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Title

E3S Case Chapter 22: Conventional & Fire Safety

Executive Summary

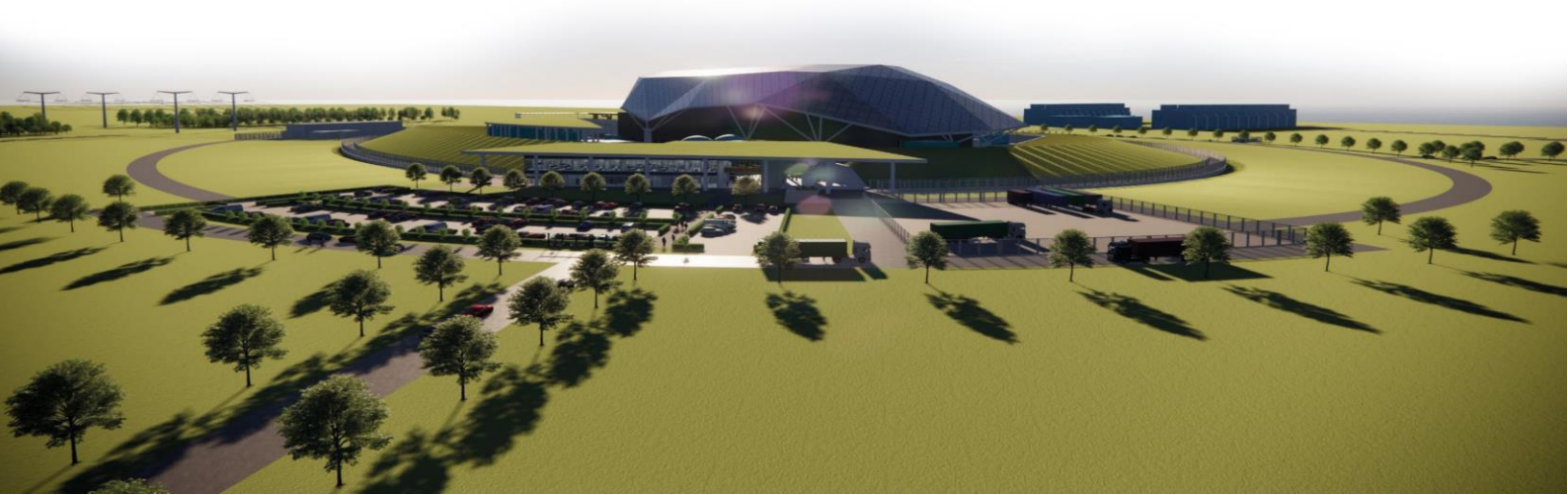
This chapter of the Environment, Safety, Security & Safeguards (E3S) Case presents the conventional and fire safety aspects of the Rolls-Royce Small Modular Reactor (RR SMR) at the Preliminary Concept Definition (PCD) stage of the design programme. The chapter provides the preliminary evidence supporting the Claim that the RR SMR is designed to eliminate, reduce, or control, so far as is reasonably practicable, the conventional health and safety and fire risks to workers and the public that may arise during the lifecycle of the plant.

The high-level RR SMR policies are described, including the relevant regulations, codes and standards for conventional and fire safety that are applicable to RR SMR. Strategies and processes for implementation of policies are also described, noting some key strategies such as the Construction (Design and Management) (CDM) strategy are still in development at PCD.

The outputs of processes are presented, where available at PCD, to demonstrate how conventional and fire safety is embedded into the design, with particular focus on how design decisions support compliance with conventional and fire safety codes and standards. Hazard identification studies have also been undertaken at PCD that have identified conventional and fire safety hazards, and measures to eliminate or mitigate them. Further conventional and fire safety assessments will be undertaken as the design is developed.

A preliminary set of design requirements have been established relating to conventional fire and human factors, to support development of design solutions. Further requirements, including those relating to conventional health and safety, will be developed in support of the future revision of the E3S Case.

For this stage of the project (the optioneering phase), no single design solution has been selected and all decisions will be revisited before a single solution is taken forward; therefore, the processes and procedures described in this Chapter sets the groundwork to support the position that RR SMR conventional health and fire safety risks are being identified and mitigated through design, noting further evidence to support the Claim is being developed through the ongoing design programme.



Contents

22.1 Introduction

22.1.1 Introduction to Chapter

Chapter 22 of the Rolls-Royce Small Modular Reactor (RR SMR) Environment, Safety, Security & Safeguards (E3S) Case forms part of the Pre-Construction Safety Report (PCSR), as defined in E3S Case Chapter 1: Introduction, Reference [1].

Chapter 22 presents the overarching summary and entry point to the information for the conventional and fire safety of the RR SMR to protect people and environment from non-radiological risk sources, as defined at Reference Design (RD) 5 level of design maturity.

Conventional Health and Safety and Conventional Fire Safety are split into two topic areas for RR SMR, however, the E3S Case has combined these topic areas into this chapter.

22.1.2 Scope

Physical Boundaries: Conventional Health and Safety

The scope of this report related to Conventional Health and Safety covers the following physical boundaries:

1. Reactor Island (RI) [R01]
2. Turbine Island (TI) [T01]
3. Cooling Water Island (CWI) [C01]

The following physical boundaries are excluded from scope of Conventional Health and Safety:

1. Site Factory
2. Balance of Plant (BoP) [B01]
3. Electrical, Control and Instrumentation (EC&I) [E01]
4. Rigs
5. The manufacturing facilities.

Physical Boundaries: Conventional Fire Safety

The scope of this report related to Conventional Fire Safety covers the physical boundary of the whole Nuclear Power Station (i.e., RI [R01], RI [T01], CWI [C01], BoP [B01], and EC&I [E01]).

Nuclear fire safety is excluded from the scope of Conventional Fire Safety, as this is covered by internal hazards in the E3S Case Chapter 15: Safety Analysis, Reference [2].

The constructability aspect of the Nuclear Power Plant, i.e., the plans and strategy for movement and connection of the RR SMR modules are covered within the RR SMR scope of Conventional and Fire Safety.

Lifecycle

The scope for Conventional and Fire Safety shall cover the following lifecycle phases:

1. Design
2. Maintenance
3. Plant Constructability

The following lifecycle phases are excluded from this Chapter, to avoid repetition, as Conventional and Fire Safety is included in other Chapters.

1. Operations (E3S Case Chapter 13, Reference [3])
2. Commissioning (E3S Case Chapter 14, Reference [4])
3. Decommissioning and End of Life Aspects (E3S Case Chapter 21, Reference [5])

Design/Programme Maturity

RR SMR information presented in this revision of the PCSR is largely based on the design definition at the end of Preliminary Concept Definition (PCD), which is an interim design stage representing RD5 level of design maturity. For more information on RD5, see E3S Case Chapter 1: Introduction, Reference [1].

At PCD, Conventional Health and Safety policies and processes are in place (described in Section 22.2), noting they are subject to continual improvement and further development. Of particular importance for Conventional Health and Safety, Construction Design and Management (CDM) arrangements are still being developed.

For the future revision of the E3S Case, CDM arrangements will be in place and captured in a CDM Strategy. Currently, Rolls-Royce SMR are acting as Principal Designer to plan, manage, monitor and coordinate health and safety in the pre-construction phase, including identifying, eliminating or controlling foreseeable risks; ensuring designers carry out their duties; prepare and provide relevant information to other duty holders and liaise with the principal contractor to help in the planning, management, monitoring and coordination of the construction phase.

As part of the on-going modularisation design, CDM conventional health and safety hazards have been captured, with the support of competent designers, evidence will be reported in the future revision of the E3S Case.

The concept for the site factory will be also developed and reported in a future revision of this report. The constructability aspects of the site factory will include consideration of conventional health and safety and environmental impacts, covering the scope of the size and number of cranes required to maximise production; a high-level construction schedule and high-level requirements for the construction site layout (for example, laydown areas, logistics centres, craneage and primary construction services).

22.1.3 Claims, Arguments, Evidence Route Map

The Chapter level Claim for E3S Case Chapter 22: Conventional and Fire Safety is:

Claim 22: The RR SMR is designed to eliminate, reduce, or control, so far as is reasonably practicable, the conventional health and safety and fire risks to workers and the public that may arise during the lifecycle of the plant

A decomposition of this Claim into Sub-Claims, Arguments, and link to the relevant Tier 2 Evidence will be presented in future revision of this report. The complete suite of evidence to underpin the Claims in the E3S Case will be generated through the RR SMR design and E3S Case programme and documented in the Claims, Arguments, Evidence (CAE) Route Map, Reference [6], described further in E3S Case Chapter 1: Introduction, Reference [1].

22.1.4 Applicable Regulations, Codes & Standards

Conventional Health and Safety

The RR SMR is being designed to ensure compliance with relevant regulations, codes and standards for Conventional Health & Safety, which represent Relevant Good Practice (RGP), please note this list is not exhaustive:

1. Health and Safety at Work Act 1974 (HSWA)
2. Management of Health and Safety at Work Regulations 1999
3. Construction (Design and Management) Regulations 2015
4. Lifting Operations and Lifting Equipment Regulations 1998
5. Provision and Use of Work Equipment Regulations 1998
6. Control of Substances Hazardous to Health Regulations 2002 (as amended)
7. Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)
8. Confined Spaces Regulations 1997
9. Dangerous Substances and Explosive Atmospheres Regulations 2002
10. Control of Major Accident Hazards Regulations 2015
11. Manual Handling Operations Regulations 1992
12. The Work at Height Regulations 2005
13. Safe use of lifting equipment: Lifting Operations and Lifting Equipment Regulations 1998: Approved Code of Practice (ACoP) and guidance L113
14. Safe work in Confined Spaces: Approved Code of Practice and guidance, L101

15. Managing health and safety in construction: Construction (Design and Management) Regulations 2015: Guidance on Regulations L153

16. The Control of Major Accident Hazards Regulations: Guidance on Regulations L111

17. Manual handling: Manual Handling Operations Regulations 1992: Guidance on Regulations L23

18. Legionnaires' disease The control of legionella bacteria in water systems. Approved Code of Practice and guidance on regulations L8

19. BS 5975: 2019 Code of Practice for Temporary Works

20. Workplace (Health, Safety and Welfare) Regulations 1992

21. The Control of Noise at Work Regulations 2005

22. The Electricity at Works Regulations 1989

23. Pressure Systems Safety Regulations 2000

Conventional Fire Safety

The RR SMR is being designed to ensure compliance with relevant regulations, codes and standards for Conventional Fire Safety, please note this list is not exhaustive but all legislation is covered in the design requirements for systems.

1. HSWA

2. Regulatory Reform (Fire Safety) Order 2005

3. Office for Nuclear Regulation (ONR) Technical Assistance Guide (TAG) – Internal Hazards

4. Western European Nuclear Regulators Association (WENRA) Safety Reference Levels for Existing Reactors

5. International Atomic Energy Agency (IAEA) – Protection against Internal Fires & Explosions in the Design of Nuclear Power Plants

6. Design Guidance - Approved Document B.

7. Design Guidance - British Standard (BS) 9999:2017 – Fire Safety in the Design, Management and use of Buildings – Code of Practice (BS 9999)

8. Design Guidance - British Standard 7974 – Parts 1 to 7

22.2 Conventional and Fire Safety

22.2.1 Introduction

This section presents the high-level documentation (e.g., policies, strategies, processes, guiding principles, requirements etc.) and the underpinning assessments that inform conventional and fire safety.

22.2.1 Conventional Safety Policies

RR SMR has the following conventional safety policies in place:

1. Health, Safety and Environment Policy, Reference [7]
2. Sustainability Policy, Reference [8]
3. Nuclear Safety Culture Policy, Reference [9]
4. RR SMR Human Factors Policy for Accommodating Humans into the Built Environment, Reference [10]. This policy covers the following:
    a. Policy statements to set the intent for Human Factors input into RR SMR design
    b. Human Factors requirements for the RR SMR design
    c. Reference to relevant standards
    d. Guidance for the application of Human Factors policy, requirements and standards to the RR SMR design.
    e. Guidance for the application of Human Factors policy, requirements and standards to the RR SMR design.

The health and safety policy sets out the general approach to health and safety, ambitions, accountabilities and explains management arrangements for health and safety in RR SMR.

The sustainability policy highlights commitments and responsibilities to safeguarding the environment, supporting people and the surrounding communities.

The Human Factors policy sets out the duties of the company to customers, supply chain and to future generations to ensure the highest standards and safest solutions achieve a healthy, mature, and sustainable Nuclear Safety Culture.

22.2.3 Conventional and Fire Safety Strategies

Construction, Design and Management Strategy

The CDM strategy is currently in development, which provides guidance to the business on CDM regulations (2015), see Reference [11]. The strategy covers:

1. The law that applies to the whole construction process on all construction projects, from concept to completion

2. What each dutyholder must or should do to comply with the law to ensure projects are carried out in a way that secures health and safety

3. Client Duties

4. Health and Safety Duties and Roles

5. General Requirements for all Construction Sites

Whilst the CDM strategy is in development, competent designers are considering CDM, evidence will be provided in the future revision of the E3S case.

Site Factory Dust Control Strategy

The RR SMR Site Factory has two key objectives:

1. Protect the site from the environment

2. Protect the environment from the site

The current proposal is to complete the major works associated with the RR SMR construction within the footprint of the main factory. Activities such as blasting, drilling and concreting carry with them a high risk of dust particles being released into the atmosphere. Reference [12] outlines the strategy for mitigating and managing this potential environmental and health hazard and can be summarised by the following actions:

1. Minimising concrete works resulting in dust emission by prefabricating elements

2. The use of clean zones within the factory area & cleaning facilities for operatives

3. The use of electrical plant and handheld tools to minimise emissions

4. Vaulted entrances to act as ‘air locks’ between the internal and external environments

Further development on the conventional health and safety aspects associated with constructability of the RR SMR will be reported in future revisions of the E3S Case.

Target Audience Description

The Target Audience Description (TAD) document provides a description of the anticipated capabilities of the intended user population, providing a basis for requirements allocated to design teams.

The TAD (or ‘user profile’) is a description of the different types of operators that will interact with the RR SMR facility, systems and equipment, and their capabilities and physical characteristics.

The overall aim of the TAD is to convey the physical characteristics and design constraints arising from a defined, future ‘user population’, to help ensure the design of the SMR facility, systems and equipment adequately accommodates the operators.

The TAD will be developed for the future revision of the E3S Case and will be summarised in E3S Case Chapter 18: Human Factors Engineering, Reference [13].

Conventional Fire Strategies

A Site-Wide Fire Strategy, Reactor Island Fire Strategy, Turbine Island Fire Strategy will be developed for the future revision of the E3S Case.

22.2.4 Conventional and Fire Safety in Design: Processes

The following processes (and associated assessments, see Section 22.2.5) are in place to implement Conventional and Fire Safety Strategies (including CDM) reduce risks to As Low As Reasonably Practicable (ALARP).

Conduct Design Optioneering Process C3.2.2-2

This process generates design concepts and performs structured selection from them to reach a preferred solution. The process aims to ensure that RGP is identified and considered, that there is traceability in the decision-making process, that all necessary stakeholders are involved, and that the decision is formally approved and recorded (i.e., decision files).

Engineer safe, secure, safeguarded and environmentally sound products Process C3.2.2-3

The engineering of safe, secure, safeguarded and environmentally sound products is an iterative process that develops with the design, identifying gaps against E3S principles (see Reference [14]), requires design work to address them (i.e., Hazard Identification (HAZIDs), Hazard and Operability studies (HAZOPs), Hazard Log, internal hazard layout reviews, human factors assessments).

Definition Review (DR) Process C3.2.1-2

This process is used to provide technical governance for the development of product Structures, Systems and Components (SSCs) throughout the design lifecycle. It ensures a multi-disciplinary review of the SSCs at key points in its definition such that corrective actions can be taken as required. These reviews are chaired by delegates of the Chief Engineer who are independent from the work that is being reviewed. This process is repeated at each DR gate review in line with the governance plan (i.e., associated DR checklists and minutes).

Design for Conventional Health and Safety Process C3.2.2-4

This process is used to identify Conventional Safety requirements and demonstrate compliance (i.e., Health, Safety and Environment Checklists and Risk Assessments of Significant Hazards).

Define and Manage Requirements Process C3.1.1

This process defines, develops, documents and releases a set of clear and consistent requirements that address the needs of all stakeholders. The method seeks to ensure that all lifecycle stages are considered and that an agreed set of requirements is available against which a design solution can be developed and verified. Requirement definition is not necessarily linear and is inherently iterative, and so this process will be revisited many times

throughout design (via the Dynamic Object-Orientated Requirements System (DOORS) requirements management database).

22.2.5 Conventional and Fire Safety in Design: Assessments

Design Decisions

The processes set out in Section 22.2.4 are implemented through the systems engineering design process outlined in E3S Case Chapter 1: Introduction, Reference [1]. A (non-exhaustive) list of design decisions with conventional and fire safety considerations are summarised below, including the relevant conventional health and safety codes and standards that the decision supports, noting further work is required to demonstrate full compliance (e.g., Health, Safety and Environment Checklists and Risk Assessments of Significant Hazards).

1. Site Factory Concept Review, Reference [15], determined that a site factory concept is a baseline supporting constructability and compliance with: HSWA; CDM regulations; Regulatory Reform (Fire Safety) Order 2005; Lifting Operations and Lifting Equipment Regulations 1998; Manual Handling Operations Regulations

2. Mechanical Handling Systems, Reference [16], selected the use of the following equipment, supporting compliance with: HSWA; CDM regulations, Provision and Use of Work Equipment Regulations and Lifting Operations and Lifting Equipment Regulations 1998:

    a. Mobile mechanical handling equipment for all lifting, handling and inspection operations involving less than 2te weight

    b. Fixed mechanical handling system for the CWI pumphouses, general storage areas / workshop for lifting operations with loads greater than 2,000kg

3. Turbine Building Electric Overhead Travelling (EOT) Crane Sizing, Reference [17] and Turbine Building EOT Crane, Reference [18], selected a permanent major outage EOT Crane, based on Operating Experience (OPEX) and industry standards supporting compliance with HSWA; CDM regulations and Lifting Operations and Lifting Equipment Regulations 1998

4. Water Supply System, Reference [19], selected the use of mains water (potable water), supporting compliance with HSWA; CDM regulations; Legionnaires' disease: the control of legionella bacteria in water systems and Control of Substances Hazardous to Health Regulations)

5. Cooling Tower (CT) arrangement, Reference [20], supporting compliance with HSWA; CDM regulations; Legionnaires' disease: the control of legionella bacteria in water systems and Control of Substances Hazardous to Health Regulations

6. CT Model Decision, Reference [21], Cooling Medium, Reference [22] and Submerged Filter, Reference [23], supporting compliance with HSWA; CDM regulations; Legionnaires' disease: the control of legionella bacteria in water systems and Control of Substances Hazardous to Health Regulations

7. System Sizing (Air Conditioning), Reference [24], System Architecture – Air Conditioning Systems, Reference [25], System Architecture – Heating Systems, Reference [26], System Architecture – Ventilation Systems, Reference [27], System Architecture – Heating and Venting and Air Conditioning Systems, Reference [28], Buildings Requiring HVAC,

Reference [29] and Chilled Water System, Reference [30]. supporting compliance with HSWA; CDM regulations and Control of Substances Hazardous to Health Regulations

8. Stator/Rotor Primary Cooling with Hydrogen as a Coolant Validation, Reference [31], which selected a hydrogen cooling system for the main generator, supporting compliance HSWA; Dangerous Substances and Explosive Atmospheres Regulations

9. System Sizing (fire systems), Reference [32], Turbine Building General (various floors - fires), Reference [33] and Main Cooling Water System – Buildings (fire), Reference [34]. The following decisions support compliance with HSWA; Regulatory Reform (Fire Safety) Order 2005; CDM regulations; Approved Document B; British Standard (BS) 9999:2017; British Standard 7974 – Parts 1 to 7:

    a. Class A fires will be extinguished using a Fire water system that will be centralised

    b. Class B, C, Electrical and Class F fires will use localised fire extinguishing systems

    c. Class B Fires will use Foam extinguishing

    d. Class C Fires will use Inert Gas extinguishing (however, handheld portable fire extinguishers may use dry powder)

    e. Electrical Fires will use Inert Gas extinguishing

    f. Class F Fires will use Wet Chemical extinguishing

Further details of the decisions described above are presented in Reference [35].

Conventional Health and Safety Checklists

The Health and Safety Checklists are used to create informed Designers Risk Assessments (DRA) and risk registers enabling clear communication and management of significant risks.

The checklist guides users to identify relevant legislation, specific hazards and mitigation measures (including environment conditions). The implementation of Health and Safety Checklists is still in development.

The Health and Safety Checklists identify hazards associated with the following lifecycle of the product:

1. Manufacture
2. Construction
3. Installation
4. Commissioning
5. Operation
6. Maintenance
7. Decommissioning

8. Construction (Design and Management)

HAZID/HAZOP Assessments

The requirement to formally identify and assess hazards, provide control and protection features, and demonstrate their suitability forms the basis of any safety justification. As such, robust hazard and fault identification is essential to any demonstration of safety.

Hazard identification relies on a structured and systematic approach to identify potential hazards and are undertaken early in the design process and throughout design development. The aim is to ensure that the site and plant layouts eliminate or minimise the potential for detrimental effects should hazards materialise. Risks to conventional health and safety are part of the hazard identification process. HAZOPs are multi-disciplinary with E3S as key stakeholders. More information on the HAZOP process is provided in the Hazard Identification Strategy, Reference [36].

The following conventional and fire safety guidewords are considered during hazard identification workshops:

1. Pressure / Explosion
2. Dropped Load / Impact
3. Fire
4. Conventional Safety
5. Chemotoxic
6. Transport / Remote Handling

The following highlights some HAZIDs / HAZOPs / Structured What If Technique (SWIFT) assessments relevant to conventional and fire safety:

1. Turbine Missile Protection HAZID, Reference [37]: the potential consequences following ejection of a Low Pressure (LP) turbine blade under fault conditions
2. Turbine Island Fire and Explosion HAZID, Reference [38]
3. Effluent Treatment and Water System HAZID, Reference [39]
4. Turbine Island Main Crane SWIFT, Reference [40]
5. Reactor Island Mechanical Handling – SWIFT Workshop 1, Reference [41]

Internal Hazards Assessments

For PCD, internal hazards have captured the following conventional and fire safety hazards for areas within Reactor Island (see list below). Assessment of these hazards is described in the E3S Case Chapter 15: Safety Analysis, Reference [2].

1. Fire

2. Steam Release

3. Flammable Material

4. Blast / Missile

5. Dropped Loads

The identification of high-level conventional and fire safety hazards, and mitigating measures, inform design decisions on layout. Decisions on layout include multi-disciplinary stakeholders (including Human Factors to discuss the impacts of internal hazards on operators). Additional Internal Hazard work to support the on-going design development will be presented in a future revision of the E3S Case as evidence in the CAE Route Map becomes available.

22.2.6 Conventional and Fire Safety in Design: Requirements

Conventional Health & Safety Requirements

Conventional health and safety requirements for the design are being developed from RGP and OPEX outlined in the policies and strategies described in Section 22.2.1, as well as assessments as described in Section 22.2.5. These requirements will be assigned to SSCs through the DOORS requirements management database and verified as part of engineering process C3.2.3: Verify Product, System and Component Design. Requirements will be reported in Issue 2 of the E3S Case.

All requirements must be in place by DR3, for more information on the DR Process, see Engineering Process C3.2.1-2.

Conventional Fire Safety Requirements

A preliminary set of requirements for fire engineering has been developed as guidance for the design development, see Reference [42], covering the following areas:

1. Fire Prevention, including requirements for minimising use of combustible materials and control of ignition sources (e.g. electrical system protection, lightning protection etc.)

2. Fire Detection, including requirements for fire detection equipment specifications and locations

3. Fire Suppression, including requirements for use of fire suppression systems (and fire extinguishers where applicable), with consideration of other drivers and risk factors (e.g., increased risk of flooding, contribution to waste streams in high radiation/contamination areas etc.)

4. Mitigation of the Effects of Fire, including requirements for compartmentation, fire barrier resistance durations for civil structures, and HVAC measures to defend against the spread of fire and smoke

5. Means of Escape, including requirements for acceptable escape methods, travel distance and number of routes, signage, and lighting

6. Access & Facilities for Firefighting, including requirements for emergency access provisions, water supplies and pumping arrangements, and communications systems

A Fire Basis of Design (BoD) is planned for development that will incorporate further requirements for fire protection and fire extinguishing. The full suite of preliminary fire safety requirements will be described in the Site-Wide Fire Strategy and inform the future revision of the E3S Case.

Human Factors Requirements

Human factors consider ergonomics in design. The following Human Factors design requirements are defined for health and safety for the RR SMR, based on Reference [10].

1. The RR SMR shall ensure that risks to all populations from substances are reduced to As Low ALARP

2. The RR SMR shall ensure that risks to all populations from adverse working environment conditions are reduced to ALARP

3. The RR SMR shall ensure that risks to all populations from structures, systems or components are reduced to ALARP

4. The RR SMR shall ensure that risks to all populations from high energy items are reduced to ALARP

5. The RR SMR shall ensure that risks to all populations from the movement of items are reduced to ALARP

6. The RR SMR shall ensure that risks to all populations from trip hazards are reduced to ALARP

7. The RR SMR shall ensure that risks to all populations from working at height are reduced to ALARP

8. The RR SMR shall ensure that risks to all populations from work in confined spaces are reduced to ALARP

9. The RR SMR shall minimise the number of tasks to be conducted by an operator outside of a neutral posture

10. The RR SMR shall ensure that risks to all populations from manual handling are reduced to ALARP

11. The RR SMR shall reduce the force that must be applied from any user for task completion to ALARP.

A summary of the considerations for human factors considerations at PCD can be found in Reference [43]. Reference [44], summarises the spatial designation for stairs and lifts for Reactor Island containment access.

22.2.7 Conventional and Fire Safety in Design: Substantiation

Substantiation of conventional and fire safety requirements (see Section 22.2.6) will be captured in the DOORS following as part of the verification of SSCs, in line with engineering process, C3.2.3: Verify, Product, System and Components Design.

22.2.8 Mitigation Measures for Conventional and Fire Safety in Design

At the PCD stage, hazard identification work has been carried out which has identified conventional hazards to personnel and associated measures that can be put in place to reduce or mitigate them within the RR SMR design, see Section 22.2.5.

Further conventional and fire safety work will cover topics such as:

1. Monitoring and managing stagnant water sources to eliminate the risk of legionella (e.g., HSWA; The control of legionella bacteria in water systems. Approved Code of Practice and guidance on regulations L8)

2. Limiting the amount of toxic substances used and stored on the plant (e.g., HSWA; REACH; Control of Substances Hazardous to Health Regulations)

3. Limiting the amount of explosive substances used on the plant and ensuring that they are stored correctly (e.g., HSWA; Dangerous Substances and Explosive Atmospheres Regulations)

4. Minimising exposure of personnel to hazardous substances by automating processes (e.g., HSWA; REACH; Control of Substances Hazardous to Health Regulations).

The strategy for ensuring fire (life) safety will include similar measures for nuclear fire safety, such as fire barriers and use of non-combustible materials, however life safety also considers provisions for escape of personnel and accessibility for emergency authorities.

The design of fire (life) protection measures will consider the drivers behind engineering decisions from other disciplines to reduce risk holistically in line with the ALARP principle, particularly when placing requirements on the design, see Reference [42]. The key interfaces for the fire (life) safety area include:

1. Internal Hazards: fire suppression systems often present a hazard in the form of internal flooding; thus installation of fire suppression systems is only specified for key high fire load targets, with requirements derived from the internal hazards topic area

2. Heating, Ventilation and Air Conditioning (HVAC): the HVAC system for the site will be responsible for multiple functions related to fire protection, including smoke purging, firefighting shaft pressurisation and fire/smoke damper closure etc. The layout of the HVAC system and protection measures afforded to its components therefore influence and will be considered in the resilience of the overall fire (life) safety

3. Human Factors: for fire (life) safety requirements that are related to human performance (e.g. to ‘make-safe’ a lifting operation upon sounding of the fire alarm before evacuation), human factors engineering input will be sought

4. Radiological Protection: typical fire (life) safety measures, such as additional exit doors, may not reduce overall risk to personnel if this increases the overall worker dose. The door location, type and access/locking arrangements will need to be considered in any cases where personnel are required to move between controlled and non-controlled areas

5. Security: fire (life) strategies for personnel egress and firefighter access will consider security requirements for these areas

6. Operations & Maintenance: the additional risk of installing fire (life) safety measures in rarely accessed, hard to reach, high radiation or underground spaces will be considered

7. Roads & Networks: the site networks such as fire hydrants, drainage and roadways will be considered in the site fire engineering strategy

8. Emergency Preparedness: the arrangements for plant response during a nuclear emergency will need to interface with those for a fire emergency.

22.2.9 Mitigation Measures for Conventional and Fire Safety: In Construction

All identified conventional health and fire safety risks are escalated from assessments (see Section 22.2.5) and captured in a Health and Safety Risk Register; these risks form part of the Health and Safety Technical File which is passed over to the future operator.

22.3 Conclusions

22.3.1 ALARP

The RR SMR is being developed in accordance with the systems engineering design process, which supports minimisation of conventional and fire safety risks to ALARP. At PCD, the following evidence supporting risk reduction includes:

1. Development of strategies and policies to minimise conventional risks based on UK and international RGP & OPEX (described in sections 22.2.1 & 22.2.3), and establishing processes to embed these strategies and policies into the design as part of systems engineering processes (described in Section 22.2.4)

2. Systematic optioneering and assessment to implement processes, with down-selection of design options based on assessment against relevant E3S criteria, including conventional and fire safety (the outputs of relevant design decisions at PCD are listed in Section 22.2.5)

3. Development of conventional and fire safety requirements from strategies, policies, and assessments, that are placed onto the design to ensure the design solution incorporates appropriate measures to prevent or mitigate risks (in line with hierarchy of control (described in Section 22.2.6, noting requirements are still being developed at PCD)

The above supports the overall demonstration that risks can be reduced to ALARP, noting further evidence will be provided as the design and supporting assessments are developed.

22.3.2 Conclusions

Preliminary evidence is presented to support the overall claim that 'The RR SMR is designed to eliminate, reduce, or control, so far as is reasonably practicable, the conventional health and safety and fire risks to workers and the public that may arise during the lifecycle of the plant', which contributes to the overall E3S objective to protect people and the environment from harm, and the demonstration that risks are reduced ALARP.

22.3.3 Assumptions & Commitments on Future Dutyholder

None identified at this revision.

22.4 References

[1] RR SMR Report, SMR0004294/001, “E3S Case Chapter 1: Introduction,” March 2023.
[2] RR SMR Report SMR0003977/001, “E3S Case Chapter 15: Safety Analysis,” March 2023.
[3] RR SMR Report SMR0004247/001, “E3S Case Chapter13: Conduct of Operations,” March 2023.
[4] RR SMR Report, SMR0004289/001, “E3S Case Chapter 14: Commissioning,” March 2023.
[5] RR SMR Report SMR0004599/001, “E3S Case Chapter 21: Decommissioning and End of Life Aspects,” March 2023.
[6] RR SMR Report, SMR0002155/001, “E3S Case Route Map,” March 2023.
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22.4 Acronyms and Abbreviations

ACoP	Approved Code of Practice
ALARP	As Low As Reasonably Practicable
BoD	Basis of Design
CAE	Claims, Arguments, Evidence
CDM	Construction Design and Management
CT	Cooling Tower
CWI	Cooling Water Island
DR	Definition Review
DRA	Designers Risk Assessments
DOORS	Dynamic Object-Orientated Requirements System
E3S	Environment, Safety, Security and Safeguards
EC&I	Electrical, Control and Instrumentation
EOT	Electric Overhead Travelling
HAZID	Hazard Identification
HAZOP	Hazard and Operability Study
HSWA	Health and Safety at Work Act
HVAC	Heating, Ventilation and Air Conditioning
OPEX	Operating Experience
PCD	Preliminary Concept Definition
PCSR	Pre-Construction Safety Report
RD	Reference Design
RI	Reactor Island
RGP	Relevant Good Practice
RR SMR	Rolls-Royce Small Modular Reactor

SSC	Structure, System, Component
SWIFT	Structured What If Technique
TAD	Target Audience Description
TI	Turbine Island