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General Nuclear System Ltd.

UK HPR1000 GDA Project

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Pre-Construction Safety Report
Chapter 29
Interim Storage of Spent Fuel

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29.1 List of Abbreviations and Acronyms

ACPR1000	Advanced Chinese Pressurised Reactor
ALARP	As Low As Reasonably Practicable
BAT	Best Available Techniques
BFX	Fuel Building
BQF	Spent Fuel Interim Storage Facility
CAE	Claims, Arguments, Evidence
CGN	China General Nuclear Power Corporation
CPR1000	Chinese Pressurised Reactor
CPR1000$^+$	Chinese Improved Pressurised Reactor
DiD	Defence in Depth
DMK	Fuel Building Handling Equipment [FBHE]
DWK	Fuel Building Ventilation System [FBVS]
DR	Design Reference
EMIT	Examination, Maintenance, Inspection and Testing
GDA	Generic Design Assessment
GDF	Geological Disposal Facility
HAW	Higher Activity Waste
HLW	High Level Waste
HPR1000	Hua-long Pressurised Reactor
HPR1000 (FCG3)	Hua-long Pressurised Reactor under construction at Fangchenggang nuclear power plant unit 3
ICIA	In-core Instrument Assembly
LKD	NI 380V Normal Power Distribution System [NPDS (NI-380V)]
NPP	Nuclear Power Plant
ONR	Office for Nuclear Regulation (UK)
OPEX	Operating Experience
PCER	Pre-Construction Environmental Report

PCSR	Pre-Construction Safety Report
PMC	Fuel Handling and Storage System [FHSS]
PTR	Fuel Pool Cooling and Treatment System [FPCTS]
RCCA	Rod Cluster Control Assembly
RGP	Relevant Good Practice
RWM	Radioactive Waste Management Ltd (UK)
SAP	Safety Assessment Principle (UK)
SED	NI Demineralised Water Distribution System [DWDS (NI)]
SFA	Spent Fuel Assembly
SFAIRP	So Far As Is Reasonably Practicable
SFIS	Spent Fuel Interim Storage
SFP	Spent Fuel Pool
SFRR	Spent Fuel Retrieval and Repackaging
SSC	Systems, Structures and Components
SCCA	Stationary Core Component Assembly
TAG	Technical Assessment Guide (UK)
UK HPR1000	UK version of the Hua-long Pressurised Reactor

System codes (XXX) and system abbreviations (YYY) are provided for completeness in the format (XXX [YYY]), e.g. Fuel Building Handling Equipment (DMK [FBHE]).

29.2 Introduction

29.2.1 Overview

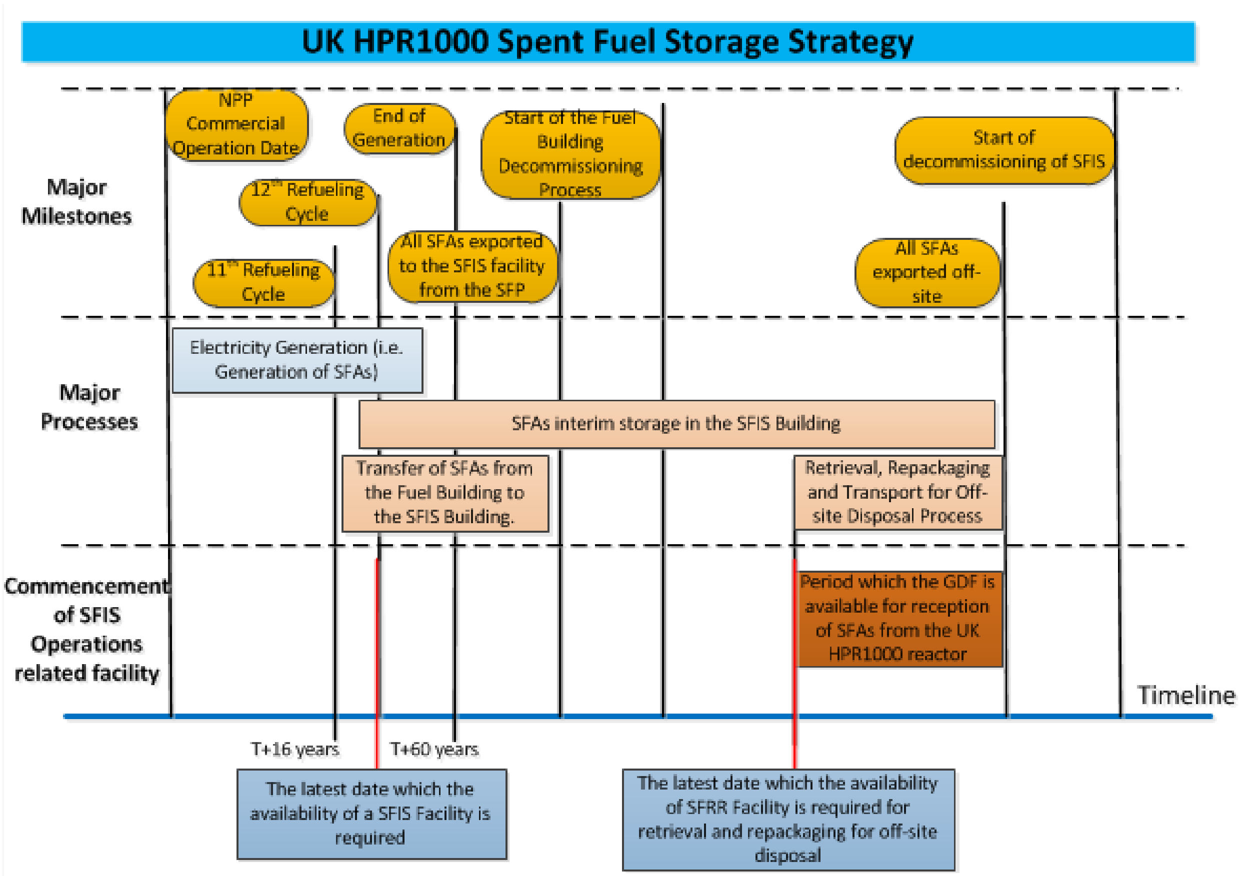
The Hua-long Pressurised Reactor under construction at Fangchenggang Nuclear Power Plant (NPP) unit 3 (HPR1000 (FCG3)) in China is designed according to the domestic policy of China. There is currently no Chinese regulation, code or standard relevant to new pressurised water reactors for on-site Spent Fuel Interim Storage (SFIS) systems and buildings. The HPR1000 (FCG3) spent fuel storage strategy consists in removing Spent Fuel Assemblies (SFAs) from the reactor and temporarily storing them on-site in the Spent Fuel Pool (SFP) of the Fuel Building (BFX) before transferring off-site to reprocessing plant. The total storage capacity of the underwater spent fuel storage racks in the SFP is enough for approximately 10 refuelling cycles, plus a full core for emergency unloading.

In the UK, the government has concluded that any new nuclear power station that might be built in the UK should be designed on the basis that SFAs will not be reprocessed and that plans for their management, including financing, should be developed, Reference [1]. For the UK version of the Hua-long Pressurised Reactor (UK HPR1000), management arrangements for the SFAs arising from the full projected life of the NPP are required to be identified by the requesting parties. These arrangements should take into account existing and planned off-site facilities for ultimate spent fuel storage.

A Geological Disposal Facility (GDF), coupled with safe and secure on-site interim storage, was recommended by Radioactive Waste Management Ltd (RWM) as the best available approach for the long-term management of SFAs. However, no GDF is currently available in the UK, and it is therefore necessary for SFAs to be stored on-site until the GDF is available for disposal of SFAs, Reference [2].

The UK HPR1000 is expected to be operated for 60 years and, therefore, a solution for spent fuel storage management (i.e. on-site spent fuel interim storage) is required prior to the GDF being available for the UK HPR1000 reactor. This chapter represents the current position of SFIS proposal for the UK HPR1000.

F-29.2-1 provides an overview of the UK HPR1000 spent fuel storage strategy.



F-29.2-1 UK HPR1000 Spent Fuel Storage Strategy

The spent fuel storage strategy for the UK HPR1000 is divided to three phases:

a) Short Term Storage in the SFP

SFAs removed from the core are first stored in the SFP approximately 10 years. Pre-Construction Safety Report (PCSR) Chapter 28 describes the storage of SFAs in the SFP following the refuelling process, as part of the fuel handling and storage process. The SFAs cooling period in the SFP has knock-on effects on the design criteria of the SFIS systems and building. For example, the minimum storage period of the SFAs may affect the potential transfer cask cooling system, and the maximum number of SFAs to be stored in the fuel storage canister may affect the dose received by operators and the public during normal operations, as well as the design basis fault and hazard events.

The SFP has the capacity to store the SFAs produced from approximately 10 refuelling cycles, assuming an average number of 72 SFAs generated from each refuelling cycle. The SFP is also required to accommodate a full core emergency unloading, which equates to 177 fuel assemblies.

More information relevant to the handling and short-term storage of spent fuel (including failed fuel), as well as Rod Cluster Control Assemblies (RCCAs) and Stationary Core Component Assemblies (SCCAs), within the BFX is presented in PCSR Chapter 28.

b) Interim Storage On-site

After short term storage in the SFP, SFAs are then loaded into a fuel storage canister and moved into the on-site Spent Fuel Interim Storage Facility (BQF) for an interim storage period of at least 100 years prior to retrieval and repackaging for off-site disposal. The facility capacity is designed to accommodate the SFAs generated during the 60 years' operation of two UK HPR1000 units.

During the Generic Design Assessment (GDA) phase, the concept design and a preliminary As Low As Reasonably Practicable (ALARP)/ Best Available Techniques (BAT) demonstration for SFIS is conducted and presented. Further design of SFIS will be conducted in the nuclear site licensing phase once the specific supplier for interim storage products has been selected.

c) Off-site Disposal in the GDF

After the on-site interim storage, the spent fuel is assumed to be transported to the GDF for final disposal. Prior to the off-site transport, the retrieval and repackaging is assumed be carried out on site, in line with assumption *Management and disposal of spent fuel* in the Base Case, Reference [3]. Currently, no final disposal facility exists in the UK. In order to ensure that SFAs can be safely disposed of in all potential scenarios, the UK HPR1000 storage facility shall consider the retrieval of SFAs from spent fuel canisters. When the GDF is available to receive SFAs from the UK HPR1000, SFAs will be repackaged into an appropriate canister depending on the final disposal facility and transportation requirements.

Retrieval and repackaging will not be carried out until the GDF is available for any new NPPs in the UK. Since this is assumed to be more than 100 years away and the repackaging canister is not yet known, the design for retrieval and repackaging is therefore out of GDA scope. This chapter presents the potential options based on current understanding of UK policy and available technology. Detailed design and relevant optioneering works will be conducted in an appropriate phase by the licensee in the future.

For spent non-fuel components, spent fuels and other higher activity waste, the waste characterisation and management strategy is presented in PCSR Chapter 23 and Pre-Construction Environmental Report (PCER) Chapter 4, Reference [4]. The systems design and relevant ALARP demonstration for waste management proposal is presented in PCSR Chapter 23. The design for interim storage of Non-Fuel Core Components (NFCCs) in BQF is presented in Sub-chapter 29.6.2.

The safety case for SFIS is produced based on the version 3 of the UK HPR1000 Design Reference (DR3), as described in the *UK HPR1000 Design Reference Report*, Reference [5]. DR3 reflects the design modifications implemented to address the identified gaps in relation to SFIS during GDA, considering the principles of ALARP and BAT. The safety assessment results are documented in this chapter and corresponding safety assessment reports. This chapter also presents suitable design information to support the BAT demonstration for current SFIS conceptual design.

29.2.2 Chapter Route Map

The Fundamental Objective of the UK HPR1000 is: The Generic UK HPR1000 could be constructed, operated, and decommissioned in the UK on a site bounded by the generic site envelope in a way that is safe, secure and that protects people and the environment.

To underpin this Fundamental Objective, five Level 1 claims and a number of Level 2 claims are developed and presented in PCSR Chapter 1. This chapter supports the Claim 3.3 derived from the high level Claim 3.

Considering the GDA scope, Reference [6], the safety route map of PCSR Chapter 29 is developed to support Claim 3.3.13, which can be seen below.

Analysis of Safety Assessment Principles (SAPs), Reference [7] and Technical Assessment Guides (TAGs), Reference [8] (issued by the Office for Nuclear Regulation (ONR)), the GDA scope for SFIS and the international Operating Experience (OPEX) of SFIS facility design are also considered in the Claims, Arguments and Evidence (CAE) structure. PCSR Chapter 29 supports the following Claims:

Claim 3: The design and intended construction and operation of UK HPR1000 will

protect the workers and the public by providing multiple levels of defence to fulfil the fundamental safety functions, reducing the nuclear safety risks to a level that is as low as reasonably practicable.

Claim 3.3: The design of the processes and systems has been substantiated and the safety aspects of operation and management have been substantiated.

Claim 3.3.13: The Spent Fuel Interim Storage process, and design of the associated systems, is substantiated.

According to Reference [9], the trail from safety claims through arguments to evidence should be clearly set out in the safety case. A route map for Chapter 29 is presented in Appendix A to help achieving this.

The objectives of this chapter are consistent with the GDA scope, Reference [6], and include:

a) Present a suitable approach to demonstrate that the potential spent fuel storage technology is capable of reducing the risk to a level that is ALARP.

b) Demonstrate that SFIS technology can be selected properly, and potential suitable SFIS options have been considered adequately for the UK HPR1000.

c) Demonstrate that the conceptual design for SFIS proposed in GDA phase is capable of safely storing spent fuel and other High Level Wastes (HLWs) generated from the UK HPR1000 operation.

29.2.3 Scope of Spent Fuel Interim Storage

The scope of this chapter is limited to SFIS as a part of the on-site fuel cycle. The on-site fuel cycle is a process that encapsulates the entire life cycle of nuclear fuel within the nuclear licensed site boundary, from the receipt of new fuel to retrieval and repackaging of SFAs for off-site disposal. Fuel handling and storage operations are presented in PCSR Chapter 28, which covers the refuelling process, new fuel receipt, handling and storage in the SFP.

The processes related to SFIS are defined as having the following start and end point:

Start point: Preparation of Systems, Structures and Components (SSC). This refers to the transfer of relevant equipment from the storage locations to the designated location in the BFX, which is prepared for fuel loading into the storage canister.

End point: Retrieval and repackaging of SFAs for off-site disposal. The spent fuel export from the NPP and off-site transportation to the final GDF is not included in this scope.

The general layout of the BQF within the NPP is not confirmed during GDA, as it is highly dependent on specific site conditions. Therefore, the transfer path of spent fuel between the BFX and the BQF is not determined in GDA phase. The final route path should be determined considering the location of buildings, which should be determined at nuclear site licensing phase considering all relevant factors including (but not limited to) the transfer time limit, depending on the SFIS equipment performance of the chosen supplier and corresponding operation instruction, and the route conditions for spent fuel transfer, such as the loading limits of the route.

The Spent Fuel Retrieval and Repackaging (SFRR) facility provides SFA retrieval capability following decommissioning of the BFX and repackaging of SFAs prior to off-site disposal. Depending on the final SFIS technology and the off-site fuel transport requirements identified in the nuclear site licensing phase, it may be possible to incorporate the retrieval and repackaging of spent fuel/canisters into the BQF. This would avoid the need for a separate SFRR facility. As the SFRR facility is not required until at least many decades after the beginning of plant operation, it’s not necessary to make a decision in GDA phase. This decision will be made by the future site licensee at an appropriate stage.

Failed fuels generated during operation of the UK HPR1000 are currently considered for storage in the SFP. The design for failed fuel storage within the SFP is presented in PCSR Chapter 28 and relevant supporting documents. The potential options for failed fuel management after removal from the spent fuel pool are presented in Sub-chapter 29.6.2. The final management strategy for failed fuel is not be determined during GDA but at nuclear site licensing phase.

The following work related to SFIS is identified to be conducted within GDA phase:

a) Technology optioneering between wet storage and dry storage.

b) SFIS conceptual design, including the storage considerations for other HLWs in BQF.

c) Matching analysis of SFIS design with current the UK HPR1000 design.

d) Preliminary safety evaluation, including the evaluation of the dose to the public.

e) ALARP demonstration.

f) Disposability assessment of spent fuel.

The scope of GDA for SFIS, including which information is included and excluded, is presented in Reference [6].

29.2.4 Chapter Structure

The structure of this chapter is as follows:

Sub-chapter 1: provides a list of abbreviations and acronyms.

Sub-chapter 2: presents the introduction to this chapter including the scope of SFIS, chapter route map, interfaces with other chapters, and key assumptions.

Sub-chapter 3: presents the applicable codes and standards for the SFIS relevant work in the UK HPR1000.

Sub-chapter 4: presents an overview of the SFIS process and the relevant SSCs.

Sub-chapter 5: presents the requirements to be considered in the SFIS design.

Sub-chapter 6: presents the SFIS design for GDA, including the technology optioneering, process flow, interface SSCs and facility layout.

Sub-chapter 7: presents the preliminary ALARP assessment of the SFIS with the focus on identification of gaps on the basis of Relevant Good Practice (RGP), technology optioneering and preliminary safety evaluation.

Sub-chapter 8: presents the record management related to SFIS.

Sub-chapter 9: presents the concluding remarks of safety case for SFIS during GDA.

Sub-chapter 10: presents the references.

Appendix 29A: presents the safety case route map for PCSR Chapter 29.

Appendix 29B: presents the preliminary layout consideration for the SFIS.

29.2.5 Interfaces with Other Chapters

The interfaces with other chapters are listed in the following table T-29.2-1.

T-29.2-1 Interfaces between Chapter 29 and Other Chapters

Chapter	**Interfaces**
PCSR Chapter 1 Introduction	PCSR Chapter 1 defines the claims that PCSR Chapter 29 should consider and support. PCSR Chapter 29 identifies the high level safety functions that must be maintained by the BQF.
PCSR Chapter 2 General Plant Description	PCSR Chapter 2 gives a brief introduction to SFIS. PCSR Chapter 29 provides information about the interim storage of spent fuel mentioned in Sub-chapter 2.14 in PCSR Chapter 2.
PCSR Chapter 3 Generic Site Characteristics	PCSR Chapter 3 provides values for site related parameters for the UK HPR1000 SFIS design presented in PCSR Chapter 29.
PCSR Chapter 4	PCSR Chapter 4 covers the UK HPR1000 safety and

Chapter	**Interfaces**
General Safety and Design Principles	design principles to be applied to the design of SFIS operations. PCSR Chapter 29 considers the general safety and design principles including the concept of Defence in Depth (DiD) and engineering substantiation in the design of SFIS which are based on PCSR Chapter 4.
PCSR Chapter 5 Reactor Core	PCSR Chapter 5 covers the fuel assembly design parameters and operational information, including size, weight and quantity, which is the necessary information for spent fuel disposability assessment and BQF design.
PCSR Chapter 10 Auxiliary System	PCSR Chapter 10 provides the design of supporting systems involved in the SFIS operations such as Fuel Building Handling Equipment (DMK [FBHE]), Fuel Pool Cooling and Treatment System (PTR [FPCTS]), etc. PCSR Chapter 29 covers the SFIS design related to some auxiliary systems presented in PCSR Chapter 10.
PCSR Chapter 14 Probabilistic Safety Assessment	PCSR Chapter 14 provides the main results of the PSA and risk insights on the process of SFIS within the BFX. PCSR Chapter 29 provides the design proposal for SFIS which should be considered for the PSA within the BFX.
PCSR Chapter 15 Human Factors	PCSR Chapter 15 provides the principles and methodology of human factors integration that shall be considered in the system and component design. PCSR Chapter 29 provides the substantiation of SFIS design, which is further estimated in the human factors area.
PCSR Chapter 16 Civil Engineering	PCSR Chapter 16 provides the general description of the BFX, which is one of the buildings included in

Chapter	Interfaces
	the SFIS operations. PCSR Chapter 29 presents the spent fuel interim storage operation related SSCs in the UK HPR1000.
PCSR Chapter 18 External Hazards	PCSR Chapter 18 provides the external hazards analysis methodology and principles for SFIS related evaluation. PCSR Chapter 29 presents the preliminary safety evaluation results based on the external hazards analysis methodology.
PCSR Chapter 19 Internal Hazards	PCSR Chapter 19 provides the internal hazards analysis methodology and principles for SFIS related evaluation. PCSR Chapter 29 presents the preliminary safety evaluation result based on the internal hazards analysis methodology.
PCSR Chapter 20 MSQA and Safety Case Management	PCSR Chapter 20 provides organisational, quality assurance and requirement management arrangements which should be integrated in the UK HPR1000 development. PCSR Chapter 29 applies the requirement management arrangements set out in Chapter 20[1].
PCSR Chapter 22 Radiological Protection	PCSR Chapter 22 provides the general radiological protection measures against direct radiation and radioactive contamination, worker dose assessment relating to spent fuel assembly handling and storages operations, and the public dose assessment from direct radiation against the spent fuel interim storage facility. PCSR Chapter 29 presents the requirements of spent fuel and In-Core Instrument Assemblies (ICIAs) handling and storage operations for worker dose

[1] This chapter will be supplemented in Mechanical Engineering Schedule with application of the coding system at nuclear site licensing phase.

Chapter	Interfaces
	assessment during normal operation and the spent fuel interim storage design proposal for public dose assessment from direct radiation.
PCSR Chapter 23 Radioactive Waste Management	PCSR Chapter 23 provides the management proposal of NFCCs. PCSR Chapter 29 presents the interim storage of spent fuel and waste NFCCs generated from the reactor.
PCSR Chapter 24 Decommissioning	PCSR Chapter 24 presents the general decommissioning consideration of the SFIS facility. PCSR Chapter 29 covers interim storage of spent fuel to be considered during decommissioning.
PCSR Chapter 25 Conventional Safety and Fire Safety	PCSR Chapter 25 provides the risk management techniques for fire safety and conventional health and safety, and the general prevention principles for SFIS. PCSR Chapter 29 provides the design information to demonstrate that the conventional health and safety risk management techniques and general prevention principles are applied in the design process of SFIS.
PCSR Chapter 28 Fuel Handling and Storage	PCSR Chapter 28 covers the Fuel Handling and Storage System (PMC [FHSS]), including the storage arrangement in the BFX and transfer of spent fuel (including failed fuel), RCCAs and SCCAs from the SFP to a transfer cask for delivery, which is the foregoing work for SFIS. PCSR Chapter 29 provides the interim storage of SFAs which is part of the overall fuel route described in Chapter 28.
PCSR Chapter 30 Commissioning	PCSR Chapter 30 provides commissioning design principles for the UK HPR1000 design, which is also considered within SFIS relevant design. PCSR Chapter 29 provides the general

Chapter	Interfaces
	considerations on commissioning for the conceptual design of SFIS during GDA.
PCSR Chapter 31 Operational Management	PCSR Chapter 31 provides the categories and sources of operating limits and conditions and generic principles of Examination, Maintenance, Inspection and Testing (EMIT) management. PCSR Chapter 29 provides the general considerations of operating limits and conditions and EMIT for the SFIS conceptual design proposal during GDA.
PCSR Chapter 33 ALARP Evaluation	The ALARP approach presented in PCSR Chapter 33 has been applied in PCSR Chapter 29 to perform the ALARP demonstration for interim storage of spent fuel, which supports the overall ALARP demonstration addressed in PCSR Chapter 33.

29.2.6 Assumptions

In order to develop an adequate case during GDA, the following assumptions for SFIS in the generic design of UK HPR1000 have been made:

a) The BQF receives the spent fuel produced by 2 UK HPR1000 units.

b) The design lifetime of the BQF is 100 years.

c) The spent fuel, after interim storage, is transported out of the plant for geological disposal.

d) The generic lifecycle assumptions for new nuclear power stations are consistent with those defined in the funded decommissioning programme, Reference [3], known as the “Base Case”.

29.3 Applicable Codes and Standards

According to PCSR Sub-chapter 4.4.7 and *General Principles for Application of Laws, Regulations, Codes and Standards*, Reference [10], the following principles are adopted for selecting the applicable codes and standards for SFIS:

a) Requirements from applicable Chinese laws, regulations and UK acts, regulations or other UK mandatory requirements must be collected and complied with.

b) Approved codes of practice should be selected in priority.

c) The RGP from international organisations or other countries recognised by UK regulators should be taken into account.

d) The experience from other GDA projects should be considered.

e) The latest version of guidance documents, codes and standards should be adopted.

Where codes and standards are used as design rules, they must be identified and evaluated to determine their applicability, adequacy and sufficiency. UK context specific expectations and RGP have been taken into account in the standards selection process. The methodology and principles are presented in PCSR Sub-chapter 4.4.7.

For UK, WENRA and IAEA relevant documents, the analysis of codes and standards is conducted and the applicable codes and standards for SFIS are identified in *Analysis Report of Applicable Codes and Standards,* Reference [11]. For SFIS, the following policies and regulations concerning NPPs, radiation protection, radioactive waste management, etc., in the UK serve as the references for the design and safety case:

a) UK acts, regulations and government policies and strategies, including:

    1) The Health and Safety at Work Act, 1974.

    2) The Nuclear Installations Act 1965.

    3) The Environment Act 1995.

    4) The Environmental Permitting (England and Wales) Regulations 2016.

    5) The Environmental Permitting (England and Wales) (Amendment) Regulations 2018.

    6) The Environmental Permitting (England and Wales) (Amendment) (No. 2) Regulations 2018.

    7) The Hazardous Waste (England and Wales) Regulations 2005.

    8) The Hazardous Waste (England and Wales) (Amendment) Regulations 2009.

    9) The Hazardous Waste (England and Wales) (Amendment) Regulations 2016.

    10) The Ionising Radiations Regulations 2017.

    11) Review of Radioactive Waste Management Policy: Final Conclusions (Cmnd 2919).

    12) Policy for the Long Term Management of Solid Low Level Radioactive Waste in the United Kingdom.

    13) UK Strategy for Radioactive Discharges 2011-2020.

b) Guidance/codes and standards issued by international and UK organisations, including:

1) Safety Assessment Principles for Nuclear Facilities.
2) Technical Assessment Guide – Safety Aspects Specific to Storage of Spent Nuclear Fuel.
3) Industry Guidance. Interim Storage of Higher Activity Waste Packages – Integrated Approach.
4) The Management of Higher Activity Radioactive Waste on Nuclear Licensed Sites.
5) Regulatory Guidance Series, No RSR 1: Radioactive Substances Regulation – Environmental Principles.
6) IAEA Safety Standards – Storage of Spent Nuclear Fuel (SSG-15).
7) Waste and Spent Fuel Storage Safety Reference Levels Report.
8) Radioactive Waste Treatment and Conditioning Safety Reference Levels.

Compliance with RGP, including applicable codes and standards, and OPEX from existing UK facilities is the starting point for the ALARP demonstration according to the ALARP Methodology in Reference [12]. To ensure this compliance, a gap analysis between the UK HPR1000 and RGP, including the applicable codes and standards, has been conducted. More information on the compliance analysis during the ALARP assessment is presented in Sub-chapter 29.7 and Reference [13].

29.4 Spent Fuel Interim Storage SSCs Overview

This sub-chapter presents a high-level description of the SSCs that are involved in the SFIS (supporting systems such as electrical systems are not presented in consistency with conceptual design scope). Further information and associated PCSR chapters are presented in T-29.4-1.

T-29.4-1 List of SSCs Involved in the SFIS

SSCs	Roles in the SFIS	Presentation in PCSR
PTR [FPCTS])	• Provide the decay heat removal function for SFAs in the SFP. • Provide the capability to flood and drain the Loading and Preparation Bays.	Chapter 10

SSCs		Roles in the SFIS	Presentation in PCSR
SFP		• House the underwater storage fuel rack containing the SFAs, RCCAs and SCCAs, including the failed fuels.	Chapter 28
BQF		• House the storage structure for spent fuel dry storage. • House the HLW packages. • House auxiliary equipment related to the SFIS process.	Chapter 29
BFX		• House the SFP, Loading Bay, and Preparation Bay. • House the majority of the Lifting and Handling Processes. • Provide external hazard protection for the SFIS SSCs. • Provide an additional confinement barrier for the SFAs. • Provide SFAs retrieval capability.	Chapter 16
SFIS Systems		• Provide decay heat removal, confinement (including shielding), lifting and handling, and criticality control function to the SFAs during handling and transfer from the SFP to the BQF, including during the entire interim storage duration in the BQF.	Chapter 29
Fuel Handling and	Spent Fuel Pool Crane	• Lifting and handling system for the SFAs between the SFP and the spent fuel cask.	Chapter 28

SSCs		Roles in the SFIS	Presentation in PCSR
Storage System	Underwater Fuel Storage Rack	• Storage location for the SFAs in the SFP.	
DMK ([FBHE])	Spent Fuel Cask Crane	• Lifting and handling system for the spent fuel cask.	Chapter 10

29.5 Design Requirements

The design requirements are categorised into general requirements, safety requirements, functional requirements and other requirements. Sub-chapter 29.5.1, 29.5.2 and 29.5.3 present the requirements that have been considered in the conceptual design of SFIS in GDA stage or that are required to be further considered in the detailed design at nuclear site licensing phase. Other requirements related to environmental protection, waste minimisation and the disposability of spent fuel are presented in Sub-chapter 29.5.4.

29.5.1 General Requirements

a) Safety Classification

The aim of the classification is to help ensure that the items are designed, manufactured, qualified, constructed, commissioned and operated according to appropriate requirements, so as to achieve sufficient reliability and fulfil the safety functions under all expected operating conditions. The safety classification principles (including seismic categorisation principles) in the *Methodology of Safety Categorisation and Classification*, Reference [14], shall be considered in the SFIS design. As SFIS is at conceptual design stage, the safety classification of SFIS SSCs is not determined at GDA stage.

b) Engineering Design Requirements

The engineering design requirements are considered in the design of the SFIS to ensure they are capable of fulfilling their safety functions. Detailed information on these requirements is presented in *General Safety Requirements*, Reference [15], including:

1) Application of the Hierarchy of Risk Reduction to the Design

The design of safety measures shall reflect the preferences identified in the hierarchy of risk reduction, including:

- Inherent safety.
- Fault tolerance.

- Passive safety.
- Engineered safety systems.
- Administrative procedures.
- Mitigation safety measures.

2) Single Failure Criterion (SFC) and Redundancy

The SFC criterion is applicable to the system that performs a safety function, such that it must be capable of performing its intended safety function in the presence of any single failure. It is beneficial to ensure the high reliability of safety systems and to maintain the plant within its deterministic design basis. The SFC is applied to each safety group considered in fault analysis. The redundancy design helps satisfy this criterion.

3) Independence

The independence principles should be applied in the design to achieve system reliability and tolerance to faults. Independence is accomplished in the design of systems by using functional isolation and/or physical separation.

4) Diversity

Diversity shall be realised appropriately by incorporating different attributes into redundant systems or components. Such attributes can be different operating principles, different physical variables, different operating conditions, different manufacturers, etc.

The concept of diversity is considered in the realisation of safety function to reduce the risk in the case that loss of the primary protection line.

5) Human Factors

A systematic approach needs to be applied to identify the factors that affect human performance and minimise the potential for human error throughout the entire plant lifecycle.

A systematic approach on human factors integration is established and applied in the design of the UK HPR1000. Human factors are integrated in the design of SFIS by taking into account the following:

- Allocating the system functions to manual activity and automatic control appropriately.
- Providing necessary information to the operator.

Through implementation of the human factors integration, the resulting system is able to operate effectively and safely, which is assessed in PCSR Chapter 15.

6) Ageing and Degradation

The design life of items important to safety is evaluated and defined. As the design lifetime of the UK HPR1000 is 60 years, the replaceability of those SSCs that are not designed for 60 years is considered in the design.

The ageing effects concerning individual components are taken into consideration in the system design:

- Sufficient margin is taken in the component design to prevent failures caused by ageing effects.
- Practical examining measures are planned during plant operation (i.e. EMIT) to address the ageing effects to the components.

For replaceable parts of components, replacement plans and layout designs are properly considered.

7) EMIT

The effective EMIT is essential for the safe operation of the plant. The design of EMIT activities are facilitated for the purpose of maintaining the capability of SSCs important to safety, so as to satisfy the reliability requirement. The principle and methodology for the periodic tests, inspection and maintenance are presented in PCSR Chapter 31 and *Examination, Maintenance, Inspection and Testing (EMIT) Strategy*, Reference [16].

Following the methodology, the EMIT requirements are incorporated in the conceptual design of SFIS to ensure the components are maintainable, inspectable and testable, commensurate with their safety class. The EMIT requirements identified during the conceptual design of SFIS within GDA will be transferred to the future designer to facilitate the detailed design at nuclear site licensing phase.

c) Protection against Internal and External Hazards

The necessary capability, reliability and functionality of items important to safety shall be ensured in the conditions arising from internal and external hazards to deliver relevant safety functions. The principles of hazard protection design, detailed in *The General Requirements of Protection Design against Internal and External Hazards*, Reference [17], shall be considered in the design of the SFIS.

Measures to protect the systems against external hazards are presented and assessed in PCSR Chapter 18. Measures to protect the systems against internal hazards are presented and assessed in PCSR Chapter 19. The internal and external hazards relevant to SFIS are identified in Reference [18].

d) Commissioning

The safety related functions shall be effectively demonstrated via commissioning before service at the licensing stage. The system commissioning program shall be established to guide the commissioning tests on site. The commissioning content, phased approach and scope are presented in PCSR Chapter 30.

e) Decommissioning

Early consideration of decommissioning during design stage plays an important role in achieving safe and effective decommissioning. According to the requirements for facilitating the decommissioning of the UK HPR1000, details being presented in PCSR Chapter 24, *Design Requirements for Facilitating Decommissioning*, Reference [19] and Consistency Evaluation for Design of Facilitating Decommissioning, Reference [20], the following aspects should be considered in the design of SFIS to facilitate the decommissioning of the nuclear power plant:

1) Design should include features to prevent radioactive contamination and limit its spread.

2) Design of the facility to avoid undesired accumulations of chemical or radioactive material, and utilisation of processes for minimising and/or reducing the volume of waste generated.

3) Seek to simplify waste management operations.

4) Provide on-site storage for spent fuel which meets, or is expandable to address, the entire facility lifetime.

5) The final disposal route of wastes generated during decommissioning should be considered at the design stage.

f) Material Selection

Material selection of systems and equipment is one of the most significant factors for the safety, waste minimisation and economy of the nuclear power plant and therefore special attention shall be paid to the material selection at the design stage for SSCs to carry out their duties with high reliability throughout the design life of the plant. The principles and the approach of material selection are presented in the *Material Selection Methodology*, Reference [21].

g) Conventional Safety

The conventional health and safety risks to workers and the public that may arise during the construction, commissioning, operation, maintenance, and decommissioning of the UK HPR1000 are identified and assessed, and the corresponding design mitigations are developed to eliminate, reduce, isolate and control them so far as is reasonably practicable using the risk management methodology detailed in PCSR Chapter 25, *UK HPR1000 Construction Design Management Strategy*, Reference [22] and *CDM Design Risk Management Work Instruction*, Reference [23].

29.5.2 Safety Requirements

Based on the general requirements in Reference [15], and the decomposition of safety functions for the UK HPR1000 in Reference [24], the safety requirements on SFIS are clarified. The following safety requirements have been considered in the technology optioneering and concept design, to ensure the proposal in GDA phase can comply with the UK context.

a) Reactivity Control

The SFAs are required to be maintained in a subcritical state during normal operations, anticipated operational occurrences and design basis accident conditions, involving handling, packaging, transfer and storage. For the reactivity control evaluation, any bias and uncertainty should be considered.

b) Heat Removal

Temperature of the SFAs is required to be maintained within specified limits so that the fuel cladding remains an effective confinement barrier during normal operations, anticipated operational occurrences and design basis accident conditions. The temperature of other storage relevant SSCs, including the cask, the concrete silo and the building should also remain within the allowable values or criteria for each of the conditions above.

c) Confinement

Confinement of radioactive material is achieved and maintained through the use of multiple barriers where reasonably practicable. The integrity of containers and storage structure should be ensured under normal operations, anticipated operational occurrences and design basis accident conditions, considering any potential internal and external hazards. The degradation of material due to the high temperature, high dose rate and long storage time should also be considered.

d) Extra Safety Functions

1) Radiation Shielding

SFIS related equipment and procedures should ensure that during normal operations, anticipated operational occurrences and design basis accident conditions, the dose to workers and the public is within the limits set by relevant laws and standards, and is reduced to ALARP. Processes with high radiation risk should be identified and relevant measures should be incorporated into the design, considering the ALARP principle.

2) Retrievability

The SFAs are required to be retrievable during normal operations (taking into account long term degradation effects), anticipated operational occurrences and design basis accident conditions. This high level safety functional requirement is specific for SFIS operations to allow maintenance, inspection, repackaging, or off-site transport as discussed in Reference [25] and Reference [26].

29.5.3 Functional Requirements

The SFIS equipment and procedures should fulfil all relevant requirements set in Reference [26], such as:

a) Compatibility with handling, transport and storage requirements, including suitability for retrieval after the anticipated storage period. The design of SFIS does not preclude the option of repackaging.

b) Any known or likely requirements for subsequent disposal or other management aspects should be included in the owner's waste and spent fuel management strategy, such as the need for further treatment or conditioning of the waste or spent fuel.

It is assumed that encapsulation of spent fuel is carried out on the originating site, in the absence of proposals for centralised packaging facilities, Reference [3].

As per the description of scope in Sub-chapter 29.2.3, the SFIS processes begin with the preparation of SFIS equipment and end with repackaging prior to off-site transport. The processes related to SFIS should fulfill the functional requirements of loading, handling, transferring, storage, retrieval and repackaging of spent fuels. In addition, to ensure that the spent fuels are in expected conditions during the interim storage period, the functional requirements of monitoring and inspection should also be fulfilled.

29.5.4 Other Requirements

The exact location of the BQF has not been decided yet. However, there will be sufficient space within the generic site boundary to accommodate the facility regardless of the SFIS technology selected.

The storage facility is designed in consistency with environmental requirements, including the functional requirements on facility to protect the environment and minimise waste.

According to UK context and the environmental requirements for UK HPR1000 design, the design of BQF should meet with the following requirements (not limited to):

a) The storage facility is designed to provide effective containment and prevent leakage of radioactive material.

b) The storage facility together with the waste packages should provide the multiple-barrier protection of the environment.

c) The storage facility and the waste packages together should provide appropriate shielding to reduce the radiation exposure to workers and the public to So Far As Is Reasonably Practicable (SFAIRP), as well as the use of BAT.

Measures to control the generation of radioactive waste, in terms of both volume and radioactivity content, are considered, beginning with the design phase, and throughout the lifetime of the facility. The control measures for radioactive waste minimisation are generally applied in the following order of priority in line with waste hierarchy during the design of SFIS:

a) Prevent and minimise waste generation.

b) Reuse items as originally intended.

c) Recycle materials.

d) Dispose as waste.

The following final disposal related requirements are considered in the technology optioneering and concept design:

a) Compatibility with repackaging into appropriate canisters for off-site transport or final disposal after the interim storage period.

b) Disposability of spent fuels at the GDF.

To ensure the spent fuel produced during the UK HPR1000 operation can be safely disposed of after interim storage, information for a disposability assessment has been provided to RWM as part of continuing engagement. During GDA step 3 and step 4, RWM has conducted the preliminary disposability assessment for UK HPR1000 during GDA phase. According to the assessment results from RWM, Reference [27], the Higher Activity Waste (HAW) and spent fuels anticipated to be produced by UK HPR1000 are expected to be disposable. A total of 11 issues are also identified by RWM with regards to the current NFCC wastes and spent fuel management plan. For each issue, responses have been provided to demonstrate that the GDA proposal and design do not lead to the impossibility to resolve the issues and therefore to waste and spent fuel that is not disposable or to significant design changes. These responses show that all issues are likely to be resolvable in the future when the required information is available and that no issue is likely to result in a waste stream that is not disposable or in significant design changes, Reference [28].

29.6 SFIS Design

29.6.1 Technology Optioneering

According to the worldwide OPEX and IAEA guidance, Reference [25], there are three different types of SFIS technology: wet storage in pools, dry storage in either storage or dual purpose casks and dry storage in vault type storage facilities.

Wet SFIS technology has historically been used for temporary storage and cooling at reactor sites and in some interim off-site storage facilities generally associated with disposal or reprocessing sites (in anticipation of the next step in the cycle). Wet SFIS technology is considered to be a mature technology.

A variety of dry SFIS technologies have been developed and applied recently in the international market. Dry SFIS technology with concrete overpacks and metal canisters has been selected as an appropriate technology at Sizewell B and Hinkley Point C in the UK. The UK ABWR also adopts a concept design of dry SFIS technology with casks. Dry storage is a mature technology, which has been developed over the past 30 years and can be regarded as an established industrial technology.

A systematic optioneering process for SFIS technology has been undertaken. The criteria for technology evaluation were developed considering OPEX from UK projects and international RGP. Within these criteria, the generation of radioactive waste during operation for different options, to ensure the minimisation of radioactive waste and environmental impact was taken into account, which ensures that the relevant requirements in sub-chapter 29.5.4 have been considered during the optioneering. After the formal process of options assessment and decision-making, dry storage in casks is selected to be the preferred technology for SFIS in GDA phase. More detailed information on the technology optioneering process is presented in Reference [13].

29.6.2 Design Proposal

29.6.2.1 Overview

The SFIS facility is assumed to be designed for two UK HPR1000 units and is planned to be constructed in two phases. The storage capacity of first phase considers the spent fuel and HLWs generated by two UK HPR1000 units over an operating period of 30 years, including RCCAs, SCCAs and ICIAs, which are non-fuel core components. The second phase capacity will be determined approximately 15~20 years after the first phase starts operation, notably taking account of the actual HLW and SFAs arising from operation and the progress of work on GDF.

The following are identified as the main new systems in the SFIS design proposal, which are located in the BQF to support SFIS normal operations:

a) Ventilation system, which is used to ensure the passive ventilation required for spent fuel and HLWs storage, the potential monitoring and control of environmental conditions for spent fuel and HLWs storage and to maintain conditions suitable for workers.

b) Water drainage system, which is used to prevent any water accumulation inside the building.

c) Facility power supply system, which is used to provide the electric power for lighting, monitoring and control, information communications and alarms.

d) Lighting system, which is used to ensure the necessary luminosity for operations and monitoring.

e) Monitoring and control system, which is used to provide radiation and temperature monitoring, and video surveillance within the facility.

f) Security arrangements, which is used to check the access authorisation of workers when entering the facility and to prevent any external invasion.

g) I&C system, which provides I&C for SSCs in the BQF and communication between the BQF and other facilities in the NPPs.

To ensure the safe management of spent fuel and HLW for the UK HPR1000, the following structures are needed:

a) SFIS Facility, which is used to provide enough space and a stable environment, and all relevant arrangements for the safe interim storage of spent fuel and HLW.

b) Facility for spent fuel retrieval and repackaging, which is used to provide enough space and a stable environment, and all relevant arrangements for safe spent fuel retrieval and repackaging before off-site disposal of spent fuel.

c) Intermediate Level Waste Storage Facility, which is used to provide enough space and a stable environment, and all relevant arrangements for the safe interim storage of Intermediate Level Waste (ILW), including HLW that becomes ILW after decay storage in BQF.

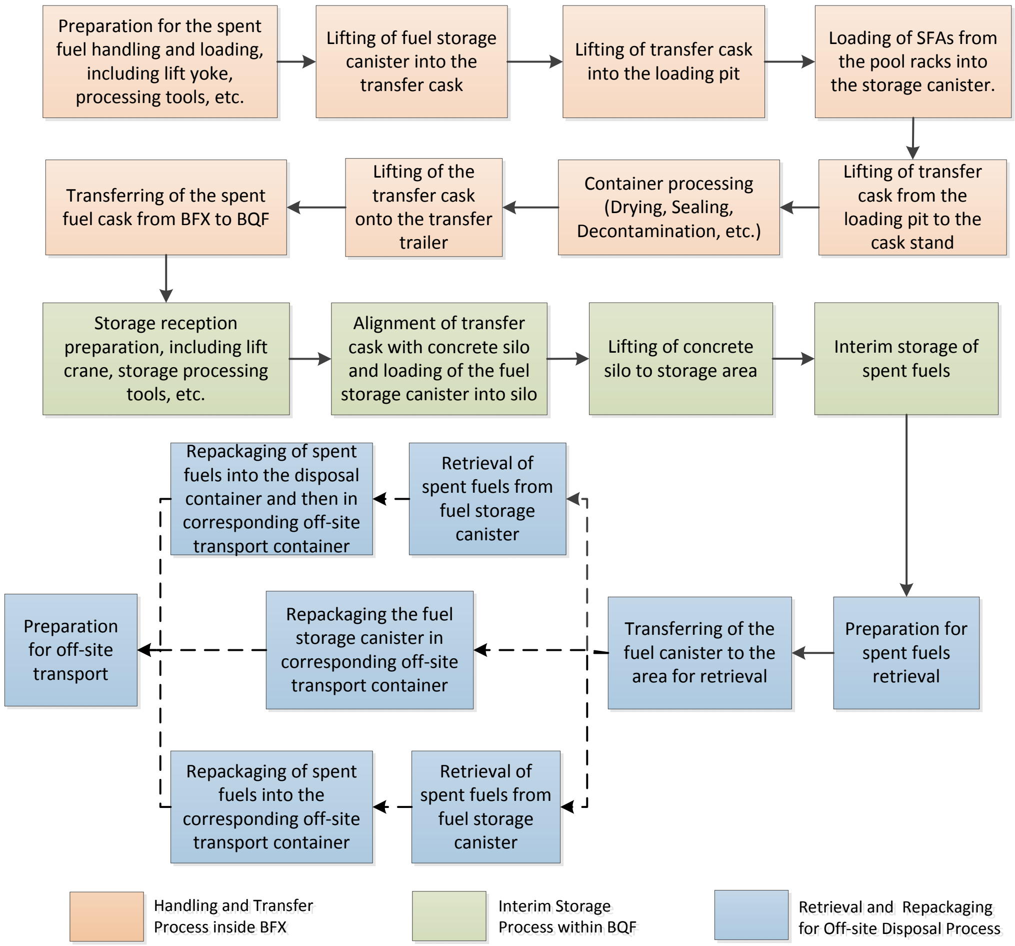
The design information is provided based on optioneering results and UK practice, which serve as an example to provide basic information to enable the preliminary GDA ALARP/BAT demonstration. The final decision on SFIS technology and corresponding equipment will be made in the nuclear site licensing phase.

Currently the failed fuel generated from operation of UK HPR1000 is proposed to be stored in the spent fuel pool until the decommissioning of BFX. Considering the international OPEX, two possible options for the containerisation/encapsulation of failed fuel after the removal from the spent fuel pool are available, as presented in Reference [25]. None of these two options is foreclosed by the current strategy for UK HPR1000. Failed fuel management is a developing area all over the world and it is likely that worldwide OPEX in this field will have increased by the time when UK HPR1000 enters decommissioning (i.e. in more than 60 years). This may potentially include new options for the management of failed fuel. The final strategy for failed fuel management will therefore be decided at an appropriate stage (e.g. close to final shutdown or during decommissioning).

29.6.2.2 Process Design

29.6.2.2.1 Overall Process for SFIS

On the basis of the technology optioneering, dry storage in casks is selected and a design based on dry storage in concrete silos is developed, notably considering UK OPEX. This allows a matching analysis and safety assessment, and then ALARP / BAT demonstration to be performed. According to discussion during GDA step 2 and the preliminary conclusion in Reference [29], the SFIS design in the GDA phase is a conceptual design, and is independent of a specific product supplier. The design proposal is presented in Reference [30].



F-29.6-1 Process Flow of SFIS

This sub-chapter describes the high level key steps of the SFIS process. The main SFIS process, which includes the most important fuel/canister/cask handling steps in the conceptual design, is presented in F-29.6-1, which shows the processes in BQF, BFX, and the designated retrieval and repackaging facility. The process can be broken down into the following sub-processes:

a) Handling and Transfer Process inside BFX.

b) Interim Storage Process within BQF.

c) Retrieval, Repackaging, and Transport for Off-site Disposal Process.

Further details on each of these sub-processes is provided below. It should be noted that during the SFIS process, inspection and monitoring measures, such as cask integrity inspection, cask surface contamination detection, sealing integrity inspection, etc., are undertaken using portable equipment and the actual measures undertaken depend on the specific products performance. The processes related to inspection and monitoring during fuel/canister/cask handling will be further developed in an appropriate future phase, when the specific product suppliers have been identified.

a) Handling and Transfer Process inside BFX

The process of spent fuel loading includes all the process flows within BFX and ends with the transfer of spent fuel into the BQF, which is designed to safely load the spent fuels from the SFP into the canisters and then transfer them to the storage facility. The main steps are shown in orange in F-29.6-1, and are as follows:

1) Preparation for the spent fuel loading

All the equipment and components involved in spent fuels loading should be well prepared before the loading process of spent fuels starts, which includes the transfer of necessary equipment from the storage area to the designed position in the BFX. The transfer cask is transferred to the BFX and lifted to the cask stand above the loading pit for inspection and necessary decontamination. The cover of the transfer cask is removed and the integrity inspection of different equipment and components is conducted.

2) Lifting of fuel storage canister into the transfer cask

The fuel storage canister is then transfer into the BFX, and the integrity and serial number of the canister is checked. The fuel storage canister is lifted above the transfer cask with the spent fuel cask crane, and aligned with the cask through the position marking on the equipment. After the alignment, the fuel storage canister is loaded into the transfer cask and the covers of the canister are removed.

3) Lifting of transfer cask into the loading pit

After preparation of the transfer cask and fuel storage canister on the cask stand, such as pumping water into the canister and cask, the spent fuel cask crane in the BFX is used to lift the transfer cask, with fuel storage canister inside, into the loading pit.

4) Loading of spent fuels in the canisters

After the transfer cask is located in the designated position, sufficient water is pumped into the loading pit to ensure the radiation protection during spent fuel handling. The gate between the spent fuel pool and the loading pit is opened and then the spent fuels (with RCCAs/SCCAs inserted) are lifted from the pool racks and loaded into the fuel storage canister using the spent fuel pool crane.

5) Lifting of transfer cask to the cask stand

When the fuel storage canister is loaded with the spent fuels, a cover for radiation protection is put on the top of the canister. Then the transfer cask is lifted back to the cask stand above the loading pit with the spent fuel cask crane.

6) Processing of the fuel canister and transfer cask

On the cask stand, the decontamination of the transfer cask is first conducted, which reduces the dose rate for workers. Then, the water within the fuel canister is drained out and the inertia gas is filled into the fuel canister using the dewatering pump and vacuum drying system, with sufficient inertia gas supply. After confirming that the right pressure within the canister lasts for a sufficient long time, the canister is sealed (using the welding equipment) and then the transfer cask is closed (by bolting). Before closure of transfer cask, the integrity of the fuel canister sealing is checked with the leakage detection equipment, in order to check the quality of welding and prevent any leakage during the subsequent operations.

7) Lifting of the transfer cask onto the transfer trailer

After closure of the transfer cask, the water in the annulus between the transfer cask and the fuel storage canister is pumped out. Once the water is drained out, the transfer time of the spent fuel starts to be recorded. The spent fuel cask crane is used to lift the transfer cask onto the transfer trailer. The design of BFX entrance facilitates the on-site transfer of transfer cask in vertical position. As a result, the transfer cask can be lifted onto the transfer trailer in vertical position for on-site transfer.

8) Transferring of the cask to BQF

The transfer trailer is operated following the designed path between BFX and BQF, which is conducted with sufficient security control and reduce the risk during the transfer of spent fuels to BQF. The design of cask transfer path between the two facilities is out of GDA scope and will be determined in site-specific phase when the detailed layout of NPP and the specific product supplier are determined.

b) Interim Storage Process within BQF

The process of spent fuel storage is mainly conducted within BQF, which includes transfer of the fuel storage cask into the concrete silo and then storage within BQF for a designed period. The main steps are shown in green in F-29.6-1, and are as follows:

1) Preparation for cask reception

   Before reception of the transfer cask, all the necessary equipment and components are transferred from the storage area to the relevant position. Then the integrity of the concrete silo is checked and it is lifted into the underground vault, with the cover removed. An adapter for opening the lower cover of the transfer cask is then installed on the top of the vault.

2) Alignment of transfer cask with concrete silo and loading of the fuel storage cask into the silo

   After the preparation for cask reception is finished, the transfer trailer enters into BQF and is parked near the underground vault. An inspection is conducted to ensure the integrity of the transfer cask. A specific lifting machine is used to lift the transfer cask onto the adapter, which is placed in advance on the top of the concrete silo. The alignment of transfer cask and concrete silo is conducted through the adapter. The lower cover of transfer cask is then opened by the adapter and the fuel storage canister within the transfer cask is loaded into the concrete silo.

3) Lifting of the concrete silo to the storage area

   After the fuel storage cask is loaded into the concrete silo, the adapter and the transfer cask are removed and the concrete cover is reinstalled on top of the concrete silo. The specific lifting machine is then operated to transfer the silo to the designated storage area. The lower cover is reinstalled onto the transfer cask and the cask is transferred to the area for equipment storage.

4) Interim storage of spent fuels

   Once the concrete silo containing fuel storage canister is in the proper position, the temperature monitoring equipment is installed to monitor the temperature of the concrete silo during storage, in order to deduce the temperature of the spent fuel and judge the integrity of the spent fuel cladding. The monitoring and inspection of relevant SSCs is considered and more information is shown in Sub-chapter 29.6.2.6. The spent fuels are then stored in BQF for the relevant period.

c) Retrieval and Repackaging

The retrieval and repackaging of spent fuels is conducted in a specific building, which may be the BFX or a specific new facility. Within the lifespan of BFX, the retrieval and repackaging of spent fuel may be conducted within this building, while after the decommissioning of BFX, a specific new facility may be required. The building where fuel retrieval and repackaging will be carried out is not determined in the GDA phase as it depends on the final decommissioning strategy, operator decisions and the condition of the BFX. The main steps for retrieval and repackaging are shown in blue in F-29.6-1 and are as follows:

1) Preparation for spent fuel retrieval

   Before the retrieval of spent fuel, all the necessary equipment and components, including the specific lifting machine in BQF, the adapter, the transfer cask, transfer trailer, cask cutting machine, cover drill etc. are transferred from the storage area to the designated position.

2) Transferring of the fuel storage canister to the area for retrieval

   The concrete silo with spent fuel is lifted into the underground vault, the concrete cover is removed, the adapter is installed and the transfer cask is lifted onto the adapter. The fuel storage canister is then transferred from the concrete silo to the transfer cask. After the fuel storage canister is loaded into the transfer cask, the lower cover of the cask is reinstalled and then the cask is lifted onto the transfer trailer, on which the transfer cask with canister inside is transferred to the area for retrieval.

3) Retrieval and repackaging of spent fuels

   For the retrieval and repackaging of spent fuel, there are currently three potential options, which will be assessed by future operators, considering the advice from RWM, as the retrieval and repackaging of spent fuels will not be conducted until the many decades after the plant has started operation. The options are:

   - Retrieval of spent fuel and repackaging into the disposal container.
   - Retrieval of spent fuel and repackaging into the off-site transport container.
   - Repackaging the fuel storage canisters into the off-site transport container.

4) Preparation for off-site transport

   Necessary processing, including the decontamination, marking, inspection, etc., is conducted before the off-site transport of spent fuel.

29.6.2.2.2 HLW ICIAs Package Management in BQF

The ICIAs packages are 500 litre robust shielded drums, which are made of ductile cast iron with 160 mm thickness. Additional internal stainless steel shielding thickness is provided, which can therefore supply sufficient shielding to protect the operator during handling and movement operations of the containers on-site without any additional shielding over-package. The general process for the waste packages is as follow:

a) Import of the HLW ICIAs waste package.

b) Storage of waste package.

c) Export of the ILW ICIAs waste package.

29.6.2.3 Equipment

The following components are identified as the main components to support normal SFIS operations including HLW ICIAs packages storage:

a) Fuel storage canister, which is used as the basic unit for SFIS operations, providing heat removal, confinement and sub-criticality control functions.

b) Transfer cask, which is used to contain the fuel storage canister and to provide radiation protection, heat removal and protection against hazards or other events during the transfer of spent fuel.

c) Concrete silo, which is used to contain the fuel storage canister and to provide radiation protection, heat removal and protection against hazards or other events during the interim storage period of the spent fuel.

d) 500 litre robust shielded drum, which is used to ensure safe handling, stackability, containment function and radiation shielding for ICIAs.

e) Dewatering pump, which is used to drain the water from the fuel storage canister.

f) Vacuum drying system, which is used to achieve a designed humidity, inertia gas concentration and pressure within the fuel storage canister.

g) Inertia gas leakage detection equipment, which is used to detect if there is any gas leakage after the sealing of the fuel canister.

h) Inertia gas supply, which is used to provide enough inertia gas to fill the fuel storage canister.

i) Welding equipment, which is used to seal the fuel storage canister.

j) Transfer trailer, which is used to transfer the fuel storage canister, within a transfer cask, between different facilities.

k) Adapter for transfer cask cover removal, which is used to open the bottom cover of the transfer cask prior to loading of the fuel canister into the concrete silo.

l) Specific lifting machine for cask/concrete silo transfer, which is used to lift and transfer the transfer cask and concrete silo inside BQF.

m) Temperature monitoring equipment in BQF, which is used to monitor the outlet temperature of the concrete silo during the storage period.

n) Radiation detection or monitoring equipment, which is used to detect or monitor the dose rate of the concrete silo surface and around the facility in order to confirm radiation protection function of the storage structure.

o) Forklift or other lifting machine for container transfer, which used to transfer the

ICIA packages within BQF.

p) Drilling machine, which is used to drill holes in the fuel storage canister for gas sampling and filling the canister with water.

q) Gas sampling cylinder, which is used to take a gas sample from the fuel storage canister to assess the integrity of spent fuel cladding before retrieval and repackaging.

r) Cutting machine, which is used to cut the welding of the fuel storage canister, allowing the removal of the canister covers and the retrieval of spent fuel.

s) Travelling crane, which is used to lift and transfer the transfer cask, fuel storage canister and other auxiliary equipment within BQF.

29.6.2.4 Interface

The SFIS consists of the activities within the BFX and BQF. To ensure the normal operations of SFIS, interface systems are identified and the feasibility of SFIS design is analysed in this sub-chapter. More information on interface SSCs is presented in relevant PCSR chapters, which are listed in Sub-chapter 29.4.2.

The following systems in the BFX are identified as the main interface systems for SFIS:

a) DMK [FBHE], which is used to lift the equipment related to SFIS operations, including the fuel storage canister, transfer cask, welding equipment, etc.

b) PMC [FHSS], which is used to load the spent fuel into the fuel storage canister.

c) Fuel Building Ventilation System (DWK [FBVS]), which is used to provide necessary ventilation during the SFIS operations undertaken in BFX.

d) NI 380V Normal Power Distribution System (LKD [NPDS (NI-380V)]), which is used to provide power supply for the equipment necessary for SFIS operations.

e) NI Demineralised Water Distribution System (SED [DWDS (NI)]), which is used to supply the demineralised water for transfer cask decontamination.

f) PTR [FPCTS], which is used to supply the borated water to fill the fuel storage canister and the loading pit prior to spent fuel loading (and retrieval).

The matching analysis, which is an assessment of the design compatibility of SSCs between the reference plant design and SFIS design in UK HPR1000, has been conducted on the basis of the current design detail of SFIS in the GDA phase, in consistency with the expectation in Reference [29]. The radioactive waste management strategy, considering the waste minimisation for waste generated from the SFIS operation, is also proposed in the matching analysis. As no specific supplier is selected during the GDA phase, parts of the information used for the matching analysis are considered based on international RGP and OPEX, including project experience in

China. Detailed analysis and justification for the matching analysis is shown in Reference [31]. The analysis shows that the normal operation of SFIS is feasible and that radioactive wastes generated by SFIS operations are capable of being managed using existing waste management arrangements.

29.6.2.5 BQF Layout

According to the *Integrated Waste Strategy (IWS)*, Reference [32], the BQF shall be designed to safely store the spent fuel, non-fuel core components and other higher activity waste produced during the NPP operation. The arrangement within BQF can be divided into the auxiliary area, operation area and storage area. The first phase layout of BQF is presented in Appendix 29B.

a) Auxiliary Area

The auxiliary area includes access for workers, access for equipment, control and monitoring room, duty room, power distribution room, fan room, etc., of which the function is to perform the control of personnel entry/exit, equipment operation, environmental conditions parameters adjustment and inspection/maintenance of storage structure.

b) Operation Area

The operation area mainly houses the function of preparation for transfer cask reception, processing of transfer cask, transferring the fuel storage cask into the concrete silo and lifting the concrete silo in the storage area. A specific lifting machine is equipped to lift the transfer cask and concrete silo in this area. This area includes:

1) Receipt/export area – designed to receive the transfer casks from the BFX, and to export the transfer casks to the specific retrieval and repackaging facility.

2) Underground concrete vault – designed for temporarily positioning the concrete silo, which contribute to transferring the fuel storage casks from the transfer cask into the concrete silo for interim storage or from the concrete silo into the transfer cask for retrieval.

3) Transfer path – designed as the specific path for lifting the loaded concrete silo to planned storage area or retrieving the concrete silo from the storage area to the underground concrete vault.

c) Storage Area

The storage area provides relatively stable environmental conditions for spent fuel and other waste storage. This area includes:

1) Concrete silo storage area – an area to store the concrete silo containing spent fuel canisters, with temperature and radiation detection to ensure safety during

interim storage period.

2) Other radioactive waste storage area – an area designed for the storage of other wastes, currently includes an integral independent room to store the 500 litre robust shielded drum with HLW ICIAs waste, which is isolated from other areas by concrete wall and roof, to provide effective containment. The ICIAs storage room is equipped with ventilation system to maintain the environmental condition for waste packages safe storage and prevent leakage of radioactive material.

3) Equipment storage area – an area to store the equipment and components that are necessary and are planned to be reused during SFIS relevant operations, when they are not used. For example, the welding system, automatic vacuum system, transfer cask, drainage pump, helium filling system, etc. are planned to be stored in this area. A specific contaminated equipment storage area is also considered in this area to store the equipment with potential contamination, such as automatic vacuum system and drainage pump.

d) Interface between BQF and Other Facility

As there is spent fuel transfer between BQF and BFX, the road connecting the facilities should facilitate the transfer of spent fuel by transfer trailer. Part of the higher activity wastes are first stored in BQF for a certain period and then be transferred to ILW interim storage facility. Therefore, the transport between the two facilities should also be considered. Furthermore, the layout of BQF in the NPP should ensure that the spent fuel within specific container can be transferred to disposal facility when available and that direct doses from BQF to members of the public is minimised.

29.6.2.6 Monitoring

During the interim storage period, the safety of spent fuel is ensured through passive patterns. Monitoring measures are designed to control the operation conditions and judge if additional measures are required.

a) Temperature monitoring

The temperature of the ventilation outlet in the concrete silo for spent fuel storage is monitored, in order to judge if the actual operation conditions are consistent with the design conditions. This enables deducing if any corrective measures are necessary to maintain safe storage conditions and lower the temperature within the structure. When the temperature of the concrete silo is within the design limit, the temperature of different components within the structure (including the canister and fuel cladding) do not exceed the design limits and therefore no failure of fuel cladding occurs.

As indicated in *Industry Guidance: Interim Storage of Higher Activity Waste Packages – Integrated Approach*, Reference [33], the robust shielded containers for ICIAs storage are typically stored in unshielded stores with forced ventilation. In order to provide good environmental conditions for packages storage, the ventilation system in SFIS is designed to control and monitor the internal environmental conditions such as air condition, temperature and humidity within the other radioactive waste storage area for equipment operation, personnel access and safe storage of ICIAs packages.

b) Radiation monitoring

The dose rate at the concrete silo surface and that around the facility is considered to be regularly monitored in order to confirm the radiation protection function of the storage structure and to identify any unexpected leakage of radioactive material. The radiation detection result can also contribute to judge if there is any failure within the storage structure.

c) Humidity and chlorine concentration monitoring

The humidity and chlorine concentration are important factors affecting the long-term performance of concrete silo. However, according to worldwide OPEX, it is not necessary to monitor the humidity and chlorine concentration within the interim storage facility. If there is a failure in the storage structure, the operator can choose to repair the silo during interim storage.

As the material of 500 litre robust shielded drum is cast iron, the humidity is an important factor that could cause degradation of the package during interim storage. Therefore, the humidity in the other radioactive waste storage area may require to be monitored and controlled by ventilation system, which will be determined according to equipment performance and site conditions in the nuclear site licensing phase.

29.6.3 EMIT Considerations

In normal operation conditions, SFIS relevant operations presented in Sub-chapter 29.6.2.2, which are mainly mechanical processes would not affect the normal operation of the NPP. The general considerations in the process to ensure safety prior to interim storage period are also presented, which will be detailed once the final product supplier is determined and the detailed design is developed.

During the interim storage period, safety is achieved by passive patterns, which have limited requirements on EMIT, apart from the following activities:

a) Security monitoring: The security planning of BQF is consistent with the security requirements within the NPP, which ensures the normal operation of SFIS.

b) Equipment inspection: The integrity of the fuel storage canister, the transfer cask and the concrete silo should be inspected and confirmed during storage.

c) Periodic test: The equipment for spent fuel handling or cask transferring, such as the transfer trailer, equipment for hoisting and equipment for inertia gas detection should be tested regularly.

d) Facility inspection: Regular inspection in the storage facility is to be carried out to detect any failure in the concrete silo during the designed storage period. If a failure is identified, the repair of the concrete silo is considered to be feasible if necessary.

29.7 ALARP Assessment

In line with the ALARP methodology, an iterative ALARP process is developed and presented in PCSR Chapter 33. Following the ALARP process, the risks associated with SFIS are demonstrated to be ALARP through the following aspects:

a) Holistic review of SFIS, including:

  1) Evolution of the design.

  2) Identification of the gaps/improvements through review of the design against RGP (and/or OPEX where relevant).

b) Undertaking optioneering to address the gaps identified and implementing the optimal options through design modification.

c) Risk assessment, and

d) Conclusion.

The outcomes of the various iterations of the ALARP process are presented in the *ALARP Demonstration of Spent Fuel Interim Storage*, Reference [34], which is the basis of this sub-chapter, aiming to summarise the ALARP demonstration for SFIS.

29.7.1 Holistic ALARP Assessment

29.7.1.1 Evolution of the Design

The development process of the Hua-long Pressurised Reactor (HPR1000) is presented in the *HPR1000 R&D History*, Reference [35]. It is developed from M310, through the Chinese Pressurised Reactor (CPR1000), the Chinese Improved Pressurised Reactor ($CPR1000^{+}$), the Advanced Chinese Pressurised Reactor (ACPR1000) to form the HPR1000 (FCG3).

Taking the HPR1000 (FCG3) as reference, the new SFIS arrangements and associated systems for the UK HPR1000 are developed during GDA to eliminate the gaps on fuel management between China and the UK and the modification within BFX is also conducted to minimise the risk of handling operations during spent fuel transfer.

During implementation of the ALARP process, gaps/improvements relevant to SFIS are identified from the following aspects:

a) Assessing the compliance of the SFIS for UK HPR1000 against the RGP (or OPEX where relevant) that:

  1) Codes and standards identified to be RGP that is listed in Sub-chapter 29.7.2,

with details being presented in *Analysis Report of Applicable Codes and Standards*, Reference [11].

2) Available and relevant OPEX that is identified, analysed and used, for reducing the risks associated with SFIS to ALARP, details being presented in *OPEX Analysis Report on Spent Fuel Interim Storage*, Reference [36].

b) Assessing the feasibility of current SFIS proposal through matching analysis, Reference [31], and identifying the potential risk through the risk assessment and preliminary safety evaluation, Reference [18] and [34].

c) Assessment of the design against RGP/OPEX from other technical areas, such as Fuel & Core, Fault Study, Internal Hazard, PSA, Radiation Protection, Environment and Mechanical Engineering.

By applying the ALARP process, the design proposal for SFIS finally form part of the UK HPR1000 DR3.

29.7.1.2 Compliance with RGP

In order to develop a robust suite of laws, regulations, codes and standards which is applied in the generic design of the UK HPR1000, a suitability analysis was undertaken through a collection, screening and comprehensive evaluation process, and RGP, including applicable codes and standards, were identified for SFIS. The results are detailed in Reference [11]. The following codes and standards relevant to SFIS are identified to be the RGP for SFIS:

a) Safety Assessment Principles for Nuclear Facilities, Reference [7].

b) IAEA Safety Standards – Storage of Spent Nuclear Fuel (SSG-15), Reference [25].

c) Industry Guidance. Interim Storage of Higher Activity Waste Packages – Integrated Approach, Reference [33].

d) The Management of Higher Activity Radioactive Waste on Nuclear Licensed Sites, Reference [37].

e) Waste and Spent Fuel Storage Safety Reference Levels Report, Reference [26].

f) Radioactive Waste Treatment and Conditioning Safety Reference Levels, Reference [38].

g) Radioactive Substances Regulation – Environmental Principles, Regulatory Guidance Series, Reference [39].

Regulatory expectation, such as TAGs in Reference [8], is also considered to guide the safety case in the UK HP1000 GDA phase.

After the identification of RGP, a compliance with RGP is conducted to identify the potential gaps for SFIS. *Technology Optioneering on Spent Fuel Interim Storage*, *Reference*, Reference [13], details the gap analysis against RGP performed for spent fuel management strategy. It presents the process applied, identifies the RGP and relevant OPEX, and identifies the two gaps/differences of spent fuel management in the UK HPR1000 DR1 against the RGP and OPEX in the UK. To eliminate the gaps between UK HPR1000 DR1 and UK practice, a conceptual design of SFIS has been developed, Reference [30], according to the requirements of relevant RGP and OPEX in UK, which ensures the consistency with RGP.

29.7.1.3 OPEX Review

In order to adequately support the demonstration of ALARP for SFIS, the systematic approach presented in *Methodology for Use of OPEX in UK HPR1000*, Reference [40], is followed to identify, analyse and use available and relevant OPEX in an appropriate way.

Available OPEX information/data relevant to SFIS are collected based on the relevant OPEX sources, including:

a) OPEX information/data obtained from China General Nuclear Power Corporation (CGN) fleet.

b) OPEX information from UK organisations and previous GDA website.

c) Publications from international organisations, such as IAEA, OECD, EPRI, etc., providing information on worldwide SFIS practices.

d) Publications from public website, providing information on SFIS practices in various countries, such as the UK, the US, Germany, Sweden, etc.

e) Operational information obtained from consultancy and workshop with EDF and other NPP operator, providing information on SFIS practices in various NPPs.

Through a comprehensive analysis, OPEX information/data and reports applicable to SFIS design for UK HPR1000 were identified and used for UK HPR1000 SFIS, Reference [36]. Five items of OPEX are screened as the applicable OPEX for SFIS design in UK HPR1000, mainly including:

a) OPEX data that are used as input for SFIS conceptual design for the UK HPR1000.

b) OPEX information relevant to SFIS proposals is used for optioneering or for justification of optimisation of SFIS for the UK HPR1000.

c) Lessons learnt from previous GDA and previous steps of UK HPR1000 that have been already considered in the generic design of UK HPR1000.

29.7.1.4 Risk Assessment

The identification and justification of the risks and hazards against the activities related to SFIS are presented in Appendix B in Reference [34], excluding:

a) Risk and Hazards identification related to lifting/handling operations in BFX, which is considered in *ALARP Assessment of the Spent Fuel Delivery Process*, Reference [41].

b) Risk and Hazards identification related to the retrieval and repackaging as this is out of GDA scope, Reference [29].

c) Risk and Hazards associated with storage of ICIAs packages in BQF, which is detailed in *Process Risks/Hazards Analysis for ICIAs Packaging, Handling and Storage Operations*, Reference [42].

The risk assessment uses two variable matrixes to assess the likelihood and consequence of a fault/hazard to evaluate the risk level. The results of risk assessment presented in Reference [34] show that the residual risks for SFIS (excluding lifting and handling in BFX, which is the scope of PCSR Chapter 28), considering the implemented elimination, reduction, isolation, control and protection design features, are reduced to a low risk level, which is considered ALARP at GDA stage and no further improvement is identified to be necessary at GDA stage. The requirements for future design and operation developed from the risk assessment has been recorded in Sub-chapter 6.12 in Reference [30].

29.7.2 Specific ALARP Assessment

In order to close the gaps identified for spent fuel management between the reference plant (i.e. UK HPR1000 DR1) and UK practice, a systematic and comprehensive options study has been undertaken considering the collected RGP in Reference [11] and OPEX in Reference [36]. The details of the optioneering study for identified gaps, including the approach, problem statement, UK standard & guidance and practices, description of technology options, options assessment and decision-making are presented in Reference [13]. This optioneering study concluded that dry storage in cask technology is the preferred option for UK HPR1000, considering the principles of ALARP and BAT.

For SFIS, the risk assessment is based on the conceptual design of SFIS proposed during GDA phase and uses two variable matrixes to assess the likelihood and consequence of a fault/hazard to evaluate the risk level. Risks related to radiological hazards, internal and external hazards, human factor and conventional health and safety hazards are analysed, assuming that design features related to the safety requirements of SFIS (listed in Sub-chapter 29.5.2) maybe impacted. The potential prevention and mitigation measures in existing design and proposed administrative measures, such as operation manual and individual protection equipment, are analysed and presented for each risk. This risk assessment, presented in Sub-chapter 8.2 and Appendix D in Reference [41], yields that the residual risks for SFIS are reduced to a low risk level and no further optimisation in GDA phase is identified to be necessary.

Other risks related to SFIS operations are also analysed and conclusions are as follow:

a) For storage of ICIAs packages in BQF, the risk assessment using the same methodology is detailed in [42] and shows that the risks can be reduced to a low level, considered ALARP at GDA phase.

b) The co-storage of RCCAs/SCCAs with spent fuel assemblies has no adverse effects on SFIS risks (it even has positive effects), as the decay heat and radioactivity of RCCAs/SCCAs are low compared to spent fuel assemblies and inserting of RCCAs and SCCAs into the spent fuel assemblies can lower the criticality risk. More information of the impact from the co-storage of RCCAs and SCCAs is presented in Sub-chapter 5.5 in Reference [18].

c) For on-site workers performing SFIS relevant operations, the cumulative dose and individual dose evaluations have been conducted based on the best available information from UK OPEX, which is expected to comply with requirement on the maximum annual individual effective dose of workers in designated area. More information is presented in Sub-chapter 7.4 in Reference [18].

d) During the conceptual design of BQF, a sensitive analysis on roof thickness and outer wall thickness has been undertaken. More information on the sensitivity analysis is presented in Sub-chapter 6.10.5 in Reference [30]. On the basis of this, the direct radiation contribution of BQF to public doses is evaluated, Reference [18], which supports the demonstration that the public doses from direct radiation is reduces SFAIRP.

To ensure that current design does not unduly constrain future operation choices and measures can be taken to reduce potential risks during operations, the following aspects have been considered to facilitate SFIS detailed design in the future. More information is presented in Sub-chapter 7.2.3 in Reference [41].

a) Cooling time in spent fuel pool.

b) Radiation protection achieved by the facility.

c) Failed fuel management proposal.

d) Construction in two phases.

e) Safety measures for partially assembled fuel cask.

29.7.3 ALARP Conclusion

Currently, the risks associated with the design proposal of SFIS are demonstrated to be ALARP and the foreclosure of potential options and improvements for the future site licensee is avoided, as detailed in Reference [41]. The ALARP process is an iterative process and has been and is continuously used to assess the SFIS proposal. As a result of ALARP demonstration during GDA, the requirements for future design is recorded in Reference [30] and will be handed over to the future licensee, in line with the relevant process and procedures relevant to transition to nuclear site licensing phase, which are described in PCSR Chapter 20.

29.8 Record Management

According to the requirement in Reference [7], sufficient records about spent fuel management must be preserved, to ensure the sustainable safe management and disposal of spent fuel.

The process of making and preserving these documents and records, including information on record management requirements and measures considered in the design and safety cases, starts during GDA phase and will continue throughout the whole lifecycle. The records need to be kept in an appropriate manner and form, taking account of the long timescales over which they may need to be retained and accessed.

The main information includes but not limited to:

a) Production process, production date of spent fuel.

b) Relevant characteristics, location and date.

c) Treatment process, production date and unique identifier of each packages.

d) Radiological inventory, physical and chemical information.

e) Location of each package in different facilities, especially for storage facility.

f) Environment conditions, monitoring and inspection records, store and package maintenance records in the storage facility.

g) Records of disposal route of each package.

The appropriate records will be preserved and maintained until GDF in the UK is available, and relevant records will be transferred by the future operator to the disposal facility.

In the conceptual design of SFIS, including the storage of ICIAs in BQF, the specific record measures are considered as follows:

a) Before the loading of spent fuel into the fuel storage canister, the in-core history of spent fuel in the pool is checked according to the record of refuelling. The information of the spent fuel to be loaded, including burn-up, cooling time, previous position in the pool, etc. is recorded.

b) The serial number of the fuel storage canister is recorded before its loading into transfer cask, which helps to match with the information of spent fuel loaded into the canister.

c) The information of each process is recorded, including the date of operation, the start time, prospective finish time and actual finish time, which contributes to the evaluation of the performance of spent fuel within the canister.

d) The serial number of the concrete silo is also recorded before the loading of fuel canister into the silo.

e) After the lifting of the concrete silo in the designated area, the storage position of each concrete silo is recorded. The position record can match with the spent fuel information and contribute to nuclear material management.

f) Any other information required by the GDF operator will also be recorded and kept and transferred to the GDF operator together with the spent fuels packages.

g) The ICIAs package characteristics and lifecycle history (i.e. package type, treatment process, production date and unique identifier), all radiological and non-radiological information (i.e. radionuclide activity concentration, chemical characteristics, surface dose rate and contamination level of waste packages), waste package management information (i.e. storage position, disposal route, monitoring and inspection records and maintenance records) and any information required by the GDF owner will be recorded to achieve the safety operation management of the facility and to provide relevant information to final disposal facility owner.

29.9 Concluding Remarks

This chapter presents the approach and results for the SFIS safety case development, which is consistent with the GDA scope, Reference [6]. During the GDA phase, a technology optioneering has been conducted to select an appropriate technology for SFIS. As a result, dry storage in casks is selected as the preferred technology. Based on the results of optioneering, and the OPEX and RGP collected, the conceptual design for SFIS is developed. The feasibility of the design is proven by the matching analysis and relevant risks are evaluated in the preliminary safety evaluation. The potential risks related to SFIS are identified and reviewed during the ALARP demonstration. The SFIS safety case, supported by the work mentioned above, demonstrates that the risk related to SFIS proposal within the GDA phase achieves an ALARP level.

29.10 References

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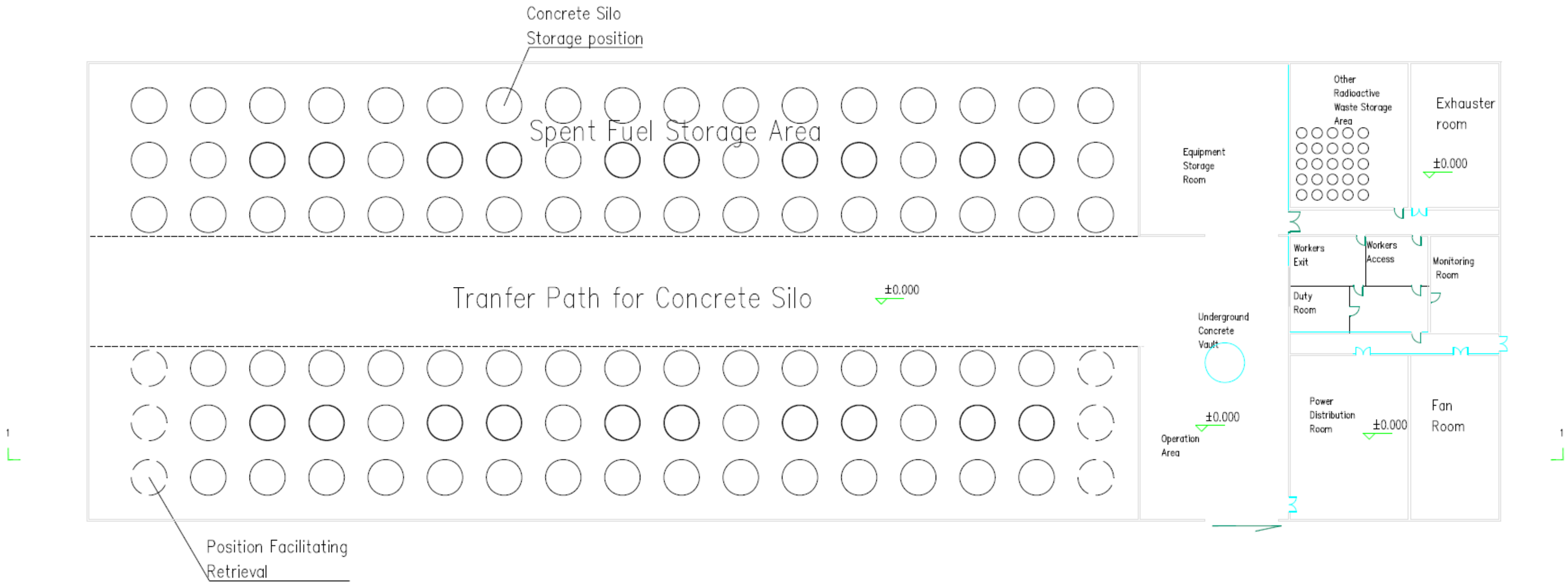
Appendix 29A Route Map

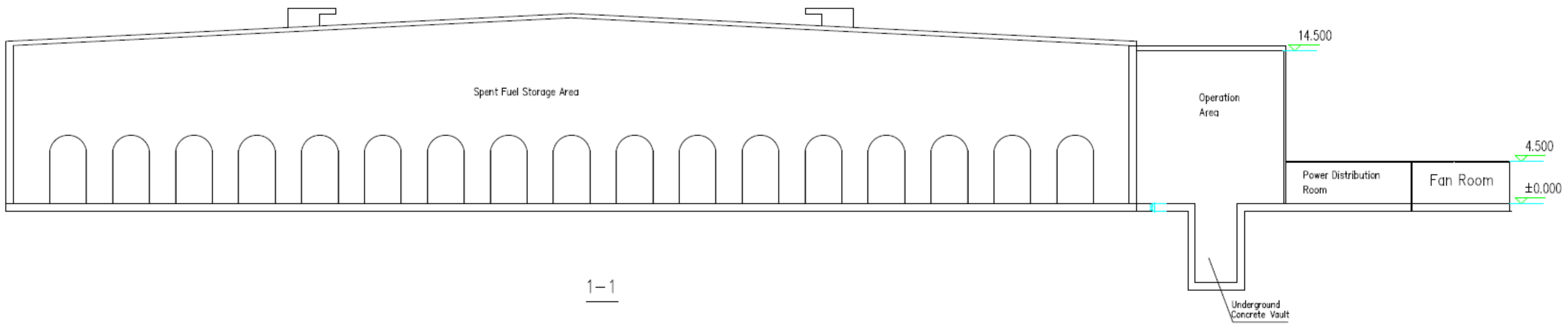
Sub-claim	Argument	Evidence	Supporting Documents
Sub-claim 3.3.13.SC29.1 All reasonable measures are adopted to ensure the technology selected satisfies the requirements in the UK.	Argument 3.3.13.SC29.1-A1 The requirements of spent fuel management, especially for interim storage in the codes and standards are analysed.	•**Evidence** 3.3.13.SC29.1-A1-E1**:** Applicable acts, regulations, codes and standards for spent fuel management, including those for spent fuel interim storage have been identified.	• Analysis report of applicable codes and standards • OPEX Analysis Report for Spent Fuel Interim Storage • Sub-chapter 29.3 in PCSR Chapter 29
		•**Evidence** 3.3.13.SC29.1-A1-E2: The requirements in the codes and standards specific for spent fuel interim storage are identified.	• Analysis report of applicable codes and standards • Technology optioneering on Spent Fuel Interim Storage • Spent Fuel Interim Storage Facility Design • Sub-chapter 29.5 in PCSR Chapter 29
	Argument 3.3.13.SC29.1-A2 The scope, process and relevant SSCs concerning spent fuel management strategy for the UK HPR1000 are clearly defined before the technology optioneering.	•**Evidence** 3.3.13.SC29.1-A2-E1**:** The overview of the spent fuel management strategy for the UK HPR1000 is presented.	• Integrated waste strategy • Radioactive waste management case for HLW • Sub-chapter 29.2.1 in PCSR Chapter 29
		•**Evidence** 3.3.13.SC29.1-A2-E2: The scope of SFIS operation, the work within the GDA phase, and relevant information concerning SFIS in other chapters are clearly identified.	• Sub-chapter 29.2.3 in PCSR Chapter 29 • Spent Fuel Interim Storage Facility Design
		•**Evidence** 3.3.13.SC29.1-A2-E3: The main process and related SSCs of SFIS operations are identified.	• Spent Fuel Interim Storage Facility Design • The Matching Analysis of Selected SFIS Technology with Current UK HPR1000 Design • Sub-chapter 29.6.2 in PCSR Chapter 29
	Argument 3.3.13.SC29.1-A3 The preliminary ALARP/BAT assessment is conducted for SFIS.	•**Evidence** 3.3.13.SC29.1-A3-E1: The RGP suitable for SFIS for the UK HPR1000 has been identified and presented.	• ALARP demonstration of Spent Fuel Interim Storage • Analysis report of applicable codes and standards • OPEX Analysis Report for Spent Fuel Interim Storage • Sub-chapter 29.3 in PCSR Chapter 29
		•**Evidence** 3.3.13.SC29.1-A3-E2**:** Gaps between the spent fuel storage strategy for the HPR1000 and RGP in the UK are identified.	• Technology optioneering on Spent Fuel Interim Storage • ALARP demonstration of Spent Fuel Interim Storage
		•**Evidence** 3.3.13.SC29.1-A3-E3: The considerations for eliminating the gaps in SFIS are presented and the corresponding forward action plan is presented.	• Technology optioneering on Spent Fuel Interim Storage • Spent Fuel Interim Storage Facility Design • The Matching Analysis of Selected SFIS Technology with Current UK HPR1000 Design • Disposability Assessment Report (issued by RWM) • Response to RWM Assessment Report on UK HPR1000 HAW and Spent Fuel Disposability
	Argument 3.3.13.SC29.1-A4 The technology optioneering is conducted in an appropriate way.	•**Evidence** 3.3.13.SC29.1-A4-E1: The requirements in the codes and standards specific for spent fuel interim storage are identified, based on which the general criteria for technology optioneering are selected.	• Technology optioneering on Spent Fuel Interim Storage
		•**Evidence** 3.3.13.SC29.1-A4-E2: The technology optioneering is conducted through a systematic methodology.	• Technology optioneering on Spent Fuel Interim Storage • Sub-chapter 29.6.1 in PCSR Chapter 29

Sub-claim	**Argument**	**Evidence**	**Supporting Documents**
	Argument 3.3.13.SC29.1-A5 The matching of selected SFIS technology with current the UK HPR1000 design is analysed.	•**Evidence** 3.3.13.SC29.1-A5-E1: The matching of selected SFIS technology with current the UK HPR1000 design is conducted in GDA phase.	• The Matching Analysis of Selected SFIS Technology with Current UK HPR1000 Design
Sub-claim 3.3.13.SC29.2 The Spent Fuel Interim Storage is capable to achieve safe storage of spent fuel.	Argument 3.3.13.SC29.2-A1 The design of SFIS considers the requirements under different conditions, including normal operations, anticipated operational occurrences and design basis accident conditions.	• **Evidence** 3.3.13.SC29.2-A1-E1: The postulated initial events related to SFIS operations are analysed according to a systematic method and worldwide experience.	• Preliminary Safety Evaluation of Spent Fuel Interim Storage • OPEX Analysis Report for Spent Fuel Interim Storage
		• **Evidence** 3.3.13.SC29.2-A1-E2: Different conditions on SFIS operations and relevant requirements are identified according to the PSA analysis result and worldwide experience.	• Preliminary Safety Evaluation of Spent Fuel Interim Storage • OPEX Analysis Report for Spent Fuel Interim Storage • ALARP demonstration of Spent Fuel Interim Storage
	Argument 3.3.13.SC29.2-A2 The design of SFIS can be proven to satisfy the safety requirements, including heat removal, criticality control, radiation protection, radioactive confinement and spent fuel retrievability under different conditions.	• **Evidence** 3.3.13.SC29.2-A2-E1: The requirements of internal and external hazards, human factors, conventional safety which is relevant to the safety of spent fuel interim storage, have been considered.	• Preliminary Safety Evaluation of Spent Fuel Interim Storage • Spent Fuel Interim Storage Facility Design • ALARP demonstration of Spent Fuel Interim Storage
		•**Evidence** 3.3.13.SC29.2-A2-E2: A safety assessment methodology, including the necessary parameters list, main process, acceptance criteria and potential design enhancement for the safety functions are presented.	• Preliminary Safety Evaluation of Spent Fuel Interim Storage
		•**Evidence** 3.3.13.SC29.2-A2-E3: Measures in the design have been identified to minimise the dose accepted by the workers during SFIS operations, through the minimizing of radiation levels, exposure time and contamination levels.	• Preliminary Safety Evaluation of Spent Fuel Interim Storage
		•**Evidence** 3.3.13.SC29.2-A2-E4: The direct dose to the public during the interim storage of spent fuel has been evaluated and measures have been identified to ensure the dose rate can reach ALARP.	• Preliminary Safety Evaluation of Spent Fuel Interim Storage
	Argument 3.3.13.SC29.2-A3 The design of SFIS considers other requirements in the nuclear power plant and is proved to be compatible with the UK HPR1000 design.	•**Evidence** 3.3.13.SC29.2-A3-E1: The SSCs in current station design that are related to SFIS operations are identified.	• Spent Fuel Interim Storage Facility Design • The Matching Analysis of Selected SFIS Technology with Current UK HPR1000 Design • Sub-chapter 29.6.2.4 in PCSR Chapter 29
		•**Evidence** 3.3.13.SC29.2-A3-E2**:** The requirements and potential effects of SFIS operations on the UK HPR1000 design are analysed.	• Spent Fuel Interim Storage Facility Design • The Matching Analysis of Selected SFIS Technology with Current UK HPR1000 Design • ALARP demonstration of Spent Fuel Interim Storage
		•**Evidence** 3.3.13.SC29.2-A3-E3**:** The evaluation is conducted to analyse if the design of SFIS can match with current the UK HPR1000 design.	• The Matching Analysis of Selected SFIS Technology with Current UK HPR1000 Design • ALARP demonstration of Spent Fuel Interim Storage
		•**Evidence** 3.3.13.SC29.2-A3-E4**:** The considerations concerning the construction and Examination, Maintenance, Inspection and Testing (EMIT) are included in the design of SFIS.	• Spent Fuel Interim Storage Facility Design • Sub-chapter 29.6.3 in PCSR Chapter 29

Appendix 29B Preliminary Layout of BQF



F-Appendix 29B-1 Preliminary Layout of BQF (Top View)



F-Appendix 29B-2 Preliminary Layout of BQF (Front View)