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PSR Part B Chapter 22 Internal Hazards

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22.1 INTRODUCTION

The Fundamental Purpose of the Generic Design Assessment (GDA) Safety, Security and Environment Case (SSEC) is to demonstrate that the Generic Small Modular Reactor (SMR)-300 can be constructed, operated, and decommissioned on a generic site in the UK to fulfil the future licensee's legal duties to be safe, secure and protect people and the environment as defined in HI-2240332, Holtec SMR GDA PSR Part A Chapter 1 Introduction [1].

The Fundamental Purpose is achieved through the Fundamental Objective of the Preliminary Safety Report (PSR), which is to summarise the safety standards and criteria, safety management and organisation, claims, arguments and intended evidence to demonstrate that the generic SMR-300 design risks to people are likely to be tolerable and As Low as Reasonably Practicable (ALARP) [1].

Part B Chapter 22 of the PSR presents the Claims, Arguments and intended Evidence (CAE) for the Internal Hazards topic that underpins the design of the generic SMR-300.

22.1.1 Purpose and Scope

The Overarching SSEC Claims are presented in HI-2240334, Holtec SMR GDA PSR Part A Chapter 3 Claims, Arguments and Evidence [2] of this PSR.

This chapter (Part B Chapter 22) links to the overarching claim through Claim 2.1:

Claim 2.1: The nuclear safety assessment identifies plant initiating events, specifies the requirements for safety measures such that safety functions are fulfilled, informs operational and emergency arrangements and demonstrates that risk is tolerable and ALARP.

As set out in Part A Chapter 3, Claim 2.1 is further decomposed across several nuclear safety assessment disciplines which are responsible for development of the nuclear safety assessment. This chapter presents the Internal Hazards aspects for the generic SMR-300 and therefore directly supports Claim 2.1.6.

Claim 2.1.6: Risks from Internal Hazards and their combinations have been demonstrated to be tolerable and As Low As Reasonably Practicable (ALARP).

Further discussion on how the Level 3 claim is broken down into Level 4 claims and how the Level 4 claims are met is provided in Subchapter 22.3.

Chapter B22, Internal Hazards, presents a discussion of:

- Overview of Internal Hazards – subchapter 22.2.
- The CAE relevant to Internal Hazards – subchapter 22.3.
- The codes and standards, Relevant Good Practice (RGP), and guidance applicable to the identification and assessment of Internal Hazards – subchapter 22.4.
- The methodology for identification of Internal Hazards – subchapter 22.5 and Appendix B.
    - The approach to combined hazards (external and internal) is outlined within PSR Chapter B21 (External Hazards).

- The identified Internal Hazards relevant to the generic SMR-300 and their potential impacts upon the generic SMR-300 – subchapter 22.6.
- The resultant Structures, Systems and Components (SSCs) that support the claims relating to Internal Hazards – subchapter 22.7.
- A technical summary of how the overarching claim for internal hazards is met and a summary of the contribution from this chapter to support the demonstration that risks are likely to be tolerable and ALARP for the generic SMR-300 design – subchapter 22.8.

A master list of definitions and abbreviations relevant to all PSR Chapters can be found in HI-2240333, Holtec SMR-300 GDA PSR Part A Chapter 2 General Design Aspects and Site Characteristics [3].

22.1.2 Assumptions

Although SSCs have been sentenced as ‘in scope’ and ‘out of scope’ within Chapter A2 of the PSR [3], SSCs which present a risk to the design significant sources of Internal Hazards have been included within this chapter, e.g. turbine disintegration. Internal Hazards from other SSCs that cannot be realistically captured at generic stage will be addressed by site-specific safety analysis.

No assumptions have been made regarding the location of the SMR-300 in relation cooling systems that may be required, e.g., coastal intake for a coastal site or cooling from a body of water for inland sites, this decision shall be made during site-specific phase.

Information relating to the dry store facility, including the UMAX is considered within HI-2240351, Holtec SMR GDA PSR Part B Chapter 24 Fuel Transport and Storage [4].

22.1.3 Interfaces with other SSEC Chapters

The Internal Hazards chapter interfaces with the following PSR chapters.

The generic design aspects and site characteristics are described in Part A Chapter 2 General Design Aspects and Site Characteristics A2 (Generic Design and Site Characteristics) [3].

Part B Chapter 1 Reactor Coolant Systems and Engineered Safety Features [5], Part B Chapter 2 Reactor Fuel and Core [6], Part B Chapter 4 Control and Instrumentation Systems [7], Part B Chapter 5 Reactor Supporting Facilities [8], Part B Chapter 6 Electrical Engineering [9], Part B Chapter 19 Mechanical Engineering [10] and Part B Chapter 20 Civil Engineering [11] present the SSCs relating to their topic area which will be substantiated/ qualified/ validated against relevant Internal Hazards.

Part B Chapter 12 Control of Non-Radiological Hazards [12] interfaces closely with B22 in relation to the design of Internal fire protection, which covers the design and fire safety provisions for evacuation routes, control of external fire spread and fire-fighting access. Internal fire in this chapter focuses on the nuclear safety while chapter B12 is for life safety in the event of fire and fire prevention measures. In addition to fire this chapter also covers Nuclear Site Health and Safety and outline the approach to CDM for the generic SMR-300.

All identified and screened Internal Hazards are to be treated as initiating events in the Design Basis Accident Analysis (DBAA). PSR Part B Chapter 14 ‘Design Basis Accident Analysis’

[13] presents the DBAA for reactor faults and at Revision 1, will present a Preliminary Fault Schedule (PFS).

Part B Chapter 15 BDBA, Severe Accidents Analysis and Emergency Preparedness [14] presents an assessment of BDB Internal Hazards and the generic site response to Severe Accidents that may lead to core damage. Part B Chapter 16 Probabilistic Safety Assessment [15] supports the DBAA and Beyond Design Basis Analysis (BDBA) with an objective to demonstrate that the design of the generic SMR-300 is balanced such that risk is tolerable and ALARP.

Internal Hazards also interfaces with Part B Chapter 17 Human Factors [16]. The Human Factors discipline supports the identification, analysis and modelling of human failures related to Internal Hazards and is responsible for the substantiation of any developed human-based safety claims.

Internal Hazards interfaces closely with Part B Chapter 21 External Hazards [17] due to their nature. Combinations of hazards is a key topic such that an External Hazard could lead to one or more consequential Internal Hazards.

22.2 OVERVIEW OF INTERNAL HAZARDS

22.2.1 Internal Hazard Definition

Internal Hazards are defined within the Office of Nuclear Regulation (ONR) Safety Assessment Principles (SAPs) [18] as:

'…hazards to the facility or its structures, systems and components that originate within the site boundary and over which the Dutyholder has control in some form. The term is usually limited to apply to hazards external to the process'.

The term 'hazard' refers to any event which by damaging SSCs or civil structures has the potential to cause singly or in combination:

- One or more initiating faults which are within the Design Basis.
- A significant reduction in the reliability and availability of plant safeguards.
- A more severe initiating fault than that assumed for Design Basis calculations.
- An initiating fault which is not included within the Design Basis.

Internal Hazards which are sufficiently frequent that they must be considered in the design are known as Design Basis (DB) hazards. This is specified in the SAPs [18] by the engineering principle EHA.3:

'For each internal or external hazard, which cannot be excluded on the basis of either low frequency or insignificant consequence, a design basis event should be derived.'

Internal Hazards that occur more frequently than 10^{-5} per year are considered to be DB hazards. Less frequent Internal Hazards still require assessment in order to ensure that there are no cliff-edge effects and that a balanced design has been achieved.

Generally, the overall aim of the Internal Hazards specification and analysis is to achieve a balance between the design requirements for Internal Hazards and those from other plant faults. The Internal Hazards requirements are not to be over-specified (or under-specified); the aim is to achieve an adequate degree of safety with respect to Internal Hazards.

Protection against Internal Hazards is achieved mainly by prevention, limitation of severity and mitigation which is provided by segregation/ separation or by qualification. In some cases, a combination of approaches is used.

22.2.2 Internal Hazard Locations

Internal hazards by definition occur within the site boundary; however, a further distinction can be made whereby these hazards occur 'internal' to buildings or 'external' to building, e.g. within the yard. Typically, Internal Hazards that occur within the safety related buildings are the most significant due to their vicinity to SSCs important to nuclear safety. For Internal Hazards that occur external to buildings, the ability of the external civil and structural SSC to provide an additional safety measure helps reduce the risk of SSC important to nuclear safety being impacted. Within this report the distinction between these 'internal' and 'external hazards is not covered, however, during hazard identification, subchapter 22.5.1.1, this will be explicitly captured to ensure differentiation.

22.2.3 Internal Faults

The Internal Hazards identified within subchapter 22.5 have the potential to result in Internal Faults should the design/ layout of the SMR-300 not preclude hazards or have insufficient/ inadequate safety measures to prevent the hazard developing into a fault sequence.

The fault groups applicable to the SMR-300 that have been identified within Chapter B14 ‘Design Basis Accident Analysis’ [13], their identification and classifications are captured and explained further within Chapter B14.

As part of ongoing work within Chapter B14, a Consolidated Fault List (CFL) is being produced based upon extant PWR information, as well as undertaking a comprehensive fault identification exercise, to identify PIEs for the generic SMR-300 design. The PIEs considered for the SMR-300 design will need to include all foreseeable failures of duty systems and SSCs of the plant, as well as human failures and possible failures arising from internal and external hazards, whether in full power, low power or shutdown states, in the reactor, the fuel pool, fuel handling system, waste operations or some other activity containing sources. This will be undertaken as part of the Step 2 development and will be finalised using the results of the full deterministic and probabilistic safety analyses for design basis and beyond design basis faults (as applicable) in the site specific PCSR stage.

22.3 INTERNAL HAZARDS CLAIMS, ARGUMENTS AND EVIDENCE

The primary purpose of a CAE approach is to capture the golden thread of a safety case narrative demonstrating how plant and operational evidence is brought together to justify that a high-level or fundamental claim is true. In the context of the GDA of the generic SMR-300, that is how the Fundamental Purpose of the overarching SSEC (presented in Part A Chapter 1) is achieved.

The Fundamental Purpose follows a golden thread throughout the SSEC to CAE via the objectives of the PSR, Preliminary Environmental Report (PER) and Generic Security Report (GSR). The overarching SSEC claims are presented in Part A Chapter 3 [2].

This chapter contributes directly to Claim 2.1, which is focused on the demonstration of the identification of hazards/ initiating events and faults and ensuring the risks presented by them are ALARP.

Claim 2.1: The nuclear safety assessment identifies plant initiating events, specifies the requirements for safety measures such that safety functions are fulfilled, informs operational and emergency arrangements and demonstrates that risk is tolerable and ALARP.

As set out in Part A Chapter 3 [2], Claim 2.1 is further decomposed across several nuclear safety assessment disciplines which are responsible for development of the nuclear safety assessment. This chapter presents the Internal Hazards aspects for the generic SMR-300 and therefore directly supports Claim 2.1.6.

Claim 2.1.6: Risks from Internal Hazards and their combinations have been demonstrated to be tolerable and As Low As Reasonably Practicable (ALARP)

Claim 2.1.6 has been further decomposed within Part B Chapter 22 to provide confidence that the relevant requirements on structures will be met during all lifecycle phases.

The Internal Hazards analysis is predominantly focused around two main areas:

- Deriving safety features to be placed on SSCs to prevent, protect and mitigate against Internal Hazard.
- Analysis of Internal Hazards to demonstrate that the identified safety features ensure relevant safety objectives and targets are met.

This has been done by breaking down Claim 2.1.6 into four further sub-claims which support these two main areas.

Claim 2.1.6.1 is an enabling claim for both the above areas by ensuring that the characterisation and methodologies that the Internal Hazards will be assessed against, are appropriate.

Claim 2.1.6.2 and 2.1.6.3 support the derivation of safety features by identifying all relevant Internal Hazards and ensuring SSCs are correctly specified in terms of safety functions and classification, derived from the safety analysis.

Claim 2.1.6.4 presents the analysis to demonstrate that the plant can reach a safe state following an Internal Hazard, noting that the maturity of evidence for this claim will be limited at a PSR stage as the Preliminary Fault Schedule (PFS) is developed.

Table 1 shows the breakdown of claim 2.1.6 and identifies which chapter of this PSR these claims are demonstrated to be met.

Table 1: CAE Chapter B22

Claim No.	Claim	Chapter Section
2.1.6.1	Internal Hazards are characterised and evaluated using appropriate methodologies.	22.4 Internal Hazards Codes and Standards
2.1.6.2	A comprehensive set of Internal Hazards and their combinations are identified and screened for assessment.	22.5 Internal Hazards Identification
2.1.6.3	Safety functions and safety measures are identified, categorised, and classified based on their importance to nuclear safety for all Internal Hazards and provide sufficient lines of protection based on the fault frequency and consequence.	22.7 SSCs with Internal Hazard Safety Functions
2.1.6.4	Analysis demonstrates that for all Internal Hazards, the identified safety features, in conjunction with operator actions, enable the plant to reach a safe state.	22.6 Internal Hazards Evaluation

A summary of the current CAE route map for Chapter B22 is provided in Appendix A and a further update on claim decomposition, argument development and evidence maturity will be provided in the subsequent update of the Chapter B22.

22.4 INTERNAL HAZARDS CODES AND STANDARDS

Claim 2.1.6.1: Internal Hazards are characterised and evaluated using appropriate methodologies.

This subchapter outlines the codes and standards used in the identification and assessment of Internal Hazards.

The Requesting Party (RP) has recognised that UK nuclear safety regulations are based on a non-prescriptive regime and consequently the technical codes and standards that must be used for nuclear power plants are not prescribed. However, the codes and standards must represent RGP.

22.4.1 Guidance Documents used to develop SMR-300 for Internal Hazards

Internal Faults for the SMR-300 are assessed based upon US Nuclear Regulatory Commission (NRC) regulations. Internal Hazards, as defined by the ONR, are not specifically assessed within US NRC guidance, however, this does not mean they are not covered, some Internal Hazards are covered under existing US NRC guidance e.g., Internal Fires. This difference in regulatory approach to Internal Hazards has been identified within the HI-2240124, UK GDA Gap Analysis Report [19] and will be discussed further within this chapter. For each of the identified Internal Hazards within subchapter 22.5 the following US guidance documents, shown within Table 2, have been identified.

Table 2: Principal regulations, codes and standards

Label	Title	Revision/ Date
ACI 349 Appendix F	Special Provisions for Impulsive and Impactive Effects [20]	2013
ANSI/ANS-56.11	Design Criteria for Protection Against the Effects of Compartment Flooding in Light Water Reactor Plants [21]	2013
ASME B&PVC Code, Section III	Rules for Construction of Nuclear Facility Components [22]	2017
NFPA 804	Fire Protection for Advanced Light Water Reactors [23]	2020
NRC Branch Technical Position (BTP) 3-4	Postulated Rupture Locations in Fluid System Piping Inside and Outside Containment [24]	2
US NRC 10 CFR Part 50 Appendix A	General Design Criteria for Nuclear Power Plants [25]	-
US NRC NUREG-0800	Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants [26]	-
US NRC RG 1.115	Protection Against Turbine Missiles [27]	2
US NRC RG 1.180	Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems [28]	2
US NRC RG 1.189	Fire Protection for Nuclear Power Plants [29]	4
US NRC RG 1.102	Flood Protection for Nuclear Power Plants [30]	1
US NRC RG 1.244	Control of Heavy Loads at Nuclear Facilities [31]	0
US NRC RG 1.59	Flood Protection for Nuclear Power Plants [32]	2
US NRC RG 1.75	Criteria for Independence of Electrical Safety Systems [33]	5

An extensive list of Fire Protection Codes and Standards for the SMR-300 is presented within the HI-2240126, GDA Step 1 Codes and Standards Report [34] and is not repeated here for brevity.

22.4.2 UK and International Guidance proposed for use by the Generic SMR-300 Internal Hazards Approach

Due to the differences between the US and UK regulatory approaches a comprehensive review has been undertaken to identify Internal Hazards UK RGP and propose assessment methodologies/ philosophies for all identified Internal Hazards. Within the UK's non-prescriptive regulatory regime, the expectation is that duty holders will develop facility designs consistent with ONR guidance. ONR guidance is consistent with guidance from IAEA and WENRA. The key ONR SAPs identified in relation to Internal Hazards are listed below, this is a non-exhaustive list, other SAPs may also apply:

- EHA.1: Identification and Characterisations.
- EHA.3: Design Basis Events.
- EHA:4: Frequency of Initiating Event.
- EHA.6: Analysis.
- EHA.14: Fire, explosions, missiles, toxic gases etc – sources of harm.
- EHA.15: Hazards due to water.
- EHA.16: Fire detection and fighting.
- EHA.18: Beyond Design Basis Events.
- FA.2: Identification of Initiating Faults.
- FA.5: Initiating Faults.
- EKP.1: Inherent Safety.
- EKP.3: Defence In Depth.

ONR Guidance documents and other sources of RGP, such as the IAEA and WENRA are to be reviewed and considered in line with ONR SAP and Technical Assessment Guide (TAG) guidance, these are shown within Table 3.

Table 3: UK RGP for Internal Hazards

Label	Title	Revision
ONR Documentation		
-	Safety Assessment Principles [18]	1
NS-TAST-GD-014	Technical Assessment Guide: Internal Hazards [35]	7.1
ONR-GDA-GD-007	Nuclear Power Plants Generic Design Assessment Technical Guidance [36]	0
ONR-GDA-GD-006	ONR GDA Guidance to RPs [37]	0
NS-TAST-GD-036	Redundancy, Diversity, Segregation and Layout of Structures, Systems and Components [38]	3
NS-TAST-GD-051	The Purpose, Scope, and Content of Safety Cases [39]	4
NS-TAST-GD-094	Categorisation of Safety Functions and Classification of Structures, Systems and Components [40]	2
NS-TAST-GD-005	Guidance on the Demonstration of ALARP [41]	11.2
IAEA Documentation		
SSG-64	Protection Against Internal Hazards in the Design of Nuclear Power Plants [42]	1
IAEA-TECDOC-1944	Fire Protection in Nuclear Power Plants [43]	1
SSR-2/1	Safety of Nuclear Power Plants: Design. [44]	1
NS-G-2.1	Fire Safety in the Operation of Nuclear Power Plants [45]	1
SSG-2	Deterministic Safety Analysis for Nuclear Power Plants [46]	
SSR-2/2	Safety of Nuclear Power Plants: Commissioning and Operation [47]	1
WENRA Guidance		
-	Safety Reference Levels for Existing Reactors [48]	2021
-	Report on Safety of new NPP [49]	2013
-	WENRA Statement on Safety Objectives for New Nuclear Power Plants [50]	2010
‘Other’ Guidance		
HSE L138	Dangerous Substances and Explosive Atmospheres, Approved Code of Practice and Guidance [51]	2
HSE L122	Safety of Pressure Systems, Pressure Systems Safety Regulations 2000 Approved Code of Practice [52]	2
HSE L113	Safe Use of Lifting Equipment, Lifting Operations and Lifting Equipment Regulations 1998 [53]	2
SMiRT	UK’s Regulatory Safety Assessment of Nuclear Plants Pressure Part Failure – A Multi-Disciplinary View [54].	1
SMiRT	UK’s Regulatory Consideration of Partial Failures in High Energy Components – A Multi-Discipline View [55].	1

In line with ONR TAG guidance for Internal Hazards [35], the following extant GDA submissions have also been reviewed, chapters for Internal Hazards are referenced below, however, other chapters were reviewed as required e.g., External Hazards for combined hazards information:

- UKEPR-0002-132, PCSR Sub-Chapter 13.2: Internal Hazards Protection [56].
- SMR0003977, E3S Case Chapter 15: Safety Analysis [57].
- UKP-GW-GL-793NP, AP1000 Pre-Construction Safety Report [58].
- GA91-9101-0101-07000, Generic PCSR Chapter 7 Internal Hazards [59].
- UK HPR1000 Preliminary Safety Report Chapter 19 Internal Hazards [60].

In addition to the above, a review of applicable Regulatory Observations (RO) and Regulatory Issues (RIs) has been undertaken from previous GDA submissions. The findings of this review are outlined within the below Subchapter.

22.4.2.1 Lessons Learnt

As part of the review against RGP, a number of sources for lessons learnt have been reviewed, these include both from within GDA guidance and from previous GDA Submission ROs and RIs. The following subchapters present the lessons learnt from these sources.

The below high-level topics have been identified from their respective documents:

- Safety Measures [35]
  - Safety measures and operator actions claimed require adequate substantiation by Human Factors such that there is suitable evidence that they are both available and achievable following the occurrence of a hazard.
  - Locations of safety measures should be considered such that numerous key safety measures (class 1 and class 2) are not congregated within a single area and could be impacted/ damaged by a common cause failure.
- Combined Hazards [35]
  - Underestimation of the effort required to demonstrate the resilience of the design against combination of hazards. Challenges in the identification and rationalisation of combinations, the characterisation of combined loads (which require characterisation of the individual hazard loads, hazard sequences) and residual withstand capacity of SSCs including barriers.
- Hazard Characterisation [36]
  - Selection of appropriate hazard characterisation methodologies and tools has been identified as challenging to the ONR for some Internal Hazards such as pipe whip and jet impact, steam release and internal blast.
  - Designs which credit LBB or have not postulated failure in high energy modes of operation, find meeting ONR’s expectations challenging. The safe mode of operation assumed by US regulations is not accepted by ONR without substantial additional safety arguments, or design change. This required reinforcement of segregation barriers and slabs.
  - The characterisation and presentation of the unmitigated consequences for Internal Hazards faults has proved challenging and so has the development of claims and the safety case for Internal Hazards inside containment. The concept of *unmitigated consequences* is not familiar to US safety practitioners.
- Modelling [36]
  - Modelling tools and models. A variety of tools have been used in the three GDA projects completed in GB so far. ONR does not prescribe tools or models and is up to the RPs to select models that are suitably validated for their intended use. This has on occasions proved difficult for RP’s to do if those tools or models are simply prescribed in regulation.

The lessons learnt which are summarised above are being considered and, where possible within the scope of GDA, will be responded to in Revision 1 of this chapter. The design principles and current development of the generic SMR-300, alongside planned step 2 deliverables, provide confidence that these lessons, where relevant to a PSR, can be addressed successfully.

22.4.3 CAE Summary

The generic SMR-300 Internal Hazards Identification, characterisation and analyses has been undertaken using best practice nuclear industry codes and standards and RGP identified from recent UK GDA submissions. These codes and standards include guidance and expectations from the US NRC and ONR. Claim 2.1.6.1 has therefore been met to the extent consistent with the maturity of this project at this time; further work will be undertaken and reported in the next revision of this PSR.

22.5 INTERNAL HAZARDS IDENTIFICATION

Claim 2.1.6.2: A comprehensive set of Internal Hazards and their combinations are identified and screened for assessment.

The identification and characterisation of Internal Hazards is required in line with ONR SAP EHA.1 with notable Internal Hazards being identified within their own specific ONR EHA SAPs, e.g., EHA.14 identifies the need to cover fire, explosion, missiles, toxic gases etc. Within each Internal Hazard subchapter their respective SAPs are identified.

Internal Hazards have been identified from the codes, standards and RGP listed within subchapter 22.4. A comparison of the Internal Hazards from relevant guidance documents and extant GDA documentation has been undertaken within Table 7 of Appendix B, with the identified Internal Hazards listed below:

- Internal Fire.
- Internal Explosions.
- Internal Flooding.
- Pipe Whip and Jet Impact.
- Internal Missiles (including turbine disintegration).
- Dropped Loads.
- Toxic and/ or Corrosive Solid, Liquid or Gaseous Release.
- Vehicle Impact.
- Electromagnetic Interference.
- Combined Hazards.

22.5.1 Internal Hazards Overarching Approach

The following general approach will be followed to assess Internal Hazards for the generic SMR-300. Hazard specific discussions are captured in the Subchapter 22.6.

The fundamental derived acceptance criteria which must be met by the SMR-300 for design basis Internal Hazards, such that no design basis Internal Hazard will lead to any event not bounded by a design basis fault are:

a. The fundamental safety functions of the plant (control, cool, contain, monitor, and control releases) shall remain available.
b. There shall be no failure of fuel or the reactor coolant pressure boundary.
c. The containment function shall be maintained.
d. The ability to monitor the state of the plant shall be maintained.
e. Dose acceptance criteria for Design Basis Accidents from Internal Hazards shall be met.

22.5.1.1 Hazard Identification

In addition to the above Internal Hazards, formal hazard identification for Internal Hazards is required in line with ONR SAP EHA.1 for the generic SMR-300 design. Hazard Identification is required to be undertaken for the generic SMR-300, either using a room by room/ area by area or standalone process approach e.g., a specific high energy pipe system or standalone lifting operation. This hazard identification is required to ensure all credible sources of Internal Hazards are identified such that they can be quantified, and an assessment undertaken to ensure that suitable and sufficient safety measures are available. Identified Internal Hazards are to be recorded with sufficient detail and context to enable ease of review/ audits at a later date, e.g., vehicle impacts will identify the type of vehicle, the location of the impact, and any other hazard specific information raised during the identification process. The Hazard Identification methodology for the generic SMR-300 is outlined within Part B Chapter 14 [13].

As mentioned within subchapter 22.2.2, hazard identification work shall identify the location of the Internal Hazard with respect to the safety classified buildings. The differentiation is made between safety and non safety classified buildings as a fire within one of the safety classified buildings is likely to have more severe consequences than a fire outside a safety classified building. Internal hazards outside safety classified buildings also include hazards within the 'yard'. Generic examples for each Internal Hazards identified within subchapter 22.5.1 for varying locations are presented in Table 4.

Table 4: Example Internal Hazards from Differing Sources

Internal Hazard	'Outside Safety Classified Building' Internal Hazard Examples	'Within Safety Classified Building' Internal Hazard Examples
Internal Fire	External combustible material ignites	Electrical equipment shorts within building
Internal Explosions	Failure of hydrogen storage tanks	Hydrogen build-up from failed UPS ventilation
Internal Flooding	External water storage tank fails	Pipe failure
Pipe Whip and Jet Impact	Pipework external to the buildings fails	Failure of Reactor coolant system.
Internal Missiles (including turbine disintegration)	External gas cylinder regulator fails	Failure of coolant pump.
Dropped Loads	Temporary external crane fails	Failure of Polar Crane
Toxic and/ or Corrosive Solid, Liquid or Gaseous Release	External chemical storage tanks	Local gas bottle storage fails leading to release of asphyxiant
Vehicle Impact	HGV delivering fuel to storage tanks crashes	Internal forklift truck impacts SSC.
Electromagnetic Interference	TETRA emergency transmitters, ground penetrating radar.	Cellular phones, wireless networking and Bluetooth devices.

Interaction of Internal Hazards between buildings is to be considered. Although a generic list of Internal Hazards has been identified within subchapter 22.5 consideration is required for how individual buildings, including those outside the scope of the GDA, could impact upon buildings within the scope of the GDA. An example of this is how Internal Hazards from the turbine building, outside the scope of the GDA, could impact upon the buildings within the Nuclear Island as a result of Internal Hazards such as Internal Fires, Internal Foods etc.

22.5.1.2 Characterisation of Internal Hazards

ONR SAP EHA.1 requires the characterisation of both Internal and External Hazards to be defined. The characterisation of each Internal Hazard will differ from one to the next, e.g., blast overpressure for an explosion, impact mass/ velocity for a projectile, or a time and temperature profile for a fire. Characterisations of Internal Hazards will be recorded, and where uncertainty is present, conservative assumptions will be used. Characterisation of Internal Hazards is required to enable analysis to be undertaken. Initiating Event Frequencies (IEFs) will be recorded and where reliable values are not possible, justified estimates will be used, as covered within Chapter B14 [13].

The need to quantify the frequency of an initiating event is required in line with ONR SAP EHA.4 such that fault screening to be undertaken depending on the IEF in line with EHA.19. Screening facilitates a pragmatic approach to fault assessment to ensure that full assessments are not undertaken for hazards that present minimal overall risk to the plant/ system/ SSCs.

22.5.1.3 Unmitigated Consequences

Unmitigated consequences for Internal Hazards will be identified, i.e., the dose to each of the exposure groups should all safety measures that can credibly be affected by the hazard fail. Chapter A2 of the PSR [3] 'General Design Aspects and Site Characteristics' introduces the UK numerical targets that will be applied to the generic SMR-300 (which are equivalent to ONR SAPs [18] NT.1 to NT.9). In line with ONR SAP EHA.19, Internal Hazards with a low consequence, that 'have no significant identified consequential effect on the safety of the facility' can be screened out from further assessment, [18] para. 235(a).

22.5.1.4 Safety Measures

Using the both IEF and unmitigated consequence methodologies outlined within subchapters 22.5.1.2 and 22.5.1.3 respectively, along with the DBA methodology to be defined within Chapter B14 [13], a Safety Functional Category (SFC) be will be assigned. This SFC will inform the categorisation of the Safety Function identified to mitigate the threat. The categorisation will also inform the number, and classification, of safety measures required to fulfil the Safety Function. Substantiation of this Safety Function is then achieved through the provision of safety measures the required classification by the engineering disciplines. In addition to the required safety measures, both Defence in Depth (DiD) and ALARP principles shall be applied.

For each Internal Hazard it will be shown that the available safety measures ensure that the risks are tolerable and ALARP and the cost of implementing further safety measures would be deemed grossly disproportionate to the risk reduction gained. The ALARP methodology to be applied to the generic SMR-300 is outlined within Chapter A5 [61].

22.5.1.5 Input into Fault Schedule

To ensure the 'golden thread' through CAE, and hazard sequences are captured in an auditable manner, a fault schedule is to be produced for all credible Internal and External Hazards. This Fault Schedule will aim to provide information on the following:

- Hazard Type.
- Hazard Location.
- Hazard Pathway Progression.
- Potential Consequences.
- Available Safety Measure/s.
- Additional Safety Measure/s (DiD).

As part of work to be undertaken within Chapter B14 [13] a PFS is being developed, this PFS shall act as a vehicle to capture the above bullet points. The PFS will be a live document that will be developed during design development and throughout the lifecycle of the project.

22.5.1.6 CAE Summary

An extensive review of available Codes and Standards and extant GDAs has been undertaken to identify potential Internal Hazards. This work, in combination with the work to be undertaken to assess combined hazards, provides a comprehensive set of 'generic' Internal Hazards for assessment. Claim 2.1.6.2 has therefore been met to the extent consistent with the maturity of this project at this time; further work will be undertaken and reported in the next revision of this PSR.

22.6 INTERNAL HAZARDS EVALUATION

Claim 2.1.6.4: Analysis demonstrates that for all Internal Hazards, the identified safety features, in conjunction with operator actions, enable the plant to reach a safe state.

This subchapter defines the Internal Hazards methodologies and the design philosophy to be applied to the generic SMR-300. Further assessments for Internal Hazards are expected in line with the defined methodology, to ensure that the safety measures and SSCs for the generic SMR-300 ensure risks are ALARP.

22.6.1 Internal Fire

Conventional Fire Safety for the generic SMR-300 is covered within Chapter B12 Control of Non-Radiological Hazards [12]. Internal Fire and Conventional Fire have a key interface for defining the holistic design protection against fires, and aligning the design of fire compartments, evacuation routes, fire alarm warning, control of external fire spread and fire-fighting systems. Conventional Fire covers the risk to life of personnel, whereas Internal Fire within this chapter focuses on the fires which have the potential challenge to nuclear safety. Assessment and sentencing of identified fire scenarios will depend upon the potential consequences.

The assessment of Internal Fire is required in line with the following ONR SAPs:

- EHA.14 ‘Fire, Explosion, Missiles, Toxic Gases etc – Sources of Harm’.
- EHA.16 ‘Fire Detection and Fighting’.
- EHA.17 ‘Appropriate Materials in Case of Fire’.

The SMR-300 has been designed in line with fire compartmentalisation guidance defined by General Design Criterion (GDC) 3 ‘Fire Protection’ in Appendix A of 10 CFR Part 50 [25] and complies with NRC Regulatory Guide 1.189 ‘Fire Protection for Nuclear Power Plants’ [29], this guidance uses the following approach. NRC RG 1.189 is a compendium of multiple guidance documents provided by the NRC. The key protection measures against Internal Fire are outlined below, these align with the hierarchy of control expected within UK regulatory guidance:

- Prevents fires from starting:
    - SSCs important to safety shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions. Non-combustible and heat resistant materials shall be used wherever practical throughout the unit, particularly in locations such as the containment and control room.
- Rapidly detects, controls, and extinguishes a fire that may occur:
    - Fire detection and fighting systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fires on SSCs important to safety. Firefighting systems shall be designed to assure that their rupture or inadvertent operation does not significantly impair the safety capability of these SSCs.
- Provides protection for (SSCs) important to safety so that a plant can continue to safely shutdown even if a fire is not promptly extinguished by the fire suppression activities:

  - The SMR-300 will comply with the applicable provisions specified in National Fire Protection Association (NFPA) 804, 'Fire Protection for Advanced Light Water Reactors', [23] related to the protection of post-fire safe-shutdown capability and the mitigation of a radiological release resulting from a fire.
  - In line with NRC RG 1.189 fire compartments shall have a three hour minimum fire resistance rating and where this cannot be achieved, either due to penetrations or material selection, further assessment shall be undertaken.

To ensure the above can be achieved a fire hazard analysis is expected to consider the following:

- Safe-shutdown analysis should be performed to demonstrate the ability of the plant to safely shut down following a fire in any given area and to meet the safe-shutdown performance goals. The analysis should identify the safe-shutdown components and circuits for each fire area and demonstrate that the plant meets the regulatory guidelines or that it provides an alternative or dedicated shutdown. This safe shutdown analysis will, as necessary, include consideration of the following factors:
  - Potential in situ and transient fire hazards.
  - Determination of the effects of a fire in any location in the plant on the ability to safely shut down the reactor or to minimize and control the release of radioactivity to the environment. This may include the containment of a fire within a given area and the occurrence of potential flashovers.
  - Suitable modelling of combustible inventories to ascertain the temperature time profile of a compartment burn in line with ONR SAPs EHA.1, EHA.5 and EHA.6. Using the output of this fire modelling the fire analysis shall define the fire-resistance requirements for fire barriers as well as the requirements for other firefighting response.
  - Specification of measures for fire prevention, detection, suppression, and containment for each fire area containing SSCs important to safety.

22.6.2 Internal Explosions

Internal Explosions cover any explosions that occur within the site boundary, off-site explosions, typically outside the control of the licensee, are to be covered within Chapter B21 External Hazards [17]. Assessment of Internal Explosions is required in line with ONR SAP EHA.14 Fire, Explosion, Missiles, Toxic Gases etc – Sources of Harm'.

As noted within the ONR SAPs [35], ignition of flammable gases or vapours in confined or congested conditions, which result in acceleration of the flame front to produce significant overpressure and thermal effects. Depending on the subsonic or supersonic characteristics of the flame progression, explosions can involve deflagration and/ or detonation phenomena, respectively, with the latter having more destructive effects. Deflagrations can progress to detonation (commonly known as Deflagration to Detonation Transition (DDT)) depending on plant geometry and building/ compartment atmosphere.

In addition to the above 'ignition' explosions, the failure of high pressure systems can result in an 'explosion'. Blast waves from deflagration, detonation or high pressure system failure events interact with surrounding SSCs including nuclear safety barriers and can lead to failure due to blast waves directly, or impact by entrained debris/ missiles.

Within the US, the assessment of Explosions is covered under the assessment of Fire, consequently, the SMR-300 has been designed in line with General Design Criterion (GDC) 3 ‘Fire Protection’ in Appendix A of 10 CFR Part 50 [25] and complies with NRC Regulatory Guide 1.189 ‘Fire Protection for Nuclear Power Plants’ [29]. NRC RG 1.189 is a compendium of multiple guidance documents provided by the NRC.

The internal explosions assessment will identify sources of internal explosions and in line with the hierarchy of control and ONR guidance [35] the following approach should be applied, from most preferential to least, this approach broadly aligns with that within NRC RG 1.189 where elimination of sources of explosions are preferable.

- Elimination of Explosive Sources:
    - In line with ONR SAP EKP.1 the design shall seek to minimise the presence of explosive sources, both chemical and sources of over-pressure. The exact approach to eliminating explosive sources will depend upon the explosive sources identified. An example of potential elimination is where an explosive material is required, e.g., hydrogen, this could be substituted for another material.
- Prevention of Explosion:
    - In line with UK Regulations, locations/ areas where potential explosive/ flammable material is present shall be subject to Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) assessments.
    - Where systems containing high energy, pressure, or explosive materials are present there is the potential for an internal explosion to occur. Systems are designed to appropriate codes and standards, suitable Examination, Inspection, Maintenance and Testing (EIMT) schedules are to be in place to monitor these systems for degradation and defects.
    - Locations where explosive gases are present/ stored shall ensure they remain below their Lower Explosive Limits (LELs) for their respective atmospheres, this includes areas were batteries/ Uninterruptible Power Supplies are present as overcharging of these items is a credible source of hydrogen generation. It is anticipated that the SMR-300 will employ the use of ventilation within battery rooms to prevent the LELs being reached.
        - The use batteries within the SMR-300 design philosophy has been identified and therefore, the requirement for adequate hydrogen liberation from these batteries to prevent LELs being reached is key.
- Protective Measures:
    - Should it not be possible to eliminate or prevent an explosion, analysis of the explosion is to be undertaken to define and quantify the hazard and its potential consequences, e.g., overpressure and missile generation leading to degradation of an SSC important to Safety. Following this analysis, should insufficient suitable and sufficient safety measures be present, additional measures will be provided to the defined withstand to protect SSCs important to safety.

22.6.3 Internal Flooding

Flooding is required to be considered in line with ONR SAP EHA.12 ‘Flooding’ and EHA.15 ‘Hazards due to water’, external flooding is covered within Chapter B21 ‘External Hazards’

[17]. Internal flooding has the potential to damage/ compromise SSCs related to safety, either via spray or submersion. Sources of internal flooding typically consider the release of water from pipes/ tanks/ vessels; however, consideration is also given to other fluids. Toxic and corrosive liquid leaks from systems/ vessels are covered within subchapter 22.6.8.

Internal flooding covers any source of flooding within the site boundary, this includes flooding sources such as large water tanks from outside buildings (but excluding external hazards such as rainfall).

The SMR-300 will be designed to comply with the following for Internal Floods:

- NRC GDC 2 'Design Bases for Protection against Natural Phenomena [25].
- NRC GDC 4 'Environmental and Dynamic Effect Design Basis' [25].
- US NRC 1.59: Design Basis Floods for Nuclear Power Plants [32].
- US NRC 1.102: Flood Protection for Nuclear Power Plants [30].
- ANSI/ANS-56.11: Design Criteria for Protection Against the Effects of Compartment Flooding in Light Water Reactor Plants [62].

In addition to 'flooding' an Internal Flood event may also impact upon SSCs via the following mechanisms, this is a non-exhaustive list which will be developed further during formal hazard identification:

- Compression wave forces.
- Differential Pressures.
- Waves.
- Humidity changes.
- Thermal effects from hot or cold fluids.

The following approach for the SMR-300 Internal Flooding risk evaluation is performed in line with ASME/ANS RA-Sa-2009, Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications [63].

- Plant Partitioning
  - A plant partitioning activity is performed to evaluate the design and establish physical boundaries in which the effects of flooding can be contained. These boundaries define flood areas, which consist of a building, a room within a building or other defined area.
- Identification of Internal Flooding Source and Characterisation
  - Potential sources of internal flooding are identified by review of SSC lists and system descriptions. Flooding from fluid-containing components may be initiated by both SSC failure and operational/ human errors. Sources of flooding include the following:
    - High and moderate energy line breaks.
    - Firefighting activities.
    - Failure of non-seismic and non-extreme weather protected piping, tanks and vessels.
    - Internal Flooding from External Sources.

- Internal Flood Scenarios:
    - Internal flooding scenarios are developed to assess the effect of potential flooding in an area on the SSCs in that area. The potential scenarios consider propagation pathways, mitigation factors, and the affected SSCs. Protection measures considered include: flood doors, height of SSCs, sumps/ drains, and SSC qualification.
    - The following assumptions are used to determine flood water volumes in rooms and areas:
        - Floor drains and sump pumps are not credited for reducing flood water volume during the event. Rooms or areas with floor grating are credited.
        - Backflow through floor drains is not considered. Flood water volumes are assumed to be bounded by the direct flooding pathways.
        - Interior doors, unless specified as a watertight/waterproof door, are assumed to fail open or provide a high leak flow rate between rooms.
        - In areas with multiple sources, each source is considered separately.
        - All components located within a flood zone are assumed to fail if flood height reaches 30cm (one foot) unless the components are above the assessed flood level.

In line with ONR, WENRA and IAEA guidance the flooding assessment will, for all identified sources of internal flooding, quantify the maximum volume of fluid release as well as the potential flooding routes, e.g., via doorways, into neighbouring rooms, and potential blockages that could lead to increased levels of flooding within rooms.

A flooding assessment will use the internal flooding levels and volumes to assess and provide suitable design requirements for safety measures such that they remain functional following an internal flooding event. In line with the hierarchy of control, preference will be placed on prevention of flooding, should this not be possible the provision of drainage and placement of SSCs above the maximum flood height will be used. In addition, the SMR-300 will use segregated safety trains (Holtec requirement 3.3.16 within the Fundamental Design Philosophy Report [64]) such that a flood within one compartment is isolated from other safety trains preventing the concurrent flooding of redundant SSCs important to safety. Should elimination and segregation of SSCs important to safety from internal flooding not be possible, SSCs will be qualified against the postulated flood height.

Within the UK the assessment of moderate energy pipe failures is to be carried out for full bore pipe failures, i.e. the Standard Review Plan Branch Technical Position 3-4 ‘Postulated Rupture Locations in Fluid System Piping Inside and Outside Containment’ [24] will not apply. Reference [24] states that ‘Fluid flow from a leakage crack should be based on a circular opening of area equal to that of a rectangle one-half pipe diameter in length and one-half pipe wall thickness in width’. It is recognised that the US approach does not reflect the current ONR position.

22.6.4 Pipe Whip and Jet Impact

Assessment of Pipe failure is required in line with ONR SAP EHA.14 Fire, Explosion, Missiles, Toxic Gases etc – Sources of Harm’. Pipe whip and jet impacts are typically associated with high energy pipe systems and a guillotine failure that results from deformation of the pipe, typically around a fixed point, causing it to bend and whip. Jet impacts occur when the high energy fluid from the system impacts an SSC or other equipment. The impact of such events upon nearby SSCs can result in their failure, and inability to support their required safety functions. The SMR-300 design protects against pipe whip in line with the NRC GDC 4 'Environmental and Dynamic Effects – Design Bases' and NUREG-1061 Volume 3 requirements.

Analysis will be undertaken on high-energy[1], and where applicable, lower energy systems, based upon the potential consequences following a pipe whip/ jet impact. In addition to pipework that poses a pipe whip/ jet impact risk, consideration will be given to other pipework systems where the fluid pressure/ volume of fluid could lead to significant consequences.

Where high/ medium energy pipe systems are identified, localised SSCs that could be impacted by pipework failures will be identified and evaluated. Should SSCs be identified as vulnerable to potential pipe whip/ jet impact additional safety measures may be required.

Within the SMR-300 design, the routing of pipework is such that, where possible, pipework, is routed away from SSCs related to safety. Defence in depth for pipe whip and jet impacts will be employed whereby the pipework is substantiated to suitable codes and standards for the fluid being transported to minimise the likelihood of a failure. The SMR-300 pipework is designed in line with classification within the following:

- American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (B&PVC) Code, Section III 'Rules for Construction of Nuclear Facility Components' [65].
- NRC Branch Technical Position (BTP) 3-4 'Postulated Rupture Locations in Fluid System Piping Inside and Outside Containment' [24].

For Civil and Steel Structures the following design standards are being used:

- ACI 318-19, Building Code Requirements for Structural Concrete and Commentary [66].
- ANSI/AISC 360-16, Specification for Structural Steel Buildings [67].

Specific codes and standards for SSCs relating to interfacing disciplines e.g., Chapter B18 Structural Integrity [68] and Chapter B19 Mechanical Engineering [10] are covered within their respective PSR Chapters.

Within the US, Leak Before Break (LBB) exemptions are applied to pipework to demonstrate extremely low probability of pipe rupture to reduce the volume of protective hardware required. Within NRC guidelines, the use of LBB is not a required design condition, it is a form of analysis to justify the removal of protective hardware. The Light Water Reactor (LWR) Standard Review Plan (SRP) for LBB (SRP 3.6.3) on class 1 piping has the following 'screening criteria' for application of LBB:

- Assessment to be applied to entire system/ line.

[1] High-energy systems are defined by the ONR [35] as pipelines where the pressure is equal or greater than 2.0 MPa and/ or the operating temperature is 100ºC or greater in the case of water.

- Cannot be used for piping susceptible to erosion-corrosion, creep, etc. (i.e., no degradation mechanisms that can cause long surface cracks).
- Systems with a history of fatigue cracking cannot be considered.
- Pipes with likely water hammer are not considered.
- Piping systems with possible brittle fracture are not considered – Indirect failure must be shown not to cause rupture.

The provision of redundant safety systems in the SMR-300 in segregated locations minimises the risk of a single failure impacting multiple safety trains. Where pipework cannot be routed away from SSCs important to safety, physical barriers/ brackets/ restraints can be implemented to separate safety systems from the potential pipework impact. The methodology for identifying High Reliability (HR) and Very High Reliability (VHR) components and their definitions is outlined within Chapter B18 Structural Integrity [68]'.

In addition to ONR SAP and TAG guidance, the following multi-discipline review documents have been produced by the ONR:

- 'UK's Regulatory Safety Assessment of Nuclear Plants Pressure Part Failure – A Multi-Disciplinary View' [54].
- 'UK's Regulatory Consideration of Partial Failures in High Energy Components – A Multi-Discipline View [55].

The conclusion of reference [55], and the ONRs current approach to LBB is summarised below:

It is ONRs expectation that partial failure (LBB) cannot be used as the primary safety case argument. Instead, an ALARP demonstration is required for worst-case scenarios such that the application of defence in depth, along with structural integrity claims, can underpin the safety case argument. As such, within UK GDAs to date, a LLB argument has yet to be accepted in isolation to reduce the volume of protective hardware required to protect against pipe whip/ jet impact.

22.6.4.1 Room Pressurisation

As a result of high energy lines breaks[2], there exists the potential for safety classified rooms to become pressurised, in addition to this, pressurisation may occur as a result of an Internal Fire. As noted within the ONR TAG [35] pressure effects may include global effects from room pressurisation, leading to structural challenge on walls, floors, ceilings, doors, windows, cladding, etc. This may occur at a significant distance from the release point, such as through the engineered release route.

Consideration of pipework and vessels that could fail leading to the pressurisation of a room shall be identified and considered to ensure that should they occur, no SSCs are compromised which could impact the SMR-300's ability to fulfil safety functions.

[2] High Energy line breaks are defined the by the ONR within the Internal Hazards TAG [35] in line with WENRA Guidance [89] as: 'A system to operate in high energy mode when the pressure is equal or greater than 2.0MPa and/or the operating temperature is 100ºC or greater in the case of water'.

22.6.5 Internal Missiles

Assessments of Internal Missiles is required in line with ONR SAP EHA.14 'Fire, Explosion, Missiles, Toxic Gases etc – Sources of Harm'. Internal missiles cover a variety of origins, including failure of rotational equipment, over pressurisation of equipment including pipes/ tanks/ vessels, fragmentation following an explosion, or from a gravitational force i.e., dropped loads (covered within subchapter 22.6.7). Internal missiles have the potential to physically impact SSCs leading to damage, such that they are unable to fulfil their safety function. To enable the consequences of Internal Missiles to be understood the mass, velocity and impact location need to be characterised.

Missiles from external sources, such as wind and tornados are outside the scope of this subchapter and are covered within Chapter B21 External Hazards [17].

The design philosophy for protecting against such missiles is to prevent the generation of a missile in preference to substantiating the SSC to withstand an impact. Where missile sources cannot be eliminated, the SMR-300 has been designed in line with NRC GDC 4 'Environmental and Dynamic Effects Design Bases' [25] and in line with US NRC RG 1.115 'Protection Against Turbine Missiles' [27], using the following design philosophy:

- Locating the system or component in a missile-proof structure.
- Separating redundant systems or components from the missile path or range.
- Providing local shields and barriers for systems and components.
- Designing the SSC to withstand the impact of the most damaging missile:
    - The SMR-300 design philosophy for SSC withstands for internal missiles in line with Appendix F 'Special Provisions for Impulsive and Impactive Effects' of ACI 349.
- Providing design features to prevent the generation of missiles.
- Orienting missile sources to prevent missiles from striking safety-related SSC.

The implementation of redundant and segregated safety trains with suitable safety barriers in place to withstand credible internal missiles within the SMR-300 design aims to limit the impact of an Internal Missile to a single safety train.

22.6.6 Turbine Disintegration

Although Turbine Disintegration can be considered within 'Internal Missiles', due to the catastrophic nature of the disintegration and the associated consequences, assessment of this hazard is considered separately, as noted within TAG-014 [35]. The requirement to assess this hazard is in line with ONR SAP EHA.14 'Fire, Explosion, Missiles, Toxic Gases etc – Sources of Harm'.

The failure of the main turbine leading to the generation of missiles is a major hazard, however the plot plan for proposed sites has the turbine axis is in line with the reactor, so that any missile from the turbine will be directed away from the reactor building and the safety-related SSCs.

The frequency of turbine disintegration is low, and the probability of impact on SSCs following turbine disintegration is also low. As noted within ONR TAG [35] guidance, the US NRC Regulatory Guidance 1.115 [27] provides the general expectation for turbine disintegration analysis that expects missile protection for relevant SSCs to ensure the integrity of the reactor coolant pressure boundary. It also expects that the plant can be shut down (and maintained in a safe shutdown condition) or that the plant is capable of preventing accidents resulting in potential offsite exposures, as applicable. This will be achieved primarily by judicious site layout.

22.6.7 Dropped Loads

Assessment of dropped loads is required in line with ONR SAP EHA.14 Fire, Explosion, Missiles, Toxic Gases etc – Sources of Harm'. A dropped load has the potential to result in damage to SSCs important to nuclear safety leading to loss of containment, redistribution of nuclear material and loss of bulk shielding etc. Within the UK the term 'dropped load' does not solely refer to the vertical dropping of a load, it also covers the following:

- Impacting Loads (swinging leading to horizontal impact etc).
- Overlifting.
- Snagged Loads.
- Hangmans drops.

Within the US, if a 'lifting device' or 'special lifting device' is deemed to be 'single failure proof' as defined within NUREG-0612, no assessment of the dropped loads is required to be undertaken. Stress compliance criteria for 'lifting devices' are taken from the applicable code and standard for the type of lifting equipment being used. For a 'lifting device' to be considered single failure proof, leading to a dropped load, the design safety factors established based on the requirements of the aforementioned codes should be doubled, or a redundant 'lifting device' should be provided e.g., an additional sling or lift. Stress criteria for 'special lifting devices' are defined within ANSI N14.6.

Within US guidance if a lifting device does not fulfil the 'single failure proof' criteria then a dropped load analysis is required, dependent upon the type of lifting device that fails, assessments are undertaken either in line with NUREG-0612 or ANSI N14.6.

Within the UK the assessment of dropped loads requires the assessment of the consequences following a dropped load [35] to be assessed via suitable modelling or analysis. Following assessment of the consequences of a dropped load where necessary suitable and sufficient safety measures that are required will be identified.

The analysis of lifting equipment will confirm that either a dropped load will not occur, due to use of high integrity equipment, or a dropped load will not result in damage to SSCs related to safety. Lifting equipment is currently expected for the below activities:

- Movement of fuel and associated systems.
- Movement of Casks and other transportation issues.
- Preparation of RPV for refuelling activities
- Movement of SSCs during EIMT activities.

Analysis of dropped loads will assess the capabilities of lifting equipment and employ the defence in depth approach to ensure that should lifts be required, these shall be routed to minimise possible interactions with SSCs. Where possible, lifts should be eliminated, either through design optimisation or alternative movement methods. Should it not be possible to remove or reroute lifts away from SSCs related to safety further analysis will be undertaken to either substantiate a safety measure to protect the SSC or ensure that the SSC can withstand the dropped load.

Heavy loads are not typically lifted within the CS of the SMR-300 during power operations since most heavy loads are associated with refuelling operations, and a heavy load drop would not result in a plant trip during normal power operations. There is the potential for lifts to be undertaken within the RAB during power operations which, should they fall, could result in a reactor trip.

Within the UK all lifts required within the generic SMR-300 facility and site will comply with the Approved Codes of Practice (ACoP) for Lifting Operations and Lifting Equipment Regulations (LOLER) [69] and Provision and Use of Work Equipment Regulations (PUWER) [70] guidance.

22.6.8 Toxic and/ or Corrosive Solid, Liquid or Gaseous Release

Assessment of Toxic and/ or Corrosive Solid, Liquid or Gaseous Release is required in line with ONR SAP EHA.14 Fire, Explosion, Missiles, Toxic Gases etc – Sources of Harm'. The release of toxic and corrosive substances has the potential to result in a wide variety of consequences (radiological and non-radiological) depending upon the substance and location e.g., a corrosive substance in a high energy pipeline could result in a pipe whip/ jet impact or toxic vapour release into a confined area that could result in an asphyxiation risk to personnel. Combustible and explosive materials are covered within their respective Internal Hazard subchapters above.

Toxic and/ or corrosive substances produced as a result of a fire are to be covered under Internal Fires, in line with NRC Guidance, the release of such materials from other sources is covered within this subchapter.

For the assessment of the release of Toxic and/ or corrosive substances the SMR-300 will take the following approach. Information pertaining to the type, location and quantity of hazardous material expected for the generic SMR-300 will be identified and the potential consequences of its inadvertent release postulated. Dependent upon the identified consequences, varying safety measures may be required to ensure the risks are ALARP. These will be assessed on a case-by-case basis.

In line with the hierarchy of control principle the emphasis initially will be on removing these potential sources of Internal Hazards. Should this not be possible their quantities will be minimised to only what is required for normal operations. Following this, hazardous materials that are identified as having potential adverse impacts will have engineered safety measures applied. Depending upon their type of storage, volume and location these safety measures will differ, however, examples could include the provision of bunds to prevent the migration of the material, double piping such that should a pipe fail there will be secondary containment, etc. In addition to these physical engineering safety measures, suitable EIMT schedules will be in place to monitor SSCs important to nuclear safety.

22.6.9 Vehicle Impact

Dependent upon the size and velocity of a vehicle, a vehicle impact has the potential to cause significant damage to SSCs important to safety, either structurally or through secondary hazards such as fire or loss of transport containment. Within the US this hazard is captured under a Loss of Large Area (LOLA) analysis, which is undertaken to assess the plants response to major impacts and loss of areas, typically from malicious events.

The assessment of vehicle impacts will assess the key parameters of a vehicle and the location an impact could occur, this could be from vehicles internal to the buildings used to move process equipment or carry out repairs, or externally from larger transport vehicles, e.g., Heavy Good Vehicles (HGV). Within the design of the SMR-300, the use of haulage transports to bring in casks is planned which could result in a vehicle impact. The requirements for vehicles on site are dependent upon the site-specific location and the operational needs of the generic SMR-300, which will be defined during Licence Application stage, when details of the site-specific plot plan are available.

For vehicle impact the following high level design philosophy, based on the principle of hierarchy of control, will be followed for the SMR-300. The presence of vehicles within vulnerable parts of the site will be removed/ prevented or minimised; where this is not possible physical barriers will be put in place to prevent impacts of buildings and SSCs. Should barriers not be suitable, SSCs will be substantiated to withstand credible impacts from vehicles. The installation of vehicle impact barriers external to the generic SMR-300 is likely to have no impact upon the building structural performance. Areas of potential structural weakness or vulnerability to vehicle impacts will be assessed and safety measures provided accordingly, e.g., kerbs, impact barriers, bollards etc. Finally, administrative controls will be in place to limit the speed of vehicles on site.

The use of redundant segregated safety trains for the generic SMR-300 design minimises the risk of a single vehicle impact leading to loss of safety function.

22.6.10 Electromagnetic Interference

EMI has the potential to impact the functionality of electrical SSCs, should EMI impact upon SSCs important to safety then the nuclear safety of the NPP could be compromised and is required to be assessed in line with ONR SAP EHA.10. EMI can arise from varying sources, including lightning strikes (covered under Chapter B21 'External Hazards'), electrical SSCs such as generators, Uninterruptible Power Supply (UPS's), switch stations, Heating Ventilation, Air Conditioning (HVAC) systems, Bluetooth wireless links, wireless Local Area Networks (LANs) and communication facilities on emergency vehicles etc. Hazard Identification (HAZID) will be undertaken to ensure all credible sources of EMI from normal and potential maintenance operations, applicable to the generic SMR-300, are identified.

For the SMR-300, the EMI hazard is addressed by equipment qualification. Protection is provided in line with NRC RG 1.180 'Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems' [28]. Where appropriate equipment will be qualified to IEC EMC 61000 family of standards.

Redundancy and independency of Electrical, Control & Instrumentation (EC&I) equipment to protect against impacts of EMI are protected against via the implementation of NRC RG 1.75 'Criteria for Independence of Electrical Safety Systems' [33].

Protections against EMI and other grid resilience safety measures used within the SMR-300 design are outlined in detail 'HI-2240339, Holtec SMR GDA PSR Part B Chapter 6 Electrical Engineering' [9] of the PSR, a high-level summary of some of these safety measures are outlined below:

- Isolation of 1E Class and non-Class systems.
- Optical isolation of systems and use of fibre optical cables.
- Relay protection via harmonics and DC filters.
- Multiple earthing systems, separate earthing for instrumentation and computer systems.
- Lightning Protection Systems.

22.6.11 Combined Hazards

In line with ONR SAPs EHA.4 and EHA.5, the consideration of combined hazards is required. Combined hazards are where the occurrence of multiple hazards occur either simultaneously or are causally linked with a compounding effect such that safety measures could be challenged/ defeated. Combinations of External and Internal Hazards can occur, typically whereby the external hazard leads to a consequential Internal Hazards, e.g., Earthquake leads to an Internal Fire.

The approach to Combined Hazards for External-Internal is not presented within this PSR Chapter and is covered within Chapter B21 External Hazards [17]. For combinations of Internal-Internal Hazards, in line with the approach for External- External and External-Internal, the ASAMPSA_E [71] approach shall be followed whereby a matrix of hazards will be generated. Methodology and terminology is defined in full within PSR Chapter B21 'External Hazards' [17].

22.6.12 CAE Summary

The key requirement of the SMR-300 is to protect the reactor and its support systems from all credible identified Internal Hazards, including their combinations, and to provide containment and shielding to protect people and the environment.

The identified Internal Hazards are based upon RGP and extant GDA submissions are deemed to identify all generic Internal Hazards in support of claim 2.1.6.2. The identification of specific Internal Hazards based upon room layouts, item locations, pipe routing etc is currently being undertaken.

The PFS will act as the vehicle to capture Internal Hazards along with their safety measures. Substantiation and validation of these safety measures will be provided by their corresponding disinclines, e.g. civil engineering, mechanical engineering etc.

22.7 SSCs WITH INTERNAL HAZARD SAFETY FUNCTIONS

Claim 2.1.6.3: Safety functions and safety measures are identified, categorised and classified based on their importance to nuclear safety for all Internal Hazards and provide sufficient lines of protection based on the fault frequency and consequence.

This subchapter presents the current list of identified in-scope SSCs with Internal Hazards-related Safety Functional Requirements (SFR) and non-Safety Functional requirements (N-SFRs) and outlines the methodology and process followed for their identification. This subchapter supports Claim 2.1.6.3, excerpted from Chapter A3 of the PSR Claims, Arguments and Evidence [2]. Further discussion of the CAE is presented in Subchapter 22.3:

For the identified in-scope SSCs with requirements applicable to Internal Hazards, their corresponding SFRs and N-SFRs have been extracted into Table 8 as they are deemed to have a requirement applicable to Internal Hazards. The identified list of SSCs is non-exhaustive and will be refined and updated for Rev. 1. The SSCs and their respective SFRs and N-SFRs have been identified according to the following approach:

- Chapter A2 'General Design Aspects and Site Characteristics' [3] presents a list of SSCs which have been identified as in-scope, this list is based upon the Design Reference Point (DRP), also covered within Chapter A2.
- For each of the in scope SSCs, where documentation is available, the following documentation types have been reviewed to identify the requirements applicable to Internal Hazards (e.g., Fire requirements, Structural requirements against Pipe Whip):
    - System Design Descriptions (SDD).
    - Control System Descriptions (CSD).
    - Design Specifications (DS).
- Following the updates to SMR-300 documentation, a review of these documents shall be undertaken to identify any new/variations in SSC listed within Table 5 and Table 8.
- High-Level Safety Functions have been derived according to the Safety Functions within the SDDs, CSDs, and DSs. Where clear identification of the High-Level Safety Function is not possible within the source document, the High-Level Safety Functions have been derived based upon SQEP Engineering Judgement from the claims presented in the GDA Scope document HI-2240121, Holtec SMR GDA Scope [72].
- System Group descriptors have been allocated according to Holtec procedure HPP-160-3036 [73], although directly applicable to the SMR-160, the same convention shall apply to the SMR-300.
- US SMR Class for the identified in-scope SSCs has been populated according to Chapter A2 'General Design Aspects and Site Characteristics' [3]. In summary, A, B and C are 'Safety-Related and D, E and F are 'Non-Safety Related'.
- Table 8 captures the output of the above exercise and identifies initial SSCs relating to cand N-SFRs.

Table 5: High-Level Plant Functions for SSCs relating to Internal Hazards

SSC Description	System Acronym	US SMR Class[3]	Holtec High-Level Function
Main Steam System	MSS	B	Containment Integrity
DC Power Distribution System	DCE	C	Control of Reactivity
I&C Power Distribution System	ICE	C	Control of Reactivity
Main Control Room Habitability System	MCH	C	Containment Integrity
Containment Isolation System	CIS	C	Containment Integrity
Reactor Auxiliary Building	RAB	C	Containment Integrity
Containment Enclosure Structure	CES	C	Containment Integrity
Passive Containment Heat Removal System	PCH	B	Containment Integrity
Containment Structure	CS	B	Containment Integrity
Reactor and Coolant System	RCS	Various (A-B)	Control Reactivity
Residual Heat Removal System	RHR	A	Post-Accident Heat Removal
Plant Safety System	PSS	C	Control Reactivity
Reactor Pressure Vessel	RPV	A	Containment Integrity
Steam Generator	SGE	A/B	Containment Integrity
Passive Core Cooling System	PCC	A	Post-Accident Heat Removal
Diverse Actuation System	DAS	D	Control Reactivity
Plant Control System	PCS	D/F	Post-Accident Heat Removal
Control Rod Drive System	CDS	A	Control Reactivity
Excore Instrumentation System	EIS	C	Control Reactivity

All other functions are classed as non-safety functions. The safety and non-safety functions of each Civil Engineering SSC are presented in Appendix C.

22.7.1 Categorisation and Classification

The safety categorisation and classification methodology currently defined for SMR-300 by Holtec international utilises the US NRC Regulatory Guide 1.26, Revision 6 [74] and related guidance documents.

The generic SMR-300 for introduction to the UK will require the adoption of appropriate national and international nuclear specific codes and standards to meet UK regulatory expectations, so that it is fit for use as the starting point for a future licensee's site-specific project.

Holtec acknowledge the existence of differences in the approach to safety categorisation and classification between the NRC regulatory guides and other national and international standards.

The differences in the approach to safety categorisation and classification have been identified via the gap analysis [19] and the US/ UK regulatory framework and principles [75]. The

[3] The classification of 'Safety Functional Requirement' and 'Non-Safety Functional Requirement' is in line with US classification. As further work is undertaken these classifications are to be updated to align with the UK Categorisation and Classification.

methodology for safety categorisation and classification is outside the scope of this chapter and is to be undertaken within Chapter B14.

22.7.2 CAE Summary

The key requirement of the SMR-300 is to protect the reactor and its support systems from all credible identified Internal Hazards, including their combinations, and to provide containment and shielding to protect people and the environment.

To meet Claim 2.1.6.3, provisional SSCs have been identified for Internal Hazards based upon the available design information and a provisional strategy for categorisation and classification provided within Chapter B14 and its supporting deliverables. As design development continues, the list of SSCs shall be developed further.

22.8 CHAPTER SUMMARY AND CONTRIBUTION TO ALARP

This sub-chapter provides an overall summary and conclusion of the Internal Hazards Chapter and how this Chapter contributes to the overall demonstration of ALARP for the generic SMR-300. Chapter A5 [61] sets out the overall approach for demonstration of ALARP and how contributions from individual Chapters are consolidated.

This subchapter therefore consists of the following elements:

- Technical Summary;
- ALARP Summary
  - Review against Relevant RGP;
  - Demonstration Against Risk Targets;
  - Evaluation of Risk (where applicable);
  - Risk Reduction Options;
  - GDA Commitments and Forward Actions.
- Conclusion.

A review against these elements is presented below under the corresponding headings.

22.8.1 Technical Summary

PSR Chapter B22, Revision 1 demonstrates that the Internal Hazard SSC within the scope of this report will meet the high-level Claims of the SSEC and that the SSC can be substantiated at Pre-Construction Safety Report (PCSR) stage. This is demonstrated through the following level 3 claim:

Claim 2.1.6: Risks from Internal Hazards and their combinations have been demonstrated to be tolerable and As Low As Reasonably Practicable (ALARP).

The key requirement of the SMR-300 is to protect the reactor and its support systems from all credible identified Internal Hazards, including their combinations, and to provide containment and shielding to protect people and the environment. The identification of specific Internal Hazards based upon room layouts, item locations, pipe routing etc shall be undertaken in future design stages with the PFS acting as the vehicle to capture Internal Hazards along with their fault progressions, consequences and safety measures. Substantiation and validation of these safety measures will be provided by their corresponding disinclines, e.g. civil engineering, mechanical engineering etc.

Internal Hazards protection will employ the hierarchy of safety principle, these are in order of most to least preferable:

- Eliminate:
  - The hazard is eliminated completely, e.g., the design of the plant precludes the need for moving equipment etc so drop loads, for example, are no longer credible.
- Reduce:
  - The source of the hazard of the hazard are reduced, e.g., radiological/ explosive inventory is reduced.

- Isolate:
    - The hazard has been isolated e.g., explosive sources are isolated, either through location away from vulnerable areas or through the installation of adequate protective barriers such as a blast wall.
- Control:
    - Using administrative controls, e.g., there are time limitation for operators/ staff working in high radiation areas.
- Protect:
    - Operators are provided with Personal Protective Equipment (PPE), e.g., respirators etc.
- Discipline:
    - Enforcement of safe systems of work, e.g., site speed limits for vehicles, training of staff for emergency situations etc.

For each of the identified Internal Hazards the SMR-300 design will either eliminate/ prevent the hazards or provided suitable and sufficient safety measures, to the release of radioactivity to the environment. The design philosophies for each of the identified Internal Hazards has been outlined within subchapter 22.6.

PSR Revision 1 will define the hazards considered in the design, based upon current design information. In conjunction with Chapter B14 [13], and the PFS to be produced as one of its deliverables, Internal Hazards that are identified will be assessed for safety measures and sentenced to the required disciplines, e.g. physical withstand barriers will be sentenced to Civil Engineering.

For Revision 0 it is deemed that the maturity of the safety justification presented in B22 ‘Internal Hazards’ is appropriate for a PSR and identification of relevant hazards, identification of SSCs to protect, prevent and mitigate from the effects of hazards and sound methods of evaluation of hazards provide confidence that the level three claim. Claim 2.1.6, will be able to be met in future safety submissions and risks evaluated as tolerable and ALARP.

22.8.2 ALARP Summary

22.8.2.1 Review against RGP

Due to the differing regulatory approaches between the UK and US, Internal Hazards are assessed in differing ways. Within the UK formal hazard identification is required to enable the ‘golden thread’ to be followed from identification to progression to available safety measures. In the US a more prescriptive approach is taken that does not require formal hazard identification. Instead, fault types are prescribed by the NRC and analysed in detail primarily using Probabilistic Safety Assessment (PSA).

Not all Internal Hazards covered within subchapter 22.6 are reflected in available design information. Those Internal Hazards for which design information is currently unavailable will be addressed in future revisions of this document. A full list of Internal Hazards that require consideration within the UK have been identified from the most significant RGP in Table 7. These Internal Hazards are considered in differing ways within the US and UK assessment approach, those of notable difference requiring further work to be undertaken, either within the GDA process or within the licensing phases.

Provided the associated differences are clearly defined and any gaps managed, the approach used is considered to be good practice and additional effort required to ensure alignment is considered to reduce risk in line with the ALARP principle.

Forward actions will form the basis for setting out the process to justify any gaps from UK RGP. Forward Actions have been collated and are managed via the process Chapter A4, 'Lifecycle Management of Safety and Quality Assurance' [7].

22.8.2.2 Demonstration Against Risk Targets

The numerical targets against which the demonstration ALARP is considered can be found in PSR Chapter A2 [3]. Internal Hazards SSCs, through the defined safety functions, will contribute to the demonstration of ALARP by comparison against the risk targets in the following ways:

- By ensuring the cumulative risk from identified Internal Hazard fault progressions are below the required targets 4-9, along with the identification of a list of contributors (basic events, system failures, human errors, etc.) ranked according to risk importance measures.
  - There are a number of importance measures routinely used in PSA studies but the two identified within Chapter B16 that are most useful in ALARP assessments are Fussell-Vesely (FV) Importance and Risk Achievement Worth (RAW), full details of the insights available through PSA are subject to Chapter B16 Probabilistic Safety Assessment [15].
- By achieving their safety classification as a duty system or a protection system, where claimed, they will contribute to the achievement of accident risk Targets 4-9.

Risks below the Basic Safety Objectives (BSOs) are considered broadly acceptable, however, the RP is still required to identify further risk reduction measures in line with the ALARP approach. Risks between the BSOs and Basic Safety Levels (BSLs) require a consideration of risk reduction options. Risks above the BSLs are not acceptable for new plants.

22.8.2.3 Evaluation of Risk

For Internal Hazards the evaluation of the normal operations and accident risks against Targets 1-9 has not been provided at this stage of design, however, this information will be presented in the following chapters:

- Chapter B10 Radiological Protection [76] for normal operations.
- Chapters B14 'Design Basis Accident Analysis' [13], B15 'Beyond Design Basis and Severe Accident Analysis, and Emergency Preparedness' [14] and B16 'Probabilistic Safety Analysis' for accident conditions [15].

22.8.2.4 Risk Reduction Options

This is a placeholder to identify and review relevant Position Papers and Design Decision Papers with a view to demonstrate which option(s) is/are ALARP.

It will summarise those option evaluations, and it will briefly explore if other risk reduction options have or could be considered and either:

- Present the ALARP argument for why those options have not been implemented.
- Present the ALARP argument for why those options will be implemented in future.
- Create a Forward Action to consider the option(s) at some future point (noting this still must be a point where a meaningful design improvement could be made).

The process for the assessment of risk reduction options is presented in 'HPP-3295-0017-R0, Holtec SMR-300 Generic Design Assessment Reference Design Process and GDA Prospective Design Change Register' [77].

22.8.2.5 GDA Commitments and Forward Actions

At Revision 0 there are no GDA commitments identified for Chapter B22, Internal Hazards.

Forward Actions have been collated and are presented in Chapter A4, Lifecycle Management of Safety and Quality Assurance [7].

22.8.3 Conclusion

The conclusion of Chapter B22 of the PSR is that:

- The Chapter Claims identified have been met to a maturity aligned with the current vision of the PSR. Further claims, arguments and evidence will be presented in due course as the design develops.
- All generic Internal Hazards have been identified to a level suitable for a PSR.
- Ongoing input of Internal Hazards into the draft PFS being produced as part of B14 'Design Basis Accident Assessment' will ensure safety functions and identified safety measures are categorized and classified to provide suitable and sufficient lines of protection.
- Provisional SSCs have been identified for Internal Hazards based upon the available design information and a provisional strategy for categorisation and classification provided within Chapter B14 and its supporting deliverables. As design development continues, the list of SSCs shall be developed further.
- Safety and non-safety functions have been identified for the Internal Hazard SSCs based upon available information.

Part A Chapter 5 of this PSR 'ALARP Summary' [61] concludes that it can be demonstrated that the generic SMR-300 reduces risks to ALARP and provides confidence that the Fundamental Purpose of the SSEC can be fulfilled at PCSR stage.

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22.10 LIST OF APPENDICES

Appendix A Internal Hazard CAE Route Map

Table 6: Chapter B22 CAE Route Map

Corresponding Overarching SSEC Claim(s)	PSR Chapter Claim(s)	PSR Chapter Sub-Claim(s)
Claim 2.1: The nuclear safety assessment identifies plant initiating events specifies the requirements for safety measures such that safety functions are fulfilled, informs operational and emergency arrangements and demonstrates that risk is tolerable and ALARP.	**Claim 2.1.6:** Risks from Internal Hazards and their combinations have been demonstrated to be tolerable and ALARP.	**Sub-claim 2.1.6.1:** Internal Hazards are characterised and evaluated using appropriate methodologies.
		Sub-claim 2.1.6.2: A comprehensive set of Internal Hazards and their combinations are identified and screened for assessment.
		Sub-claim 2.1.6.3: Safety functions and safety measures are identified, categorised and classified based on their importance to nuclear safety for all Internal Hazards and provide sufficient lines of protection based on the fault frequency and consequence.
		Sub-claim 2.1.6.4: Analysis demonstrates that for all Internal Hazards, the identified safety features, in conjunction with operator actions, enable the plant to reach a safe state.

Appendix B RGP and Extant Internal Hazards Review

Table 7: RGP and Extant Internal Hazards Sources

Primary Hazard (Name as given in source document)	Preferred Terminology for Project	Source Document(s)								
		ONR SAPs / TAG14	ONR-GDA-GD-007 May 2019 - Section 3.11	IAEA Safety Standards Series No. SSG-64	IAEA Safety Standards SSR-2/1 (Rev.1)	UK EPR	RR SMR	UK AP1000	UK ABWR	UK HPR1000
Fire	Internal Fire	X	X		X	X	X			X
Internal Fire				X				X	X	
Explosions	Internal Explosions	X	X		X		X			
Internal Explosions				X		X			X	X
Blast (pressurised equipment)							X		X	
Explosive Materials						X				
Flooding/ Spray	Internal Flooding	X			X		X		X	X
Internal Flooding			X	X		X		X	X	X
Immersion									X	
Release of fluid					X					X
Pipe Whip and Jet Impact	Pipe Whip and Jet Impact	X	X		X		X		X	X
Pressure Part Failure								X		
Pipework System Failures			X							X
Pipe breaks				X		X				
Internal Missiles	Internal Missiles	X	X	X		X			X	X
Turbine Missiles		X							X	
Missiles					X		X			
Rotating Machinery			X							

Primary Hazard (Name as given in source document)	Preferred Terminology for Project	Source Document(s)								
		ONR SAPs / TAG14	ONR-GDA-GD-007 May 2019 - Section 3.11	IAEA Safety Standards Series No. SSG-64	IAEA Safety Standards SSR-2/1 (Rev.1)	UK EPR	RR SMR	UK AP1000	UK ABWR	UK HPR1000
Tanks, pumps, and valve failures						x				
Dropped Loads	Dropped Loads	x				x	x	x	x	x
Heavy Load Drops				x						
Collapsed Loads										
Collapse of structures and falling objects[4]					x					x
Toxic and/ or Corrosive Solid, Liquid or Gaseous Releases	Toxic and/ or Corrosive Solid, Liquid or Gaseous Releases	x	x					x		
Release of hazardous substances inside the plant				x			x			
Noxious release following a fire						x				
Hot Gas and Steam Release	Hot Gas and Steam Release	x	x				x		x	
Vehicular Transport Impacts	Vehicle Impact	x					x			
Vehicle impact			x							

Collapse of structure to be covered under specific Internal Hazard withstands e.g. protection from a blast overpressure. Collapse of a structure from External Hazards is covered within Chapter B21 'External Hazards'.

Primary Hazard (Name as given in source document)	Preferred Terminology for Project	Source Document(s)								
		ONR SAPs / TAG14	ONR-GDA-GD-007 May 2019 - Section 3.11	IAEA Safety Standards Series No. SSG-64	IAEA Safety Standards SSR-2/1 (Rev.1)	UK EPR	RR SMR	UK AP1000	UK ABWR	UK HPR1000
Onsite Transport Accidents								X		
Electromagnetic Interference	Electromagnetic Interference	X	X	X		X	X	X	X	
Radio Frequency Interference									X	
Combinations of Hazards	Combinations of Hazards	X					X			X

Appendix C High-Level, Safety and Non-Safety Functions for Internal Hazards

Table 8: REDACTED

REDACTED