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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

ALARP	As Low As Reasonably Practicable
BAT	Best Available Techniques
CGN	China General Nuclear Power Cooperation
DiD	Defence in Depth
DMK	Fuel Building Handling Equipment [FBHE]
DWK	Fuel Building Ventilation System [FBVS]
EMIT	Examination, Maintenance, Inspection and Testing
GDA	Generic Design Assessment
GDF	Geological Disposal Facility
HAW	Higher Activity Waste
HLW	High Level Waste
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
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
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

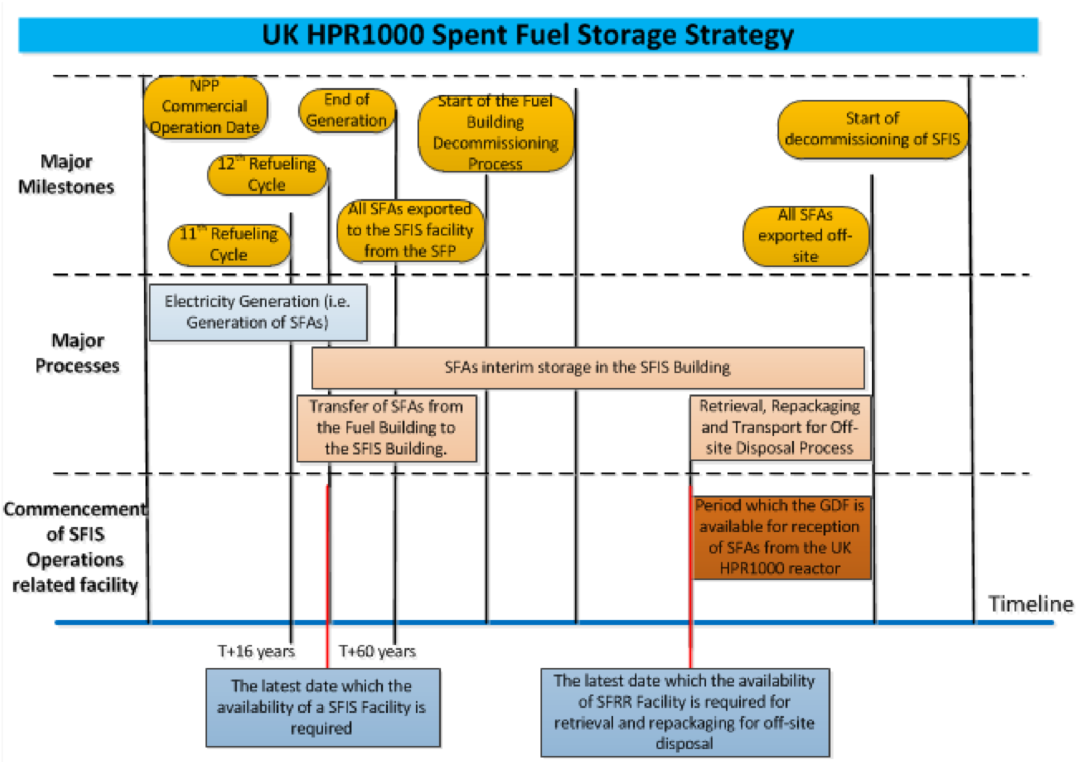
The Hua-long Pressurised Reactor under construction at Fangchenggang Nuclear Power Plant (NPP) unit 3 (HPR1000 (FCG3)) in China is designed according to the domestic policy of China. There are currently no Chinese regulations or codes relevant to new pressurised water reactors for on-site Spent Fuel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

The UK 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 waste management, including financing, should be developed, Reference [1]. For the UK version of the Hua-long Pressurised Reactor (the 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 interim storage was recommended by the 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 spent fuel interim storage for the UK HPR1000.

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



F-29.2-1 the 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 directly from the core are first stored in the SFP for several years. 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 SFA 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 spent fuel cask cooling system, and the maximum number of SFAs to be stored in the spent fuel cask 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 design of the SFP is also required to accommodate a full core emergency unload, which accounts to 177 fuel assemblies. A Spent Fuel Interim Storage Facility (BQF) will therefore be required by about the 10^{th} refuelling cycle.

More information relevant to fuel handling and short-term storage within the BFX is presented in PCSR Chapter 10 and Chapter 28.

b) Interim Storage On-site

SFAs will be loaded into a transfer cask and moved into an on-site BQF for interim storage 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 operational lifetime of two the UK HPR1000 units.

During the Generic Design Assessment (GDA) phase, the concept design and preliminary As Low As Reasonably Practicable (ALARP)/ Best Available Techniques (BAT) demonstration related to 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 decided.

c) Off-site Disposal in the GDF

After the interim storage on site, the spent fuel is assumed to be transported to the geological disposal facility for final disposal and the retrieval and repackaging is considered to be conducted on site, consistent with assumption in the Base Case in Reference [3]. Currently, there is no final disposal facility 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.

As retrieval and repackaging will not be conducted until the GDF is available for new NPPs in the UK, which is assumed to be in more than 100 years, the design for retrieval and repackaging is 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 non-fuel waste in the core and other higher activity waste, the waste characterisation and management strategy is presented in PCSR Chapter 23.

The present safety case for Interim Storage of Spent Fuel is produced based on the design reference version 2.1, as described in *the UK HPR1000 Design Reference Report*, Reference [4]. The safety assessment results are documented in this chapter and corresponding safety assessment reports.

29.2.2 Chapter Route Map

The objectives of this chapter are consistent with the GDA scope, in Reference [5], as follows:

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 concept design for SFIS proposed in GDA phase is capable of achieving safety storage of spent fuel generated from the UK HPR1000 operations.

The safety route map of PCSR Chapter 29 is developed to support Claim 3.3.13 *The Spent Fuel Interim Storage process, and design of the associated systems, is substantiated*, considering the current GDA scope, in Reference [5]. The safety route map of PCSR Chapter 29 is a part of the overall route map to support the UK HPR1000 design and is in accordance with the safety case considerations of the UK HPR1000 presented in PCSR Chapter 1. Therefore, the claims development is consistent with the overall route map arrangement of the project.

The analysis of Safety Assessment Principle (SAP), Reference [6] and Technical Assessment Guide (TAGs), Reference [7] issued by Office for Nuclear Regulation (ONR), the GDA scope for SFIS and the experience of SFIS facility design are also considered in the Claims, Arguments and Evidence (C-A-E) structure.

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 [8], 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 identified in this sub-chapter and is presented in Appendix A. This route map is intending to set out a "direction of moving forward" in Chapter 29.

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 containing 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 & Storage operations are presented in PCSR Chapter 28, which covers the refuelling process, new fuel receipt and the entire length of 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 in the BQF 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 geological disposal facility is not included in this scope.

As the general layout of the BQF within the NPP will not be determined in GDA scope, which may be modified and further designed according to specific site conditions, the transfer path of spent fuel between the BFX and the BQF is not determined in GDA phase. The final route path will be determined based on the SFIS equipment performance of the chosen supplier, detailed process flow design and locations of buildings designed in the nuclear site licensing phase.

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. It is possible that, depending on the final SFIS technology and the off-site fuel transport requirements identified in the nuclear site licensing phase, the retrieval of spent fuel/canisters may be able to be incorporated into the BQF. This would avoid the need for a separate SFRR facility. As the SFRR facility is not required until at least 100 years 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 and the requirements for SFRR may have little impact on rest of the plant design.

Failed fuels generated during operation of the UK HPR1000 are currently considered to be stored in the SFP. For SFIS, necessary design features have been considered to assure the safety of spent fuel during interim storage. Inspection and monitoring measures are considered to detect, deduce and identify any potential failure of spent fuel. Once the failure of spent fuel is confirmed, the retrieval of spent fuel will be conducted and the failed fuel will then be stored within the SFP. In the case of failed fuel storage area is full and BFX is required to be decommissioned, failed fuels can be sealed within the specific failed fuel cans, and then be packaged and managed within the spent fuel canister according to the worldwide OPEX. The final management strategy of failed fuels should be developed according to the decision of NPP’s operator. The design for failed fuel storage has been presented in PCSR Chapter 28 and relevant supporting documents. During the GDA phase, the final management strategy of failed fuel will not be determined.

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

a) Technology optioneering between wet storage and dry storage.

b) Conceptual design.

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, and what information is included and excluded, is presented in Reference [5].

29.2.4 Chapter Structure

The structure of this chapter is as follows:

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

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

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

Sub-chapter 4: present an overview of SFIS process and the relevant Systems, Structure and Components.

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

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

Sub-chapter 7: present the preliminary ALARP assessment on 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: present the record management related to spent fuel interim storage.

Sub-chapter 9: present the conclusions remarks.

Sub-chapter 10: present the references.

Appendix 29A: present the safety cases route map of PCSR chapter 29.

Appendix 29B: present the preliminary layout consideration of spent fuel interim storage facility.

29.2.5 Interfaces with Other Chapters

The interfaces with other chapters are listed in the following table.

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 the UK HPR1000 SFIS design presented in Chapter 29.
PCSR Chapter 4 General Safety and Design Principles	PCSR Chapter 4 covers the UK HPR1000 safety and 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), safety classification of SSC, engineering substantiation, etc. 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 operation information, including size, weight, quantity, etc., which is the necessary information to 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 Chapter 10.

Chapter	Interfaces
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 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 building, which is one of the buildings included in the SFIS operations. PCSR Chapter 29 presents the spent fuel interim storage operation related SSC in the UK HPR1000.
PCSR 18 External Hazards	PCSR Chapter 18 provides external hazards analysis methodology and principles for SFIS related evaluation. PCSR Chapter 29 presents the preliminary safety evaluation result based on the external hazards analysis methodology.
PCSR 19 Internal Hazards	PCSR Chapter 19 provides internal hazards analysis methodology and principle for SFIS related evaluation. PCSR Chapter 29 presents the preliminary safety evaluation result based on the internal hazards analysis methodology.
PCSR Chapter 22 Radiological Protection	PCSR Chapter 22 provides the general radiological protection measures against direct radiation and radioactive contamination, and the evaluation of

Chapter	Interfaces
	public direct radiation from spent fuel interim storage facility. PCSR Chapter 29 presents the SFIS proposal for dose evaluation.
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 Non-fuel Core Components (NFCCs) generated from reactor.
PCSR Chapter 24 Decommissioning	PCSR Chapter 24 presents the general decommissioning consideration of the SFIS facility. PCSR Chapter 29 covers SFIS as part of decommissioning.
Chapter 25 Conventional Safety and Fire Safety	Chapter 25 provides the conventional health and safety risk management techniques and the general prevention principles for SFIS. 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 transfer of SFAs in the BFX from the SFP to a transfer cask for delivery, which is the foregoing work for SFIS. PCSR Chapter 29 provides the interim storage of SFA which is part of the overall fuel route described in Chapter 28.
PCSR 30 Commissioning	PCSR Chapter 33 provides commissioning design principles for the UK HPR1000 design, which is also considered within SFIS relevant design.
PCSR Chapter 33	The ALARP approach presented in Chapter 33 covers the ALARP approach adopted for the work included

Chapter	Interfaces
ALARP Evaluation	in PCSR Chapter 29, which supports the overall ALARP demonstration addressed in 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, excluding the failed fuel, produced by 2 units of the UK HPR1000.

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 defined in the funded decommissioning programme, Reference [3], known as the “Base Case”.

These assumptions are not final decisions, and may be modified as the GDA phase progresses.

29.3 Applicable Codes and Standards

For SFIS, the following policies and regulations concerning the NPP, radiation protection and radioactive waste management in the UK serve as the references for relevant work:

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

b) The Nuclear Installations Act 1965.

c) The Ionising Radiations Regulations 2017.

d) Hazardous Waste Regulations 2005.

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

f) The Environment Act 1995.

g) UK Strategy for Radioactive Discharges 2011-2020.

h) Review of radioactive waste management policy: Final Conclusions.

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

When considering the applicable codes and standards for SFIS, the standards applied for the engineering substantiation are:

a) Internationally recognised in nuclear industry.

b) The latest or currently applicable approved standards.

c) Consistent with the plant reliability goals necessary for safety.

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 Chapter 4.

On the basis of UK, WENRA and IAEA relevant documents, the analysis of codes and standards is conducted and the applicable codes and standards are identified, in Reference [9]. As a result of the analysis, the following codes and standards relevant to SFIS are applied in Chapter 29.

a) IAEA Safety Standards – Storage of Spent Nuclear Fuel (SSG-15), Reference [10];

b) Industry Guidance. Interim Storage of Higher Activity Waste Packages – Integrated Approach, Reference [11];

c) The Management of Higher Activity Radioactive Waste on Nuclear Licensed Sites, Reference [12];

d) Waste and Spent Fuel Storage Safety Reference Levels Report, Reference [13];

e) Radioactive Waste Treatment and Conditioning Safety Reference Levels, Reference [14].

Regulatory expectation, such as GDA scope in Reference [15], SAPs in Reference [6], and TAGs in Reference [7], is also considered to guide the safety case in the UK HP1000 GDA phase.

Compliance with RGP, including OPEX from existing UK facility, is the starting point for the ALARP demonstration according to ALARP Methodology in Reference [16]. Furthermore, the design or modification of the spent fuel interim storage in the UK HPR1000 takes full account of existing RGP and OPEX. Gaps analysis between the UK HPR1000 and RGP has been conducted in Reference [17].

29.4 Spent Fuel Interim Storage Overview

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

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

<table>
<tr><th colspan="2">SSC</th><th>Roles in the SFIS</th><th>Presentation in PCSR</th></tr>
<tr><td colspan="2">Fuel Pool Cooling and Treatment System (PTR [FPCTS])</td><td>• Provide the decay heat removal function for SFAs in the SFP.
• Provide capability to flood and drain the Loading and Preparation Bays.</td><td>Chapter 10</td></tr>
<tr><td colspan="2">SFP</td><td>• Houses the underwater storage fuel rack containing the SFAs, including the failed fuels.</td><td>Chapter 28</td></tr>
<tr><td colspan="2">BFX</td><td>• Houses the SFP, Loading Bay, and Preparation Bay.
• Houses the majority of the Lifting and Handling Processes.
• Provides external hazard protection for the SFIS SSC
• Provides an additional confinement barrier for the SFAs.
• Provides SFAs retrieval capability.</td><td>Chapter 16</td></tr>
<tr><td colspan="2">BQF</td><td>• Houses all SSC for the entire duration of the Interim Storage Process.
• Potentially serves as an additional confinement barrier for the SFAs.</td><td>Chapter 29</td></tr>
<tr><td colspan="2">SFIS Systems</td><td>• Provides 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 the entire interim storage duration in the BQF.</td><td>Chapter 29</td></tr>
<tr><td rowspan="2">Fuel Handling and Storage System</td><td>Spent Fuel Pool Crane</td><td>• Lifting and handling system for the SFAs between the SFP and the spent fuel cask.</td><td rowspan="2">Chapter 28</td></tr>
<tr><td>Underwater Fuel Storage Rack</td><td>• Storage location for the SFAs in the SFP.</td></tr>
</table>

SSC		Roles in the SFIS	Presentation in PCSR
DMK	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. It is assumed that the BQF has to store the SFAs until a GDF is available in the UK. The design lifetime and requirements of SFIS will be revised once the UK HPR1000 spent fuel disposability assessment has been undertaken and an estimated commercial operation date of the reactor has been provided.

29.5.1 General Requirements

a) Safety Classification

The aim of the classification is to help ensure that the items are designed, manufactured, 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 in Reference [18] shall be considered in the SFIS design.

b) Engineering Design Requirements

1) Reliability Design of SSC

- Single Failure Criterion (SFC)
- Independence
- Diversity
- Ageing and Degradation

2) Human Factors

The design shall allocate functions properly, and support personnel in the fulfilment of their responsibilities and in the performance of tasks. The design also needs to identify human actions that may affect safety and proportionately analyse all tasks important to safety, and limit the likelihood of operational errors and their impact on safety. Principles relevant to the human factors shall be considered in the design.

c) Protection against Internal and External Hazards

According to Reference [19], the fundamental safety functions for a NPP shall be protected against hazards, such that accidental radioactive releases are limited.

The necessary capability, reliability and functionality of items important to safety shall therefore be ensured in the conditions arising from internal and external hazards.

Measures to protect the system against internal hazards are presented in Chapter 19 and measures to protect the system against external hazards are presented in Chapter 18. The internal and external hazards relevant to SFIS are identified in Reference [20].

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 test on site. The commissioning content, phased approach and scope are presented in Chapter 30.

e) Examination, Inspection, Maintenance and Testing (EMIT)

The design should facilitate EMIT activities for the purpose of maintaining the capability of SSC important to safety to perform essential safety functions, so as to satisfy the reliability requirement.

The types of inspections, maintenance, periodic tests, relevant requirements and the methodology of completeness analysis are presented in Chapter 31. The above activities are specified taking into account the design code requirements, reliability analysis and potential degradation mechanisms, commensurate with the safety class of the system. These requirements/principles shall be considered in the system design.

f) Decommissioning

Decommissioning shall be considered during the design stage for the UK HPR1000. At the current stage, the general considerations of decommissioning are mentioned in Chapter 24 and mainly include:

1) Consideration of facilitating decommissioning;

2) Consideration of decommissioning strategy; and,

3) Consideration of the preliminary decommissioning plan for the UK HPR1000.

g) Material Selection

Material selection of systems and equipment is one of the most significant factors for the safety, waste minimisation and economy of the NPP, and therefore special attention shall be paid to the material selection at the design stage for SSC 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 Reference [21].

h) Conventional Safety

The activities relevant to health and safety during construction, commissioning, operation and maintenance, and decommissioning are also considered during the SFIS design, in consistency with the requirements in Reference [22].

29.5.2 Safety Requirements

Based on the general requirements in Reference [23], 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 meet 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 SSC, including the cask, the structure 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 [10] and Reference [13].

29.5.3 Functional Requirements

The SFIS equipment and procedures should fulfil all relevant requirements set in Reference [13], 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, in 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 following final disposal related requirements are considered in the technology optioneering and concept design:

a) Compatibility of the SFAs to be repackaged into the appropriate canisters for off-site transport or final disposal after the interim storage period;

b) Disposability of spent fuels for final disposal.

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. The progress of the disposability assessment will be tracked and updated. The response to the disposability assessment result from RWM will be also provided once the assessment results are available.

29.6 SFIS Design

29.6.1 Technology Optioneering

According to the worldwide Operating Experience (OPEX) and IAEA guidance, in Reference [10], 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 over-packs 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. 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 [17].

29.6.2 Design Proposal

29.6.2.1 Overview

The SFIS facility is assumed to be designed for two the UK HPR1000 units and is planned to be constructed in two phases. The storage capacity of first phase considers the spent fuel and High Level Wastes (HLW) generated by two UK HPR1000 units in an operating period of 30 years, including Rod Cluster Control Assemblies (RCCAs), Stationary Core Component Assemblies (SCCAs) and In-Core Instrument Assemblies

(ICIAs), which are non-fuel core components. The second phase capacity will be determined approximately 30 years later, taking account of the actual High Level Waste (HLW) arising from operation, possible decommissioning waste and the progress of work on GDF.

According to the *Methodology of Safety Categorisation and Classification*, Reference [18], the function categorisation of SFIS is determined according to the severity of on-site and off-site consequences. During the GDA phase, the design depth of SFIS remains at a conceptual level and no specific supplier will be determined. Therefore, detailed information of equipment is not considered in the GDA phase, and so the safety class of systems and equipment are based on both worldwide and China General Nuclear Power Cooperation (CGN) OPEX.

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

a) Ventilation system, which is used to ensure passive ventilation required for spent fuel storage and to maintain temperatures 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) Instrumentation & Control system, which provides instrumentation and control for SSC 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.

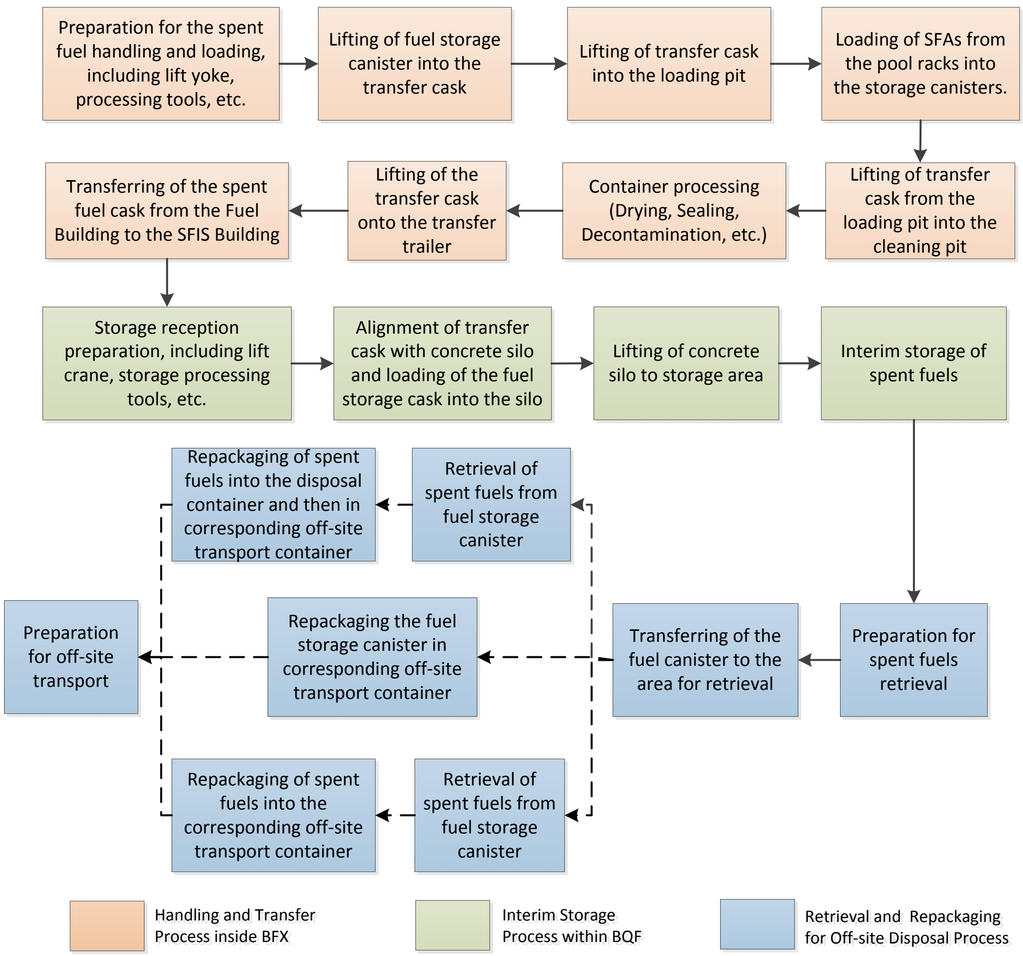
b) Facility for spent fuel retrieval and repackaging, which is used to provide enough space and a stable environment, and all relevant arrangements for safe spent fuel retrieval and repackaging after the decommissioning of the BFX.

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 waste that becomes ILW after years of 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.

29.6.2.2 Process Design

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 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 [15], 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 [25].



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 detail 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 equipment and components related to spent fuel loading should be prepared before the loading process starts. Preparation includes the transfer of necessary equipment from the storage area to the designed position in the BFX, decontamination of casks used for fuel transfer (as needed), and integrity checking of different equipment and components. The transfer cask is then transferred to the BFX and lifted into the cleaning pit for decontamination.

2) Lifting of fuel storage canister into the transfer cask

The fuel storage canister is then transfer into the BFX, and the integrity and the canister number of the canister is checked. The fuel storage canister is then loaded into the transfer cask with the spent fuel cask crane.

3) Lifting of transfer cask into the loading pit

After preparation of the transfer cask and fuel storage canister in the cleaning pit, the spent fuel cask crane is used to lift the fuel storage canisters, loaded within the transfer cask, into the loading pit.

4) Loading of spent fuels in the canisters

   After the transfer cask is located in the relevant position, the gate between the spent fuel pool and the loading pit is opened in order to flood the transfer cask with SFP water. The SFAs are then lifted from the pool racks and loaded into the transfer cask using the spent fuel pool crane.

5) Lifting of transfer cask into the cleaning pit

   When the fuel storage canister is loaded with the spent fuel, a radiation protection cover is put on the top of the canister. The transfer cask is then lifted into the cleaning pit with the spent fuel cask crane.

6) Processing of the fuel canister and transfer cask

   Within the cleaning pit, the decontamination of the transfer cask is conducted, which reduces the dose rate for workers. Then, water within the fuel canister is drained out and the inertia gas is pumped into the fuel canister using the dewatering pump and vacuum dry system, with sufficient inertia gas supply. After confirming the right pressure within the canister, the canister is sealed (using welding equipment) and then the transfer cask is sealed. Before the sealing of transfer cask, the integrity of the fuel canister sealing is detected with the leakage detection equipment, in order to prevent any leakage during the subsequent processes.

7) Lifting of the transfer cask onto the transfer trailer

   After the sealing of the transfer cask, the spent fuel cask crane is used to lift the cask onto the transfer trailer. As the transfer cask is tall and not convenient for transfer in the vertical position, the crane and the trailer can turn the transfer cask to horizontal position. However, the transfer cask can also be transported in vertical position if required. The transfer position of the cask will be determined in the nuclear site licensing phase, after the selection of a specific product supplier.

8) Transferring of the cask to BQF

   The transfer trailer is operated on the designated path between BFX and BQF. The arrangements for cask transfer between the two facilities is out of GDA scope and will be determined in the nuclear site licensing phase when the detailed layout of NPP and the specific product supplier are both determined.

b) Interim Storage Process within BQF

The process of spent fuel storage is mainly conducted within BQF, which aims to transfer the fuel storage cask into the concrete silo and then store the spent fuel 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 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 is permit to enter 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 sent 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 spent fuel 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 SSC 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 for retrieval is lifted into the underground vault, following which 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 spent fuel 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 opinions of RWM, as the retrieval and repackaging of spent fuels will not be conducted until the decommissioning of the NPP. It is not necessary to take any decision during GDA phase. The options are as follows:

   - 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, testing, etc., is conducted before the off-site transport of spent fuel.

29.6.2.3 Equipment

The following components are identified as the main additional components to support normal SFIS operations:

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

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

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

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

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

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

j) 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.

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

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

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

n) Forklift or other lifting machine for container transfer, which used to transfer the In-Core Instrument Assembly (ICIA) packages within BQF.

o) Drilling machine, which is used to drill holes in the fuel storage canister, permitting the gas sampling and the filling of water into the canister.

p) 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.

q) 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.

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 SSC 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) Fuel Building Handling Equipment (DMK [FBHE]), which is used to lift the equipment related to SFIS operations, including the fuel storage canister, transfer cask, welding equipment, etc..

b) Fuel Handling and Storage System (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 in the cleaning pit for transfer cask decontamination.

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

The matching analysis, which is an assessment of the physical and design compatibility of SSC 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 [15]. 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 is shown in Reference [26]. 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 [27], 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, with temperature and radiation detection to ensure the safety during interim storage period.

2) Other waste storage area – an area designed for the storage of other wastes. In current waste management strategy, the ICIA waste packages are planned to be stored in this area.

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. For example, the welding system, automatic vacuum system, transfer cask, drainage pump, helium filling system, etc. are planned to be stored in this area.

d) Interface between BQF and Other Facility

As there will be 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 will be 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 if available.

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 confine the operation conditions and judge if additional measures are required.

a) Temperature monitoring: The temperature of the ventilation outlet in the concrete silo is monitored, in order to measure the air temperature within the silo, which can be used to deduce the temperature of spent fuel cladding without opening of the fuel storage canister. If the temperature of the ventilation outlet exceeds the operation limits, retrieval of spent fuel should be conducted to directly check if there is any failure in the fuel cladding.

b) Radiation monitoring: The dose rate of the concrete silo surface and that around the facility is considered to be regularly detected 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.

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 facility. If there is a failure in the storage structure, it is easy to repair the silo during interim storage. Therefore, it is not expected to be necessary to monitor these two factors during operations. However, in order to reduce the risk of the degradation of the storage structure, the need to monitor these two factors will be justified in the design based on specific site conditions.

29.6.3 EMIT Considerations

In normal operation conditions, SFIS relevant operations are presented in Sub-chapter 29.6.2.2, which are mainly mechanical processes and 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 further 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

As the starting point for the demonstration of ALARP, comparison of spent fuel management in design reference 1 against applicable RGP (or OPEX where relevant) has been holistically and systematically undertaken, and practicable options to address identified gaps have been studied and determined by an optioneering process. As a result of the technology optioneering, the dry storage in casks technology is the preferred option for SFIS in the GDA phase. The design proposal is based on this.

The design reference 2.1 developed by implementing practicable options is subjected to further evaluation by insights from holistic risk assessment. In consistency with the detail of the conceptual design and the lack of a specific supplier, the risk assessment work of SFIS remains at a high level, which is commensurate with the scope of GDA, Reference [15]. The preliminary safety evaluation is conducted to identify the potential risks of SFIS, necessary input and methodology for safety assessment, as well as the criteria for SFIS products to ensure the safe operation and interim storage, in Reference [20]. The results of preliminary safety evaluation will contribute to supplier selection and detailed SFIS design in the nuclear site licensing phase. The assessment of direct dose to the public is conducted and presented in Reference [28].

The detail of this demonstration is discussed in *ALARP Demonstration Report of Spent Fuel Interim Storage*, Reference [29].

29.8 Record Management

According to the requirement in Reference [6], 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 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; and,

g) Records of disposal route of each package.

The appropriate records for Higher Activity Waste (HAW) packages will be preserved and maintained until GDF in the UK is available, and the waste records will be transferred by the future operator to the disposal facility.

In the conceptual design of SFIS, 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 recorder 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.

29.9 Concluding Remarks

This chapter presents the approach and plans adopted for the SFIS safety case development, according to the current GDA scope, in Reference [5]. The SFIS safety case demonstrates that the work within the GDA phase achieves the ALARP / BAT demonstration, in consistency with the GDA scope, and that foreclosure of potential options and improvements for the future site licensee is avoided.

During the GDA phase, technology optioneering has been conducted to select an appropriate technology for SFIS in the GDA phase. As a result, dry storage in casks is selected as the preferred technology. Based on the results of optioneering and OPEX in the GDA phase, 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.

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Appendix 29A Route Map

Sub-claim	Argument	Evidence	Supporting Documents
Sub-claim 3.3.13SC29.1 All reasonable measures are adopted to ensure the technology selected satisfies the requirements in the UK.	Argument 3.3.13SC29.1-A1 The requirements of spent fuel management, especially for interim storage in the codes and standards are analysed.	•**Evidence** 3.3.13SC29.1-A1-E1**:** Applicable acts, regulations, codes and standards for spent fuel management, including those for spent fuel interim storage have been identified, presented in Sub-chapter 29.3.	• Analysis report of applicable codes and standards
		•**Evidence** 3.3.13SC29.1-A1-E2: The requirements in the codes and standards specific for spent fuel interim storage are identified, presented in Sub-chapter 29.5.	• Analysis report of applicable codes and standards • Technology optioneering on Spent Fuel Interim Storage • Spent Fuel Interim Storage Facility Design
	Argument 3.3.13SC29.1-A2 The scope, process and relevant SSC concerning spent fuel management strategy for the UK HPR1000 are clearly defined before the technology optioneering.	•**Evidence** 3.3.13SC29.1-A2-E1**:** The overview of the spent fuel management strategy for the UK HPR1000 is presented, in Sub-chapter 29.2.1.	• Integrated waste strategy • Radioactive waste management case for HLW
		•**Evidence** 3.3.13SC29.1-A2-E2: The scope of SFIS operation, the work within the GDA phase, and relevant information concerning SFIS in other chapters are clearly identified in Sub-chapter 29.2.3.	• Sub-chapter 29.2.3 in PCSR Chapter 29 • Spent Fuel Interim Storage Facility Design
		•**Evidence** 3.3.13SC29.1-A2-E3: The main process and related SSC of SFIS operations are identified, in Sub-chapter 29.6.2.	• Spent Fuel Interim Storage Facility Design • The matching analysis of selected SFIS technology with current the UK HPR1000 design
	Argument 3.3.13SC29.1-A3 The preliminary ALARP/BAT assessment is conducted for SFIS.	•**Evidence** 3.3.13SC29.1-A3-E1**:** The RGP suitable for SFIS for the UK HPR1000 has been identified and presented, presented in Sub-chapter 29.3.	• ALARP demonstration of Spent Fuel Interim Storage • Analysis report of applicable codes and standards
		•**Evidence** 3.3.13SC29.1-A3-E2**:** Gaps between the spent fuel storage strategy for the HPR1000 and RGP in the UK is identified.	• Technology optioneering on Spent Fuel Interim Storage • ALARP demonstration of Spent Fuel Interim Storage
		•**Evidence** 3.3.13SC29.1-A3-E3: The considerations for eliminating the gaps in SFIS are presented.	• Technology optioneering on Spent Fuel Interim Storage • Spent Fuel Interim Storage Facility Design • The matching analysis of selected SFIS technology with current the UK HPR1000 design • Disposability assessment report (issued by RWM)
	Argument 3.3.13SC29.1-A4 The technology optioneering is conducted in an appropriate way.	•**Evidence** 3.3.13SC29.1-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** 3.3.13SC29.1-A4-E2: The technology optioneering is conducted through a systematic methodology, presented in 29.6.1.	• Technology optioneering on Spent Fuel Interim Storage
	Argument 3.3.13SC29.1-A5 The matching of selected SFIS technology with current the UK HPR1000 design is analysed.	•**Evidence** 3.3.13SC29.1-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 the UK HPR1000 design
Sub-claim 3.3.13SC29.2 The Spent Fuel Interim Storage is capable to achieve safe storage of spent fuel.	Argument 3.3.13SC29.2-A1 The design of SFIS considers the requirements under different conditions, including normal	•**Evidence** 3.3.13SC29.2-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

Sub-claim	Argument	Evidence	Supporting Documents
	operations, anticipated operational occurrences and design basis accident conditions.	• **Evidence** 3.3.13SC29.2-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
	Argument 3.3.13SC29.2-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** 3.3.13SC29.2-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** 3.3.13SC29.2-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** 3.3.13SC29.2-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** 3.3.13SC29.2-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 3.3.13SC29.2-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** 3.3.13SC29.2-A3-E1: The SSC in current station design that are related to SFIS operations are identified, presented in 29.6.2.4.	• Spent Fuel Interim Storage Facility Design • The matching analysis of selected SFIS technology with current the UK HPR1000 design
		•**Evidence** 3.3.13SC29.2-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 the UK HPR1000 design
		•**Evidence** 3.3.13SC29.2-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 the UK HPR1000 design
		•**Evidence** 3.3.13SC29.2-A3-E4**:** The considerations concerning the construction and Examination, Maintenance, Inspection and Testing (EMIT) are included in the design of SFIS, presented in 29.6.3.	• Spent Fuel Interim Storage Facility Design

Appendix 29B Preliminary Layout of BQF