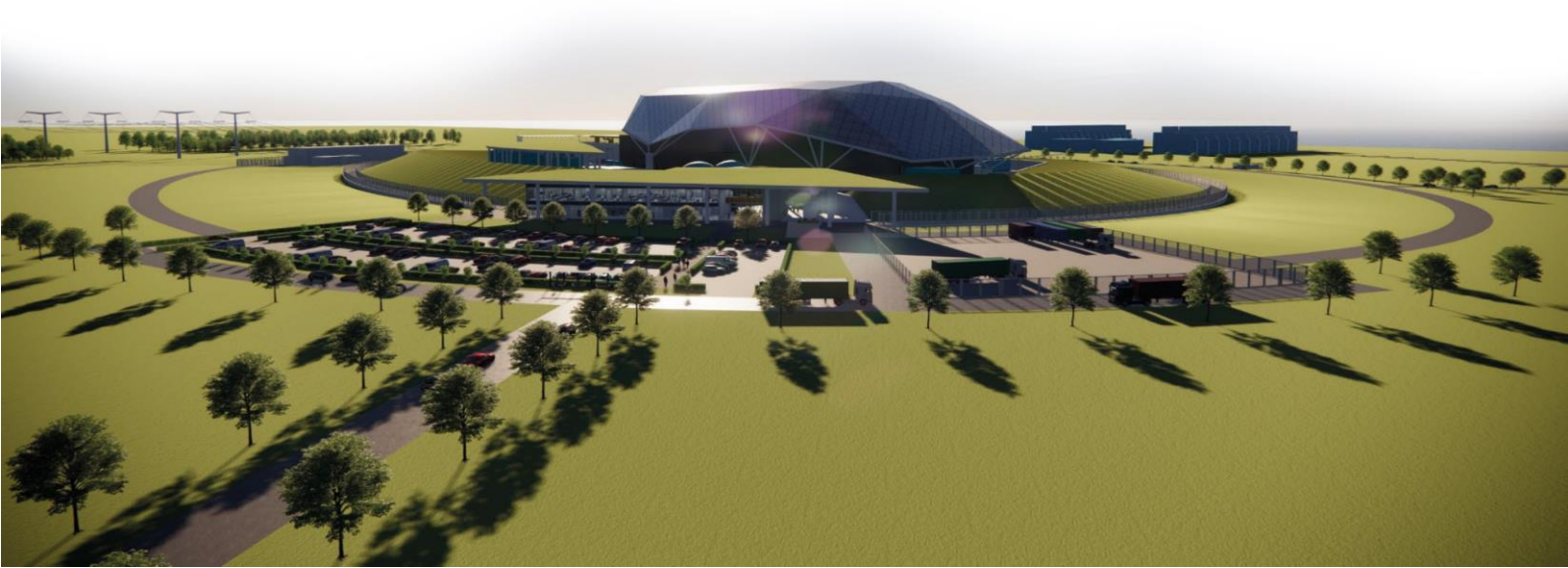
Environment, Safety, Security and Safeguards Case Version 2, Tier 1, Chapter 16: Operational Limits and Conditions



Record of Change

Date	Revision Number	Status	Reason for Change
March 2023	1	Issue	First issue of E3S Case
February 2024	2	Issue	Incorporates revised approaches defined at Reference Design 7, aligned to Design Reference Point 1, including the inclusion of: • Concept of Operations [1] • Severe Accident Management Strategy [2] This report also reflects updates to: • Deterministic Safety Case- Methodologies [3]
May 2024	3	Issue	Updated to correct revision history status at Issue 2. Chapter changes include: • Clarification in section 16.1.1 linking to E3S Design Principles • Additional detail within conclusion section for how arguments and evidence presented meet the generic E3S objective Also minor template/editorial updates for overall E3S Case consistency.

Executive Summary

This chapter of the Environment, Safety, Security and Safeguards (E3S) Case for the Rolls-Royce Small Modular Reactor (RR SMR) will ultimately present the arguments and evidence to support the claim that operational limits and conditions (OLCs) are defined by the design and safety analysis to enable safe operation of the RR SMR.

This revision presents information available at the Design Reference Point (DRP) 1, including the principles and basis for development of OLCs. As the design progresses, OLCs will be defined along with the processes to ensure they are transferred into operational documentation.

Contents

16.0 Introduction to Chapter

16.0.1 Introduction

Chapter 16 of the Rolls-Royce Small Modular Reactor (RR SMR) generic Environment, Safety, Security and Safeguards (E3S) Case presents the overarching summary and entry point to the operational limits and conditions (OLCs) of the RR SMR.

16.0.2 Scope and Maturity

Version 2 of the generic E3S Case is based on reference design 7 (RD7), corresponding to design reference point 1 (DRP1) for the generic design assessment (GDA). At RD7, OLCs for the RR SMR are still in development through the specification of requirements in the design and safety analysis. The scope of this chapter covers the bases for development of OLCs, (including the principles to define OLCs in the design and safety analysis). The process for capturing OLCs into operational documentation is under development and will be reported in future issues of the E3S Case.

Details of the operational documentation (including procedures and technical specifications) that will be developed to enable the future dutyholder/licensee/permit holder to implement the OLCs and ultimately demonstrate compliance, will be covered in E3S Case Version 2, Tier 1, Chapter 13: Conduct of Operations [4], and not within the scope of this chapter.

The design and operation of site factories, siting aspects and land quality management are not set by the generic design and are all out of scope of the generic E3S Case.

16.0.3 Claims, Arguments and Evidence Route Map

The overall approach to claims, arguments, evidence (CAE) and set of fundamental E3S claims to achieve the E3S fundamental objective are described in E3S Case Version 2, Tier 1, Chapter 1: Introduction [5]. The associated top-level chapter claim for E3S Case Version 2, Tier 1, Chapter 16: Operational Limits and Conditions is:

Claim 16: Operational limits and conditions are defined to enable safe operation of the RR SMR.

A decomposition of this claim into sub-claims, and mapping to the relevant Tier 2 and Tier 3 information containing the detailed arguments and evidence, is presented in the E3S Case Route Map [6]. Given the evolving nature of the E3S Case alongside the maturing design, the underpinning arguments and evidence may still be developed in future design stages; the trajectory of this information, where possible, is also illustrated in the route map, which aligns the anticipated arguments and evidence to future issues of the generic E3S Case (subject to ongoing planning).

A proportionate summary of the arguments and evidence from lower tier information, available at the current design stage, is presented within this chapter. A mapping of the claims to the corresponding sections that summarise the arguments and/or evidence is provided in Appendix A (section 16.4).

16.0.4 Applicable Regulations, Codes and Standards

The International Atomic Energy Agency (IAEA) requirements and guidance relevant to OLCs include:

- IAEA Safety Standards Series No.SSR-2/2(Rev.1) [7]
- IAEA SSG-70: Operating Limits and Conditions and Operating Procedures for Nuclear Power Plants [8].

Western European Nuclear Regulators' Association (WENRA) Safety Reference Levels for Existing Reactors [9], and the United States Nuclear Regulatory Commission (US NRC) Standard Technical Specifications - Westinghouse Plants (NUREG-1431) [10] also provide relevant good practice (RGP) related to development of OLCs. At RD7/DRP1 the OLCs are being developed. The process for this development is presented in section 16.1.3.

In Great Britain, the Office for Nuclear Regulation's (ONRs) Safety Assessment Principles (SAPs) [11] and Technical Assessment Guide (TAG) 035 [12], outline the regulatory expectations that are applicable to the development of OLCs.

It is noted that RR SMR utilise the terminology of OLCs consistent with IAEA terminology, whilst the ONR use the equivalent term Limits and Conditions (Operating Rules) (LCOs).

16.1 Bases for Development

16.1.1 E3S Design Principles

The RR SMR E3S Design Principles [13], state that the design definition should include the OLCs which define the conditions that must be met to prevent situations that might lead to initiating events or to mitigate the consequences of initiating events should they occur.

Adequate margins should be ensured between operational limits and the established classified systems settings, to avoid undesirably frequent actuation of systems. Limits should be established using a conservative approach to take uncertainties in the analyses into account.

OLCs should include limits on:

- Operating parameters
- Material parameters
- Chemistry parameters
- Environmental parameters
- Storage, movement, and treatment of nuclear matter
- Stipulation for minimum amount of operable equipment
- Minimum staffing levels
- Actions to be taken by the operators in the event of deviations from the operational limits and conditions and the time allowed to complete each of these actions.

Where operability requirements cannot be met or ascertained, or the plant behaves in an unexpected way, the actions to bring the plant to a safer state should be specified, and the time allowed to complete the action should be stated.

Adequate margins should be ensured between operational limits and the established classified systems settings, to avoid undesirably frequent actuation of systems. Limits should be established using a conservative approach to take uncertainties in the analyses into account.

The RR SMR E3S Design Principles [13] provides refence to the RGP used as guidance when specifying the OLCs' principle.

16.1.2 Concept of Operations and Operating Philosophies

The Concept of Operations [1] (ConOps) provides an overview of the role of the operator within the context of the RR SMR. It details the intended operation of RR SMR through the operating modes and plant states from the perspective of the operator. The ConOps provides context to Human Factors (HF) assessments by providing an early definition of the role of the operator. HF analysis is being undertaken [14], results of this will allow refinement of the operating philosophies, that are being developed to communicate the key principles related to operation of the RR SMR, and the proposals for operation to align with the requirements of the E3S Case.

Further details of RR SMR operating philosophies are included in E3S Case Version 2, Tier 1, Chapter 13: Conduct of Operations [4].

16.1.3 Flow of E3S Requirements into Operations

The Deterministic Safety Methodologies [3] provides a high-level description of how OLCs will flow from safety requirements derived in the analysis. It identifies Figure 1 taken from ONR TAG 035 [12] as a useful illustration on hierarchical approach at which OLCs should be set, as well as NUREG-1431 [10] that can be used as good practice and a checklist when identifying OLCs. Equivalent methodologies are being developed for environmental, security and safeguards aspects of RR SMR.

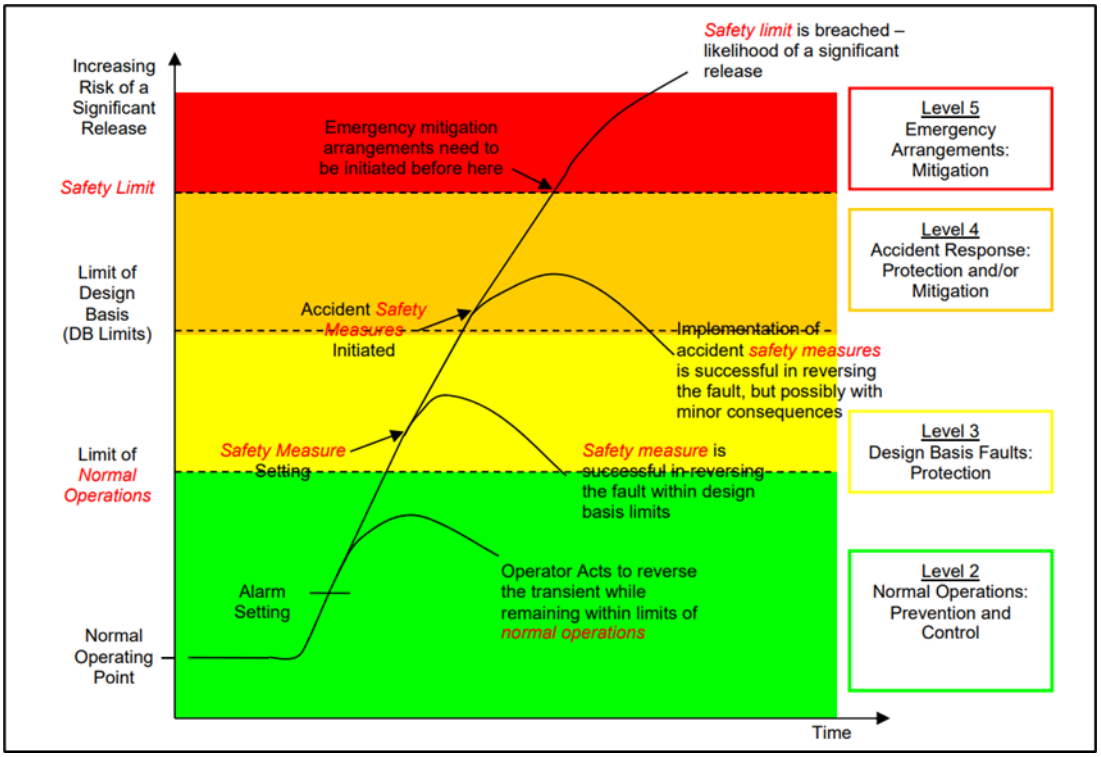


Figure 16.1-1: Illustration for setting OLCs

Broadly, OLCs stem from the following sources/fall into the following categories:

- Safety limits or important assumptions that are made in the performance analysis. Examples are:
  - 'Shutdown margin shall be within xxx limit'
  - 'The measured core reactivity shall be within ± yyy of predicted values'
- The number of redundancies of safety systems that shall be available, or performance requirements (volumes, concentrations) of safety systems. Examples are:
  - 'Three reactor coolant system loops shall be operable and in operation'
  - 'Three accumulators shall be operable'.

Further action conditions will also be specified for each OLC, derived from further safety assessment considerations, such as probabilistic analysis and sensitivity studies.

OLCs will be identified from the requirements and definitions defined in the requirement management database against each system. Dependent upon the system, these currently identify Safety Limits, the Limit of Design Basis and/or the Limits of Normal Operation, as shown in Figure 16.1-1. Adequate margins will be identified from these limits as applicable.

Action Times will be identified from deterministic fault studies and the Probabilistic Safety Assessment. These will jointly be defined in Technical Specifications for the RR SMR.

16.1.4 Development of Technical Specifications and Operating Procedures

As the RR SMR design progresses the safety analyses, as described in E3S Case Version 2, Tier 1, Chapter 15: Safety Analysis [15], will lead to the derivation of Operating Rules and OLCs. These will inform the development of Technical Specification Bases, Technical Specifications and Operating Procedures for the entire life cycle of the RR SMR, over all modes of power operation. An illustration of information flow through the documentation that leads to the production of operating procedures is provided in Figure 16.1-2. Operating procedures will be sub-divided into normal operating procedures, abnormal operating procedures and severe accident management guidelines.

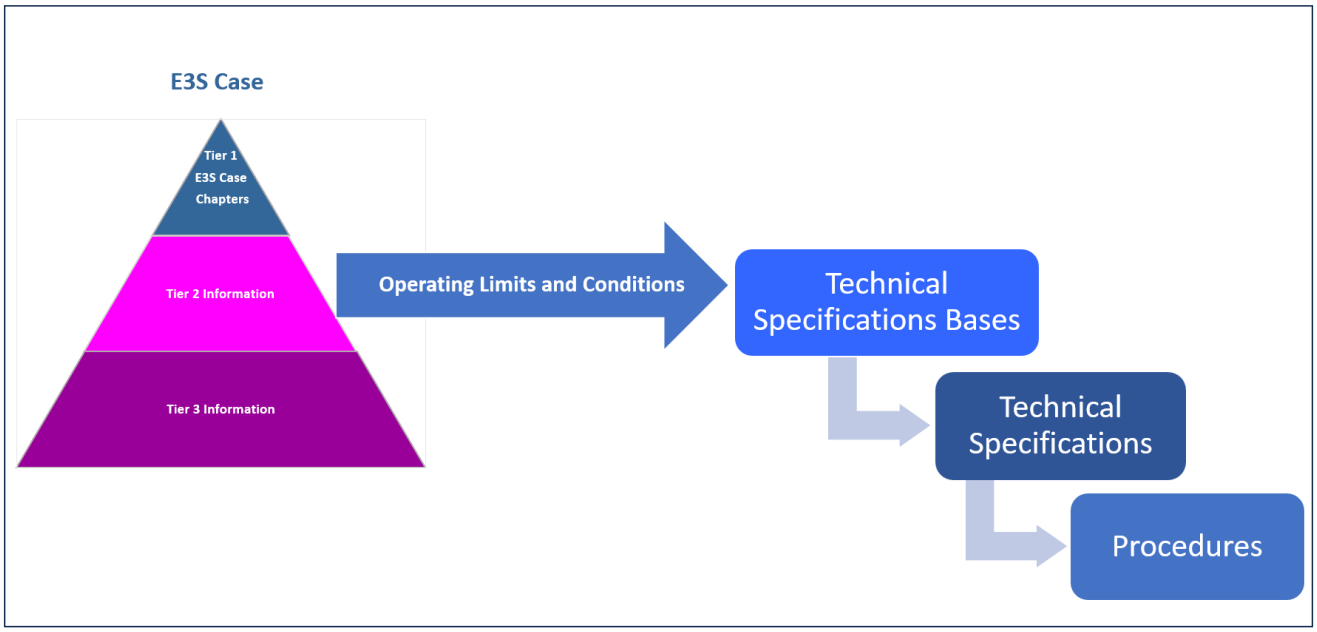


Figure 16.1-2: Information flow through operational documentation

16.2 Conclusions and Forward Look

16.2.1 ALARP, BAT, Secure by Design, Safeguards by Design

The process to define OLCs and the definition of OLCs will enable the Future Dutyholder / Licensee / Permit Holder to operate the plant safely in a manner that reduces risks to as low as reasonably practicable (ALARP), apply best available techniques (BAT) and ensure security by design and safeguards by design.

16.2.2 Assumptions and Commitments on Future Dutyholder

None identified in this revision.

16.2.3 Conclusions and Forward Look

The generic E3S Case objective is 'to provide confidence that the RR SMR design will be capable of delivering the E3S fundamental objective as it developed from a concept design into a detailed design'. This confidence is built through development and underpinning of top-level claims across each chapter of the E3S Case, through supporting arguments and evidence. The top-level claim for chapter 16 is '*Operational limits and conditions are defined to enable safe operation of the RR SMR*'.

The arguments and evidence presented in Version 2 of E3S Case chapter 16 are limited to definition of the high-level process for definition of OLCs from the design and E3S analyses.

Further arguments and evidence will be developed in line with the E3S Case Route Map and reported in future revisions of the generic E3S Case, which will further build confidence that the RR SMR can deliver its fundamental E3S objective. This broadly includes examples of OLCs based on good practice and operational experience from existing pressurised water reactors, and ultimately the implementation of the process to define OLCs for the RR SMR.

16.3 References

[1] Rolls-Royce SMR Limited, SMR0005048 Issue 1, “Concept of Operations,” March 2023.

[2] Rolls-Royce SMR Limited, SMR0005258 Issue 1, “Severe Accident Management Strategy,” May 2023.

[3] Rolls-Royce SMR Limited, SMR0000531 Issue 2, “Deterterministic Safety Case-Methodologies,” January 2024.

[4] Rolls-Royce SMR Limited, SMR0004247 Issue 3, “Environment, Safety, Security and Safeguards Case Version 2, Tier 1, Case Chapter 13: Conduct of Operations,” May 2024.

[5] Rolls-Royce SMR Limited, SMR0004294 Issue 3, “Environment, Safety, Security and Safeguards Case Version 2, Tier 1, Chapter 1: Introduction,” May 2024.

[6] Rolls-Royce SMR Limited, SMR0002155 Issue 3, “E3S CAE Route Map,” November 2023.

[7] International Atomic Energy Agency, SSR-2/2 (Rev 1), “Safety of Nuclear Power Plants:Commissioning and Operation,” February 2016.

[8] International Atomic Energy Agency SSG-70, “Operating limits and conditions and Operating Proceedures for Nuclear Power Plants,” September 2022.

[9] WENRA, “WENRA Safety Reference Levels for Existing Reactors,” 2020.

[10] USNRC NUREG-1431, Revision 5, Standard Technical Specifications – Westinghouse Plants, 2021.

[11] Office for Nuclear Regulation, “Safety Assessment Principles for Nuclear Facilities,” January 2020.

[12] Office for Nuclear Reglation NS-TAST-GD-035, “Limits and Conditions for Nuclear Safety (Operating Rules),” March 2018.

[13] Rolls-Royce SMR Limited, SMR0001603 Issue 1, “E3S Design Principles,” August 2022.

[14] Rolls-Royce SMR Limited, SMR0004363 Issue 3, “Environment, Safety, Security and Safeguards Case Version 2, Tier 1, Chapter 18: Human Factors,” May 2024.

[15] Rolls-Royce SMR Limited, SMR0003977 Issue 3, “Environment, Safety, Security and Safeguards Case Version 2, Tier 1, Chapter 15: Safety Analysis,” May 2024.

16.4 Appendix A: Claims, Arguments, Evidence

Table 16.4-1 provides a mapping of the claims to the corresponding sections of the chapter that summarise the arguments and/or evidence. The full decomposition of claims and link to underpinning Tier 2 and Tier 3 information containing the detailed arguments and evidence is presented in the E3S Case Route Map [6]. The route map includes the trajectory of Tier 2 and Tier 3 information as the generic E3S Case develops, which will be incorporated into Tier 1 chapters as it becomes available and in line with generic E3S Case issues described in [5].

Table 16.4-1: Mapping Claims to Chapter Sections

Claim	Section of Chapter 16 containing Arguments/Evidence summary
The operating assumptions, limits and conditions set by the Fault Analysis are correctly captured.	16.1.3
The operating assumptions, limits and conditions set by the Severe Accident Analysis are correctly captured.	16.1.3

16.5 Glossary of Terms and Abbreviations

ALARP	As low as reasonably practicable
BAT	Best Available Techniques
CAE	Claims, arguments, evidence
ConOps	Concept of Operations
DRP	Design Reference Point
E3S	Environment, Safety, Security and Safeguards
GDA	Generic Design Assessment
HF	Human Factors
IAEA	International Atomic Energy Agency
LCO	Limits and Conditions (Operating Rules)
OLC	Operating Limits and Conditions
ONR	Office for Nuclear Regulation
RD	Reference Design
RGP	Relevant good practice
RR SMR	Rolls-Royce Small Modular Reactor (the design)
SAPs	Safety Assessment Principles
SSCs	Structures, systems, components
TAG	Technical Assessment Guide
US NRC	United States Nuclear Regulatory Commission
WENRA	Western European Nuclear Regulators' Association