site. It defines legislation and key principles and sets expectations for fire safety provisions that will be detailed in the building fire strategies.
* Fire Protection and Extinguishing System – Basis of Design (ref. [25]) which aims to establish the fire protection and extinguishing systems to be applied within the RP’s generic design, establish the appropriate standards and fire safety requirements applicable to the fire protection and extinguishing systems which are generally applicable and / or communal to the Rolls-Royce Small Modular Reactor, and identify interfacing project documentation relevant to the determination of the performance requirements for local systems.
* Reactor Island Architectural and Layout Summary Report (ref. [27]). This report describes the design process for the RI layout, including the hierarchy of layout decisions, the systems engineering approach to layout design, and the applicable engineering governance processes.
* Containment and Interspace Systems Layout Report (ref. [28]). This document reports the RD7 mechanical and electrical Layout definition for the Containment [UJA] and Interspace [UJB] blocks located within the Reactor Island [U01].
* Safety Fluid Systems Layout Report (ref. [29]). This document reports the RD7 mechanical and electrical layout definition for the Safety Fluid Systems Block [UJT] located within the Reactor Island [U01].
* Reactor Island EC&I Systems Layout Report (ref. [30]). This document reports the RD7 mechanical and electrical Layout Definition for the Electrical, Controls and Instrumentation (EC&I) Systems Block [UJS] located within the Reactor Island [U01].
* Fuelling Systems Outside Containment Layout Report (ref. [31]). This document reports the RD7 mechanical and electrical layout definition for the Fuelling Systems outside Containment (Fuelling Block) [UFA] located within the Reactor Island [U01].
* Auxiliary and Waste Systems Layout Report (ref. [32]). This document reports the Auxiliary and Waste Systems Layout [UKA] definition.
* Strategy for the Application of Modularisation into the SMR Layout (ref. [33]). The RP’s build certainty philosophy and the principles of modularisation and standardisation are summarised in this document. It also provides an overview of the MKoP concept design.
* Modularisation Kit of Parts Primary Structure Standard Frame Design Definition (ref. [34]). This report describes the initial concept definition and evaluation for the MKoP’s primary structures.
* Modularisation Kit of Parts Barriers Design Definition (ref. [35]). This report documents the design development of the barriers package, a large work package forming part of the secondary structures commodity within the Modularisation Kit of Parts (MKoP) system. This initial issue is released at the preliminary concept stage and demonstrates that suitable design space exists, and viable concepts have been identified.
* ALARP Summary Report (ref. [36]). This document provides a summary of how the RP considers that the generic Rolls-Royce SMR reduces risks to ALARP at RD7.
* Control Facilities Description (ref. [37]). This document aims to collate and summarise the key information from a selection of standards and existing Nuclear Power Plant (NPP) documentation to begin defining the Human Factors (HF) requirements for control facilities within the Rolls Royce Small Modular Reactor.

# ONR assessment

## Assessment strategy

1. My assessment strategy for GDA Step 2 was set out in my assessment plan and agreed with the RP at the end of Step 1. This plan focussed on ‘Targeted Matters’ against which I would seek evidence-based confidence that the plant was fundamentally safe to build, operate and decommission in GB (ref. [10]).
2. Given the evolving maturity of the design, safety case and submission plan, some elements of my original plan could not be fully delivered against in this step. These elements largely relate to content that will fall within the scope of Step 3. The implications of this for my assessment are discussed in the following Section ‎4.1 sub-sections. Where gaps require further assessment in Step 3, this is highlighted in the relevant parts of Section ‎4.2.
3. In addition, as the step has progressed I have chosen to sample an additional area, modularisation. This is due to the identification that there may be significant life fire safety implications to the RP’s chosen structural design during Step 2 engagements. This is discussed in Sections ‎4.1.6 and ‎4.2.5.
4. The status of each of the areas of my assessment strategy is discussed in the following sections.

### Compliance with chosen fire safety design codes

1. I intended to assess:

* The adequacy of the selected codes and standards for their intended application in the RP’s design.
* The RP’s fire safety provisions and architectural design against the requirements of its selected design codes, seeking demonstration that these requirements are satisfied by the design and, where this is not possible, that suitable optioneering has been undertaken to reach a design that reduces the risk to life from fire to as low as is reasonably practicable (ALARP).

1. Following receipt of the RP’s submissions, I am able to fully assess the first of these points in Section ‎4.2.1 of this report. For the second point, I have not been provided with sufficient information to make a meaningful detailed judgement on the Design Reference Point 1 (DRP1) design (aligning to the Reference Design 7 (RD7)) design (ref. [38]). My initial high-level view is presented in Sections ‎4.2.1 and ‎4.2.4 This focusses on whether there are fundamental issues with the DRP1 fire safety design or gaps that preclude progression to Step 3.

### Adequacy of generic fire safety information in top level safety case

1. I intended to assess:

* The adequacy of relevant fire safety information included in Chapter 22: Conventional & Fire Safety of the top-level safety case.
* Whether the generic safety case has appropriate scope and structure with regards to fire safety, is consistent with relevant fire safety standards, is sufficient to support assessment during GDA and represents a baseline for a future licensee to develop.

1. The RP has submitted this chapter (ref. [6]) and an E3S case route map (ref. [39]). I am content that this information is sufficient to allow a meaningful assessment of fundamental adequacy, which is reported in Section ‎4.2.2‎.

### Adequacy of methodologies and approach for LFS design and analysis

1. I intended to assess:

* Whether the methodologies (e.g. for fire hazard assessment) and fire safety design principles proposed by the RP within its sitewide fire strategy are appropriate and adequate to deliver the required level of life fire safety in the proposed concept design.
* Key site wide fire safety aspects such as water supply, external fire spread and access and facilities for the fire service.
* The fire protection and suppression basis of design, judging the adequacy of selected codes and standards, design choices and assumptions for engineered fire systems.

1. As described in Section ‎3.3, the documents submitted by RR-SMR heavily focus on high level requirement setting. This allows me to make a judgement about the fundamental adequacy of codes and standards proposed. Details of sitewide fire safety provision and analysis methodologies are not at a suitable maturity for in depth assessment. However, I have chosen to sample fire safety principles presented by the RP to judge whether these are fundamentally adequate to support deployment in GB. The adequacy of the information presented and gaps is covered in my assessment in Section ‎4.2.3.

### Adequacy of plant layout

1. I intended to assess:

* Whether life fire safety has been adequately considered in the design of plant layout.
* Whether the fire safety impacts of the generic plant layout have been identified and demonstrated to be, or planned to be, minimised at all stages of the plant lifetime.
* The means of escape provision in the RI and TI, considering the compact design and any novel layout aspects.

1. As detailed in Section ‎3.3, layout is described for the RI in the layout reports (refs. [27], [28], [29], [30], [31] & [32]). These provide some visibility of access and egress provision at a high level. However, the RI Fire Strategy, where I expect that detailed consideration of provision against the requirements of the selected design codes will be reported, is based on RD6 (ref. [26]) (which preceded DRP1). A gap analysis between the RD6 and RD7 designs has been performed, but as this is qualitative it is not adequate to make detailed judgements. As a result, I have elected to make only high-level judgements on the adequacy of the generic Rolls-Royce SMR design layout with regards to life fire safety at this GDA step in Section ‎4.2.4.
2. The RP removed the Turbine Island from the scope of Step 2 (ref. [40]). As such, I have not been able to make any judgment on this area of the generic design.

### Demonstration of ALARP

1. I intended to assess:

* The RP’s justification that the risks to life from fire will be reduced to ALARP.
* The adequacy of optioneered changes to the design to address specific departures from fire safety design codes.

1. As per my assessment plan (ref. [10]), in Step 2 I expected to be able to assess RR-SMR’s optioneered solutions to the majority of departures from code, including progress against major risk gaps.
2. However, during Step 1 it was identified that some departures may have outstanding actions at the end of Step 2 for resolution in Step 3.
3. As Step 2 progressed it became clear that the majority of departures from code would be at an early stage of identification during Step 2. As a result my assessment in this area is limited to a small sample of design decisions. I have included the ALARP report (ref. [36]) produced by the RP in my sample but note that this provides little evidence for the LFS topic. The RP has not provided substantiation of ALARP claims in Step 2, but I have assessed the elements of ALARP process that I have sampled during this Step in Section ‎4.1.5.

### Modularisation

1. In addition to the items I identified in my assessment plan, I have further chosen to sample the approach taken to modularisation as relevant to life fire safety. I have focused my sample on provision for structural fire protection and fire separation in line with requirements of RGP such as   
   BS 9999 (ref. [20]). This is reported in Section ‎4.2.5.

## Assessment

### Compliance with chosen fire safety design codes

#### Adequacy of selected fire safety design codes

1. The RP states in the Site Fire Strategy that BS 9999 (ref. [20]) is adopted as the primary fire safety guidance document for the generic design (ref. [26]). Reference is also made to Approved Document B (ADB) (ref. [41]), which the RP judges is unlikely to be appropriate for the technical buildings (those containing process equipment and other plant) located within the SMR site due to their complexity. The RP also makes provisions for the use of   
   BS 7974 (ref. [42]) for areas where fire engineering principles are applied to the design. The RP states that this includes, but is not limited to, the application of smoke transport modelling, structural fire modelling, evacuation modelling etc.
2. The RP identifies further design codes within its site fire strategy (ref. [24]), RI fire strategy (ref. [26]) and fire protection BoD (ref. [25]). These include a range of UK-recognised design codes, including but not limited to:

* BS 5839-1, 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 (2017), (ref. [43])
* BS 5266-1, Emergency Lighting. Code of practice for the emergency lighting of premises (2016), (ref. [44])
* BS 9990, Non automatic fire-fighting systems in buildings. Code of practice, (2015), (ref. [45])
* BS EN 12845+A1, Fixed firefighting systems - automatic sprinkler systems - design, installation and maintenance (Incorporating corrigenda December 2015 and January 2016) (2019), (ref. [46])

1. BS 9999 (ref. [20]), BS 7974 (ref. [42]) and Approved Document B (ref. [41]) are recognised UK RGP for non-domestic buildings. The RP’s selection of BS 9999 as the primary design code meets my expectations for an adequate design code choice. The RP has identified an appropriate selection of other British Standards for all key elements of fire safety design, including detection and alarm, lighting, fire-fighting systems and structural fire response.
2. The site fire strategy identifies an area where the RP does not intend to follow BS 9999 and BS 9990. Whereas BS 9990 states that “the water supply to hydrants should be kept entirely independent from other water supplies including those for other fire-fighting systems” (ref. [45]), the RP has selected a single, common fire main serving hydrants and automatic systems (ref. [24]). The justification for this departure brings into the strategy other, non-UK design codes and guidance such as:

* IAEA Tecdoc 1944, Fire Protection in Nuclear Power Plants (2021). (ref. [22])
* NFPA 24, Standard for the installation of private fire service mains and their appurtenances (2019). (ref. [47])

1. The RP has provided an optioneering justification for this position in the form of a ‘generic departure’ assessment (coded GEN\_RM). For GDA, ONR expects that optioneering is an ongoing process which branches into increasing levels of design detail and engages a wider spread of specialist disciplines as successive milestones are reached, and the associated safety case is developed (ref. [17]). The RP confirmed in response to RQ-01076 that the assumptions that its decision is based upon, and the associated selection of non-UK design codes will be validated in Step 3 (ref. [40]). I expect to see evidence to this effect submitted by the RP at Step 3.
2. BS 9999 warns against adopting a “pick-and-mix” approach to design codes (ref. [20]). However, I am content that the RP’s submissions demonstrate that this is not the general intent and that use of alternative codes will be justified.
3. Overall, I am satisfied that the information that has been submitted is consistent with UK relevant good practice and should enable the RP to further develop the generic Rolls-Royce SMR design and associated E3S case evidence.

#### Demonstration of compliance with selected design codes

1. The maturity of the RP’s generic design development at Step 2 has not allowed it to demonstrate compliance with the codes selected.
2. One of the RP’s stated aims for the RI Fire strategy is to provide an initial high-level assessment of the RD6 SMR design with regards to requirements, and to provide commentary on potential departure risks. It also seeks to make recommendations of further work required to provide valuable assessment and/or eliminate or justify potential departures (ref. [26]).
3. It is clear from the wording of this objective that the document at Step 2 does not seek to demonstrate compliance with selected design codes. In addition, the document is based on the RD6 design, which featured a fundamentally different layout from that submitted by the RP at DRP1 (ref. [38]). As a result I have not assessed this document in detail in my assessment. This does not preclude a satisfactory outcome for Step 2 as this step is necessarily based on not fully mature design data and I have not identified any fundamental issues with the principles or codes selected for application by the RP to the RD7 design.
4. The document identifies 18 areas with the potential to depart from the selected design codes in the RD6 design (ref. [26]). The gap analysis presented against RD7 identifies some of these issues as being potentially resolved by the RD7 design. My expectation is that the RP will complete a comprehensive identification of departures from code for the relevant design in Step 3, and will provide adequate optioneered solutions and/or justifications for all non-compliances. The approach taken by the RP to addressing departures from code identified so far is discussed in Section ‎4.2.6. This approach and the work done in identifying departures in the RD6 design gives me confidence that my expectations can be met at Step 3.
5. Furthermore, I expect that where code compliance is claimed, the RP will provide comprehensive evidence to support this demonstration in Step 3.
6. At Step 2 the RP has focussed entirely on the Reactor Island. For Step 3 I expect a more holistic view of the plant to be assessed. This should include those elements removed from the Step 2 scope such as the Turbine Island and include analysis of all aspects of the GDA Scope [12].
7. As part of my assessment I have sampled the layout documents submitted by the RP (refs. [27], [28], [29], [30], [31], [32]). These provide some information on how the layout elements of the design comply with the fire requirements and RGP. This is addressed in Section ‎4.2.4.
8. In summary, for demonstration of compliance with selected design codes, insufficient detail has been presented to form a detailed judgement on the adequacy of the information and I will seek further information in Step 3. At this stage I have identified no fundamental shortfalls that will prevent the RP from demonstrating compliance, or justifying non-compliance, at Step 3.

### Adequacy of generic fire safety information in top level safety case

1. I have assessed Chapter 22 Issue 2 in the top level E3S case against the safety case expectations in NS-TAST-GD-051 (The Purpose, Scope, and Content of Safety Cases) where relevant (refs. [6], [19]).
2. I found that the chapter is structured logically to meet the needs of users. It identifies legislative requirements, applicable guidance and then describes the flow in to requirements in the RP’s design at a high level. This is in line with my expectations.
3. NS-TAST-GD-051 expects that a clear and coherent trail from safety claims through the arguments to the evidence that supports the conclusions is presented (ref. [19]). Fire claims are omitted from the Claims, Arguments, evidence map in Issue 2 of Chapter 22 (ref. [6]). However, I am content that these are adequately captured within the CAE route map that the RP has also submitted (ref. [39]).
4. NS-TAST-GD-051 expects that the case should demonstrate that risks are ALARP, and identify any actions required to manage risks ALARP in the future (ref. [19]). The RP states that the chapter outlines the arguments and evidence to underpin the high-level claim that the conventional and fire safety risks associated with the design, construction, commissioning, operation and decommissioning of the Rolls-Royce Small Modular Reactor have been reduced as low as is reasonably practicable (ref. [6]). However, at this stage I judge that no demonstration of ALARP has yet been made, this is commensurate with my expectations for Step 2. The RP makes several references to requiring further iterative design development and holistic risk review to demonstrate that risks are reduced ALARP (ref. [6]). This evidence will form a key part of my assessment in Step 3.
5. There is some discussion of the impact of novel features on fire safety design in Chapter 22 (ref. [6]), for example, in relation to module design, connections and protection. It is an expectation of NS-TAST-GD-051 that the necessary understanding of the behaviour of novel systems or processes should be established from appropriate research and development. This is yet to be demonstrated by the RP and is an area I will follow up on in Step 3.
6. I found Chapter 22 to be consistent with the information provided in the lower tier documents, and to adequately signpost to this information. Overall, I judge the chapter to be adequate for this stage in design. In Step 3 I will seek additional information and detail, in particular around the evidence presented in support of fire safety claims.

### Adequacy of methodologies and approach for LFS design and analysis

1. I have assessed the general fire strategy principles described by the RP in the Site Fire Strategy (ref. [24]). This document presents ten design principles for the generic design.
2. In the principles, the RP sets out an aim to apply the principle of ALARP holistically (considering all objectives and costs) to the specification (principle 1) and design (principle 9) of fire protection systems. This is in line with my expectations from considering UK regulatory requirements laid out in the Health and Safety at Work etc Act 1974 and the RRFSO (refs. [13], [14]).
3. The RP also identifies principles for removal or reduction of combustible inventory (principle 3), provision of suitable access and escape routes (principle 5), and provision of compartmentation, detection and alarm and fire suppression (principles 6, 7 and 8). These principles are in line with expectations in RGP such as the functional requirements of the Building Regulations (ref. [15]), guidance in BS 9999 (ref. [20]) and the general control methods listed in IAEA-TECDOC-1944 [22].
4. The RP identifies a principle that the fire loads are systematically characterised and logged (principle 4) and notes that this is part of the internal hazards assessment. This principle is in line with the expectations of the internal hazards TAG (the most relevant ONR TAG for fire hazard assessment) that the safety case should provide reference to surveys or studies of combustible substances, which should be systematic and demonstrably complete (ref. [18]). Further assessment of this aspect is addressed by the ONR internal hazards assessment report (ref. [16]).
5. The principle of developing and implementing suitable fire safety management procedures (principle 10 (ref. [24])) is in accordance with the expectations of BS 9999 (ref. [20]), although further evidence for this aspect is likely to fall out of scope of GDA and additional evidence will need to be provided during site specific activities.

### Adequacy of plant layout for fire safety

#### Reactor Island architectural layout

1. In the Reactor Island Architectural and Layout Summary Report (ref. [27]), the RP argues that the layout of the RI complies with the requirements set out in the fire strategy in the following areas:

* Segregation – the RP argues that where areas of high hazard or special fire hazard have been identified, spatial separation and/or compartmentalisation has been provided by fire-resisting barriers. The RP states that this is detailed in the systems layout reports. I have considered this argument in the system blocks layout subsections (‎4.2.4.2 to ‎4.2.4.6).
* Escape routes – the RP makes the argument that the RI layout at RD7 complies with the distance requirements of BS 9999 and that this is evidenced in the system block layout reports. I have considered this argument in the system blocks layout subsections (‎4.2.4.2 to ‎4.2.4.6).
* Fire fighting – the RP describes the six fire fighting shafts in the RD7 reactor island. I have considered these locations in the system blocks layout subsections (‎4.2.4.2 to ‎4.2.4.6).
* Detection – the RP states that detection poses a low risk to layout. I have seen no reason to disagree with this statement, however the detection and alarm design is not mature at this level of design development and I can make no judgement on its adequacy in the reactor island at this step. This is in line with ONR guidance that non-structural fire provisions are expected to be at a lower level of design maturity during GDA than structural provisions [48].
* Suppression – the RP states that space reservation and drainage capability is provided in the layout. However suppression design is very immature and I can make no judgement on its adequacy in the reactor island at this step. This is in line with ONR guidance that non-structural fire provisions are expected to be at a lower level of design maturity during GDA than structural provisions [48].

#### Containment and interspace systems layout

1. The Containment and Interspace Systems Layout Report (ref. [28]), states that the key aspect of fire safety that has been developed is the access and egress considerations into containment and the requirement to provide appropriate escape distances are defined in the RI Fire Strategy (ref. [26]).
2. The RP states that the provision of two personnel airlocks on separate sides of containment covering several levels enables a large portion of accessible areas within containment to comply with the RI fire strategy for escape route distances and supports up to 100 people accessing containment (ref. [26], [28]).
3. The two airlocks are located at levels L02 and L05 (top and bottom of containment) (ref. [28]). The RP also describes how the interspace is located adjacent to two firefighting shafts to the north and south, again providing multiple escape routes (ref. [28]).
4. The RP states that the flooring structures supporting these access routes are still to be developed and so I am unable to make a detailed judgement on the adequacy of escape provision at this stage (ref. [28]).
5. Fundamentally, I find that the provision of multiple escape routes from containment is in line with RGP. This includes the IAEA SSG-64 expectations that means should be provided to allow quick evacuation of the reactor containment through airlocks and that the measures should be adequate to deal with the largest number of personnel expected to be present during maintenance periods and outages (ref. [21]).
6. While there is as yet insufficient detail available for me to fully assess the means of escape provision from the interspace and containment, I am content that this is an appropriate level of design maturity for Step 2 and that information which has been submitted for assessment is in line with RGP. I have identified no fundamental shortfalls in this area and I shall seek further information on containment and interspace escape arrangements in Step 3, as well as detail on all fire safety elements excluded by the RP in these areas for Step 2.

#### Safety fluid systems layout

1. The Safety Fluid Systems Layout Report (ref. [29]) specifically addresses fire safety via the E3S Chapter 22 transverse requirements review. This acknowledges the risk profiling of the area in line with BS 9999.
2. The report describes access to the auxiliary block at the west (level B2) and the main access stairwell to the east (levels 0,2 and 3). The RP states “this layout ensures that escape route distances to reach a protected exit staircase or door throughout the block are ≤40m as per European Utility Requirements (EUR) for Light Water Reactor (LWR) nuclear power plants, Chapter 11” (ref. [29]).
3. EUR requirements are not the life fire safety design basis stated by the RP in the RI fire strategy (ref. [26]) and the stated 40m limit is significantly in excess of the 18m single direction travel distance base maximum stated in BS 9999 for A3 areas (and greater than the 26m for A1 areas) (ref. [20]).
4. While no detailed measurements of worst case travel distances in line with the guidance in BS 9999 are presented (ref. [20]), several such single direction routes appear to be present between the system modules.
5. In response to RQ-01249, The RP stated that the conventional fire strategy requirements were being entered into the requirements system DOORS (Dynamic Object Oriented Requirements System) and this would clearly set out that the life safety requirements and travel distances will need to comply with the guidance in BS 9999. The RP also stated that it does not propose to set out specific travel distances as recommended in Table 11 and Table 15 of BS 9999 as the risk profiles for each area are yet to be finalised. It concluded that it is yet to decide if any of the additional measures which permit an increase to the travel distance limits, allowed for in BS 9999, would be utilised (ref. [40]).
6. As such I am content that the RP recognises this is an area which requires further development to avoid or mitigate shortfalls against UK relevant good practice (BS 9999 (ref. [20])) and I will seek evidence of resolution in Step 3. Given the size of the space and the number of exits in the area, I am content that the RP will be able to develop an adequate design in Step 3. As such I do not consider this to be a fundamental shortfall in this Step 2 assessment.
7. The fluids block does not contain fire fighting shafts. However, it is adjacent to shafts north and south of the interspace, and in the auxiliary block.
8. The RI fire strategy identifies a requirement that firefighting shafts should serve every storey through which they pass and should be laid out in accordance with the requirements presented in BS 9999, Clause 20.2 (refs. [26], [20]). This is an appropriate requirement in line with RGP.
9. In the RD7 design the auxiliary building shaft only serves the fluids block at level B2. The other shaft only serves the fluids block at levels 0, 2 and 3. As well as being non-compliant with the storey access requirement, this may make achieving the hose reach requirement challenging in some areas where firefighters have to traverse stairs within the block. I note that no assessment of hose reach has been presented at Step 2.
10. In response to RQ-01249, the RP stated that the dry riser outlets positioned in the lobbies of the firefighting shafts were being mapped to check that BS 9999 hose layout distances can be achieved for all areas of the modules from the proposed access levels. It also stated that where the required hose layout distances cannot be achieved, further work would be required to ensure that it can be justified (ref. [40]).
11. I consider this to be a potential area of shortfall against UK relevant good practice (BS 9999 (ref. [20])) and I will follow up in Step 3. The detailed consideration of hose reach is not an expected inclusion in Step 2 and so I do not consider this to be a fundamental shortfall at this stage.
12. The RP states that each level of the Safety Fluid Systems Block Trains 1 and 2 is an open modular structure and does not contain any physical barriers or boundaries and acknowledges that this has a significant effect on potential fire spread (ref. [29]).
13. This design choice leads to compliance challenges for life fire safety. For example:

* The RI fire strategy identifies multiple areas of special fire hazard in the RD6 design due to high voltage cabling and hydrogen within the safety fluids block (ref. [26]). BS 9999 guidance is that areas of special fire hazard are enclosed (ref. [20]). In response to RQ-01249 the RP indicated that the special fire hazard requirement has been removed in the Safety Fluids Block for RD7 [40].
* The RI fire strategy states “compartment floors should be employed within RI so far as is reasonably practicable” (ref. [26]) and BS 9999 states that the floor of the ground storey, if the building has one or more basements should be constructed as a compartment floor (ref. [20]). I assess that in the RP’s submitted RD7 design, it is not possible to provide compartment floors within the fluids process clusters, as the floors are part of an open modular system and do to extend to the perimeter of the compartment. In response to RQ-01249 the RP indicated that compartment floors will be considered as part of design development and provision will be justified [40].
* BS 9999 states that every dead-end corridor exceeding 2 m in length should be constructed as a protected corridor (ref. [20]). The RD7 fluid block layout features ‘personnel and mechanical access corridors’ with dead ends significantly in excess of 2 m. In response to RQ-01249 the RP stated that BS 9999 compliant single direction of travel distances will limit the length of dead end corridors and as such the 2m length is not included as a requirement. The RP stated that the benefit of enclosing the corridor in fire resistant construction will be assessed on a case-by-case basis alongside alternative means of providing sufficient mitigation such as automatic fire detection and alarms to determine the ALARP solution [40].

1. The RP addressed these items and other potential departures from BS 9999, in the Response to RQ-01249. The RP’s response was that the Safety Fluid Systems Block layout is at preliminary concept definition, as such no layout decisions had been carried out against the conventional fire safety requirements at time of writing the layout reports. The RP stated that as the layout design proceeds to DR3, fire safety requirements will be allocated via DOORS. The RP stated that the layout design will then be assessed against these requirements and, where necessary non-compliances are identified, action shall be taken to ensure that the layout design reduces overall risk to ALARP (ref. [40]).
2. The RP acknowledges that there is a risk that further fire separation will be required (risk 4, medium probability, low impact) and that this may impact the number and arrangement of modules (ref. [29]). Given the significant size of the space when compared to the modular plant requirements identified by the RP, I am satisfied that the RP will be able to make design changes as required to resolve fire safety issues as the design develops and that the proposed RD7 layout does not preclude practicable options at this stage.
3. While the current design does indicate the presence of departures from code which are yet to be justified, I am content that the RP has demonstrated that these are being suitably identified and considered (commensurate with the concept design level of detail). In Step 3 I will seek evidence of comprehensive identification and resolution or justification of departures such that it is demonstrated that risk is reduced ALARP.

#### Reactor Island EC&I systems layout

1. The Reactor Island EC&I Systems Layout Report (ref. [30]) specifically addresses fire safety via the E3S chapter 22 transverse requirements review. This acknowledges the requirements on the layout that are driven by fire safety, such as the BS 9999 travel distance limits.
2. The layout report presents locations for four fire fighting shafts within the EC&I block, each with a space allocation for stairs, lobbies and a firefighting lift. While detail of this arrangement is not yet provided, the outlined provision is likely to enable the RP to meet requirements of BS 9999. This includes provision of sufficient number of fire-fighting shafts to meet the maximum hose distances, and at least two fire-fighting shafts provided in buildings with a storey of 900 m2 or more in area (ref. [20]). I note that no assessment of hose reach has been presented at Step 2, so I cannot form a detailed judgement on the adequacy of this aspect and will seek further information at Step 3.
3. No detailed measurements of worst case travel distances in line with the guidance in BS 9999 are yet available. However, the layout report illustrates a circulation arrangement that does not lead to obvious dead-end conditions (ref. [30]). More information is required to understand how circulation routes designated as being for Radiologically Controlled Areas (RCA) will be used for means of escape in case of fire. I expect the RP to present this detail in Step 3.
4. The RP has identified major walkways in the EC&I block and has assigned a 1.7 m minimum width requirement in the EC&I Systems Layout Report (ref. [30]). The RD7 layout appears to comfortably accommodate this requirement and currently allocates a full module width (3.5 m) to the main corridor. The RP identifies that minor access to EC&I rooms may have a reduced width of 800 mm when cabinet doors are open. In the RI fire strategy, the RP indicates that it anticipates that minimum escape widths required by BS 9999 and human factors transverse requirements will be met (albeit in a review of the RD6 design) (ref. [26]). Given the space allocation shown, I am content that this is likely to generally be the case for the DRP1 design, but I expect the RP to provide evidence of this and identify any departures in Step 3.
5. The RP addresses separation and segregation in the EC&I Systems Layout Report (ref. [30]). The proposed CKoP (concrete) construction of the fire fighting shafts gives me confidence that adequate fire separation can be delivered in these areas. The divisional EC&I blocks are also separated by CKoP barriers for nuclear safety purposes. This is addressed in the ONR internal hazards assessment report (ref. [16]). The RP also outlines at a high level how MKoP barrier solutions will be used to provide separation to the different classes of EC&I and provide defence in depth to meet the E3S requirements.
6. Life fire safety barrier requirements are not addressed in the layout report. The RI fire strategy lists requirements for fire separation taken from BS 9999 but no demonstration of compliance is made at this stage. As such, I have not assessed compliance in this area at Step 2 and will seek further information in Step 3.
7. The RP states that the Main Control Room (MCR) is located within the 4th EC&I cluster (ref. [30]). In the RI fire strategy, the RP identifies the MCR as a location where operators will be required to remain following the detection of fire (ref. [26]). The RP acknowledges that further work is required to define this requirement (ref. [26], FW-20). The Control Facilities Description document (ref. [37]) identifies further hazard resilience requirements:

* The MCR shall be operable following relevant hazards. This includes fire.
* The MCR shall be habitable following relevant hazards. This includes fire.

1. This is consistent with IAEA SSG-64 guidance that the main control room and the supplementary control room should be protected against the ingress of smoke and combustion gases and against other direct and indirect effects of fire and of the operation of extinguishing systems (ref. [21]).
2. No detail is presented by the RP on how any stay-put or defend-in-place strategy will be applied for the MCR, or for any of the seven other areas where the RP has identified that simultaneous evacuation may not be applied (ref. [26]). I have discussed protection of the MCR from hazards with the ONR internal hazards assessor and have confirmed that no justification for extended operator presence in the MCR post internal hazard has been provided at Step 2 in the nuclear safety case. This is commensurate with the level development of the safety case and design at Step 2.
3. I expect to see further detail provided in Step 3, including a demonstration of how occupants will be protected while within the MCR and on the route to the Supplementary Control Room (SCR) or other areas on plant.
4. In the layout report the RP describes the fire separation afforded to the main corridor serving the MCR and the relative proximity of the SCR (ref. [30]). In this document the RP states that a MKoP 4hr-rated fire barrier will be used to create three fire compartments separating the MCR, main access corridor and 4th DPS division from each other.
5. While this statement and the recognition that fire separation is required for the MCR and route to SCR gives me confidence that MCR protection requirements can be met in the developing design, no demonstration that the location of the MCR reduces risks ALARP has been made by the RP at this stage.
6. In summary, while still at a concept design stage that requires further development (commensurate the expectations of Step 2 of GDA), the EC&I layout described by the RP at this stage does not appear to pose fundamental challenges to meeting life fire safety requirements. I will seek evidence that these requirements are met by the developing design in Step 3. In particular I will seek demonstration that the location and design of the MCR, SCR and relevant access routes reduces risk ALARP.

#### Fuelling systems outside containment layout

1. In the Fuelling Systems Outside Containment Layout Report (ref. [31]), the RP states the Fire Strategy Report [37] will be used to influence the layout of the fuelling block during the design progression, to minimise any risk of fire initiation or spread. However, the RP also states that the requirements of the RI fire strategy are yet to be included in the fuelling block and development of the layout for conventional safety and fire prevention will be considered in the design phase during DR3 as part of future work.
2. As the fire safety design of the fuelling block layout is not sufficiently developed to enable me to form a judgement on its adequacy, I will seek further information in Step 3.

#### Auxiliary and waste systems layout

1. In the Auxiliary and Waste Systems Layout Report (ref. [32]), the RP describes the two pressurised nodal stair cores at the north and south edges of the auxiliary block. The RP states that these are connected by a protected major circulation route across the eastern edge of the block (ref. [32]). As a result, the RP claims that the stair cores and major circulation provide safe access and egress to the process areas in line with BS 9999 (refs. [32], [20]).
2. In line with my Step 2 assessment scope, I am content that the described arrangement provides a suitable basis for detailed means of escape provision to be developed. The protected corridor, which is enclosed in CKoP concrete barriers, appears to provide protection to escape routes that is in line with RGP such as BS 9999 (refs. [32], [20]). I will seek further evidence in Step 3.

### Impacts of modularisation on fire safety design

1. The RP describes modularisation as a key enabler of the Rolls-Royce SMR build certainty philosophy and manufacturing process (ref. [33]) and considers that the appropriate use and deployment of the MKoP will also facilitate the plant to be laid out with the appropriate features in accordance with the E3S design principles.
2. For life fire safety, I have assessed the primary considerations for the structural element of the modular design which are its fire performance and ability to provide adequate fire separation.

#### Modular structural fire performance and integrity

1. In the MKoP Structure Standard Frame Design Definition, the RP states a requirement for structural fire protection as follows:

* MKoP frames shall retain structural integrity in the event of a design basis fire of duration four hours within the context of the final installation (ref. [34]).

1. This level of integrity, if achieved, would be bounding of BS 9999 requirements in all cases, and I therefore judge it be in line with RGP (ref. [20]).
2. The RP also states a desire to apply a risk assessment approach such as specified by BS 9999 to the layout, and to determine the duration of structural fire withstand on a case-by-case basis (ref. [34]). I am content that this would be an appropriate approach, apart from areas where internal hazards requirements exceed those of BS 9999. I will engage with ONR’s internal hazards assessors in Step 3 on this topic.
3. Four hours structural integrity in fire may be challenging to achieve for a bolted steel structure. However, the options presented by the RP, intumescent paint (which the RP states would only provide up to two hours protection) and boarded encasement, are commonly applied in the UK. The RP states a preference for a boarded solution and I judge that the reasoning presented is appropriate (ref. [34]).
4. I am content that structural fire performance has been adequately considered at this stage of design development, and that the RP has identified potentially suitable options to achieve it. However, the detail of this protection is yet to be provided and as such I am unable to make a judgement on its overall adequacy. In Step 3, I expect the RP to submit details of fire integrity requirements in specific locations, how these will be achieved and substantiating evidence for the systems employed.

#### Modular fire barriers

1. In the MKoP Barriers Design Definition document, the RP presents a concept design for fire barriers comprising of a steel sandwich panel with mineral wool infill (ref. [35]). The RP states that this system will provide four-hour integrity and insulation for nuclear fire barriers and a thinner variant will be used to provide two-hour integrity and insulation for life safety barriers (ref. [35]).
2. At this stage no final options have been selected by the RP on a location-specific basis. The integration of fire barriers within a module with the floor, ceiling and the structural steel is also still to be developed. The RP acknowledges the low maturity of this integration design as a concept risk (ref. [35]).
3. The RP states that fire analysis on barriers package systems will be performed in accordance with the Site Fire Strategy Document, (ref. [24]), supported by fire test where necessary. Integrated module fire testing is also identified as a key verification activity (ref. [35]). I expect appropriate fire analysis and test evidence to be presented in Step 3.
4. The concept designs described by the RP appear to be suitable to meet the fire separation requirements of BS 9999 (ref. [20]). The sandwich panel approach is not novel to the UK generally but is not commonly utilised on existing facilities. Certificated barrier solutions therefore do exist, but I expect the RP to present applicable validation and verification results for the fully integrated modular system . I am content that RGP can be met in this area but will require further evidence in Step 3.

### Demonstration of ALARP

1. The RP makes several claims that risks are reduced ALARP, however at this stage these are yet to be substantiated. In its ALARP Summary Report, the RP acknowledges this, concluding that the developing design is capable of reducing risks ALARP, but further work is required to fully demonstrate risk reduction to ALARP (ref. [36]).
2. For my Step 2 assessment I have sampled evidence of optioneering to seek confidence that the RP has adequate processes in place to reduce risks to ALARP in the developing design.
3. The RP presents an approach for the justification of departures from codes and standards in the Site Fire Strategy (ref. [24]). I am broadly content with the approach provided. However, I noted in RQ-01076 that the example given (generic departure for single ring main) contains multiple implicit assumptions that are not characterised, justified or assigned validation routes. In response to the RQ, the RP provided an improved treatment of assumptions which I judge to be adequate in line with NS-TAST-GD-005 guidance that a review route should exist to confirm that key assumptions remain valid, and that the design continues to meet them before the relevant approval (refs. [17], [40]). I expect the RP to meet this aspect of RGP in the Step 3 submissions addressing departures from code.
4. Furthermore, I have identified that the RP has a separate approach defined for design decision-making on the project as described in the ALARP Summary Report (ref. [36]).
5. I have sampled an example of the application of this process to the fire suppression system (ref. [49]). I am satisfied that the structured approach recorded and the involvement of multi-disciplinary stakeholders provides an adequate basis for the RP to conduct ALARP decision making in Step 3.
6. Noting the two distinct optioneering processes presented, the RP stated in response to RQ-01270 that the method presented in the site fire strategy will be used to address smaller departures with less cross-disciplinary impact where it may be disproportionate to apply detailed decision analysis and produce a complex decision record. The RP stated that where departures are identified and the relevant decision chair agrees, the rationale for departures identified and the options that were considered will be clearly and concisely documented within the Site or Building Strategy documents. The RP also stated that the design decision process will be used for significant, cross-cutting design decisions and that decision records will be referenced as part justification for specific departures where applicable (ref. [40]).
7. I am content that the described approach for optioneering and demonstration of ALARP is appropriate and proportionate in line with guidance in TAG NS-TAST-GD-005 that the depth and rigour of optioneering is expected to be proportionate to the associated risk (ref. [17]).
8. I will seek evidence of comprehensive identification of departures from codes and standards, and suitable and sufficient optioneering of solutions to these departures, in Step 3.

# Conclusions

## Conclusions

1. This report presents the Step 2 life fire safety assessment for the GDA of the Rolls-Royce SMR design. The focus of my assessment in this step was the fundamental adequacy of the design and safety case. I have assessed the Tier 1 E3S chapters and relevant supporting documentation provided by Rolls-Royce SMR Limited to form my judgements. I targeted my assessment, in accordance with my assessment plan (ref. [10]), at the content of most relevance to life fire safety against the expectations of British Standards, TAGs and other guidance which ONR regards as relevant good practice.
2. Based upon my assessment, I have concluded the following:

* The RP has identified adequate fire safety design principles to support the construction and operation of its design.
* The RP has identified suitable design codes and standards to support the construction and operation of its design.
* The RP has not yet adequately demonstrated that the generic design meets the requirements of the codes and standards it has selected. Nor has it comprehensively identified departures from these codes and standards and their mitigations and/or justifications (this activity falls into the scope of Step 3). As such, the RP has not yet demonstrated that risks are reduced to ALARP and this should be comprehensively addressed in Step 3.
* The DRP1 concept plant layout submitted by the RP is an adequate basis for future design development. While there are multiple areas where significant design development is needed to meet standards and requirements, I have not identified any fundamental issues that would preclude construction and operation at this stage. I note that the RP has primarily presented the reactor island with limited information relating to the remainder of the generic design and so I can only make a judgment on the adequacy of the reactor island design.
* The modularisation approach submitted by the RP does not present any fundamental fire safety concerns at this stage. My judgement in this area is predicated on the fact that the RP has identified requirements for a high degree of structural fire performance for all modular elements. In Step 3 the RP must present evidence that these requirements are, or can be, substantiated.
* The E3S case for fire safety, comprising the top tier chapter and the underlying documents, is adequate for this stage of design development. However, I have identified several shortfalls regarding internal consistency and design iteration. The fire strategies are not consistent with the layout reference design at this point. The layout has also not been fully reviewed against the fire requirements. In Step 3, I expect the RP to present a fully aligned E3S case, with suitable evidence presented in support of claims and requirements.

1. Overall, based on my assessment to date, and subject to the provision and assessment of suitable and sufficient supporting evidence, I have not identified any fundamental safety shortfalls that could prevent ONR’s permissioning of the construction of a power station based on the generic Rolls-Royce SMR design subject to an appropriate hold point control plan.

## Recommendations

1. My recommendations are as follows:

* Recommendation 1: ONR should consider the outcomes from my assessment as part of the decision to progress to Step 3 of GDA for the generic Rolls-Royce SMR design.

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