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General Nuclear System

General Nuclear System Ltd.

UK HPR1000 GDA Project

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Title:

Pre-Construction Safety Report
Chapter 25
Conventional Safety and Fire Safety

This document has been prepared on behalf of General Nuclear System Limited with the support of China General Nuclear Power Corporation (CGN) and Électricité de France S.A. (EDF).

Text within this document that is enclosed within brackets '{…}' contains Sensitive Information and has been removed.

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TABLE OF CONTENTS

25.1 List of Abbreviations and Acronyms

ACoP	Approved Code of Practice (UK)
ADB	Approved Document B
ALARP	As Low As Reasonably Practicable
CDM	Construction (Design and Management)
CGN	China General Nuclear Power Corporation
COMAH	Control of Major Accident Hazards
DFL	Smoke Control System [SCS]
EDF E	EDF energy (UK)
ERIC	Eliminate, Reduce, Isolate, Control
GDA	Generic Design Assessment
GPP	General Principles of Prevention
HSE	Health and Safety Executive (UK)
IOSH	Institute of Occupational Safety and Health
JAC	Fire-fighting Water Production System [FWPS]
JDT	Fire Alarm System [FAS]
JPI	Fire-fighting Water System for Nuclear Island [FWSNI]
LT	Lower Tier
MSQA	Management of Safety and Quality Assurance
NPP	Nuclear Power Plant
PCSR	Pre-Construction Safety Report
RGP	Relevant Good Practice
RRO	Regulatory Reform (Fire Safety) Order
SFA	Access Compartment
SFI	Intervention Fire Compartment
SFS	Fire Safety Compartment
UK HPR1000	UK version of the Hua-long Pressurised Reactor
UT	Upper Tier

System codes (XXX) and system abbreviations (YYY) are provided for completeness in the format (XXX [YYY]), e.g. Smoke Control System (DFL [SCS]).

25.2 Introduction

The purpose of this chapter is to provide information with regards to conventional health and safety as well as conventional fire safety to demonstrate that the UK version of the Hua-long Pressurised Reactor (UK HPR1000) is compliant with the relevant requirements of UK acts, regulations, Approved Code of Practices (ACoPs), and guidance, so as to protect workers and the public.

Conventional (i.e. non-nuclear) health and safety as well as conventional fire safety are addressed as key topics of the UK HPR1000 Nuclear Power Plant (NPP) during the lifecycle. Information is provided for aspects of the design that might impact on conventional health and safety as well as conventional fire safety during construction, commissioning, operation, maintenance, and decommissioning of the UK HPR1000 NPP, and for compliance with the general requirements of UK legislation, including:

a) *The Health and Safety at Work etc. Act 1974*, Reference [1];

b) *The Management of Health and Safety at Work Regulations*, Reference [2];

c) *The Construction (Design and Management) Regulations 2015*, Reference [3];

d) *The Control of Major Accident Hazards regulations*, Reference [4];

e) *The Building Regulations 2010*, Reference [5];

f) *The Regulatory Reform (Fire Safety) Order 2005*, Reference [6].

Reducing risks, protecting people 2001, Reference [7] is used as guidance by the designer throughout the design of the UK HPR1000. The key principles of inherently safe design are applied throughout the design of the UK HPR1000.

The present safety case of Conventional Safety is produced based on the design reference version 2.1, as described in the *UK HPR1000 Design Reference Report* (Reference [8], Rev. E). The safety assessment results are documented in this chapter and corresponding safety assessment reports.

The present safety case of Conventional Fire is produced based on the design reference version 2.0, as described in the *UK HPR1000 Design Reference Report* (Reference [9], Rev. D). The safety assessment results are documented in this chapter and corresponding safety assessment reports. However, all the design changes between design reference version 2.0 and design reference version 2.1 have been assessed from Conventional Fire Safety point of view and corresponding insights have been provided to support the determination of these design changes.

25.2.1 Chapter Route Map

The ***Fundamental Objective*** of the UK HPR1000 is that: *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 objective**,** five high level claims (Level 1 claims) and a number of Level 2 claims are developed and presented in Chapter 1. This chapter supports ***Claim 2.4*** derived from the high level ***Claim 2*** and ***Claim 4.2*** derived from the high level ***Claim 4***.

Claim 2*: The UK HPR1000 design will be developed in an evolutionary manner, using a robust design process, building on relevant good international practice, to achieve a strong safety and environmental performance.*

Claim 2.4*: General Principles of Prevention (GPP) and Eliminate, Reduce, Isolate, Control (ERIC) Principles are in place to ensure the design meets the Environmental Protection, Security and Conventional Safety Objective*.

Claim 4*: The design, and intended construction and operation of the UK HPR1000 will be developed to reduce, so far as is reasonably practicable, the health and safety risks to the workers and the public, and the impact on the environment.*

Claim 4.2: *Conventional safety and conventional fire safety are managed to ensure that the conventional health and safety risks, and fire safety risks to workers and the public are reduced so far as is reasonably practicable.*

To support Claim 2.4 and Claim 4.2, two sub-claims along with relevant arguments and supporting evidences are developed. ***Sub-claim 4.2.SC25.1*** is for Conventional Health and Safety. ***Sub-claim 4.2.SC25.2*** is for Conventional Fire Safety.

a) ***Sub-claim 4.2.SC25.1****: The design of the UK HPR1000 is being developed to eliminate, reduce, isolate or control, so far as is reasonably practicable, the conventional health and safety risks to workers and the public that may arise during the construction, commissioning, operation, maintenance, and decommissioning of the NPP.*

    1) ***Argument 4.2.SC25.1-A1****: The design teams of this project, including internal designers and external designers, have the skills, knowledge, experience and the organisational capability. The skills, knowledge and experience of project participants are being assessed and recorded. There is a commitment to develop the knowledge of key internal staff to provide conventional health and safety guidance and advice to the design teams when it is required.*

        - ***Evidence 4.2.SC25.1-A1-E1****: The design teams are being provided with* *training covering the UK conventional health and safety acts, regulations, ACoPs and guidance. The training and the skills, knowledge and experience assessment arrangements are described in the UK HPR1000 Construction Design Management Strategy, Reference [10].*

2) ***Argument 4.2.SC25.1-A2****: Suitable design management arrangements with regards to conventional health and safety for this project are in place and have been communicated to all participants. These arrangements include processes and procedures for design risk management and competence assessment that provide guidance to the Construction (Design and Management) (CDM) duty holders to help them deliver the outcome stated in the high level claim.*

   − ***Evidence 4.2.SC25.1-A2-E1:*** *The management arrangements with regards to conventional health and safety for this project are outlined in the UK HPR1000 Construction Design Management Strategy, Reference [10] and the CDM Design Risk Management Work Instruction, Reference [11].*

3) ***Argument 4.2.SC25.1-A3****: The implementation of the management arrangements is being monitored, inspected, audited and reviewed at an agreed frequency, based on risk. Any corrective action required is being documented and closed.*

   − ***Evidence 4.2.SC25.1-A3-E1****: The monitoring, inspection, audit and review arrangements of the management arrangements implementation are described in the UK HPR1000 Construction Design Management Strategy, Reference [10] and the CDM Design Risk Management Work Instruction, Reference [11].*

4) ***Argument 4.2.SC25.1-A4****: The information about the health and safety risks is provided and communicated to all relevant parties and suitable and sufficient health and safety advice relative to the risks is provided to all relevant parties.*

   − ***Evidence 4.2.SC25.1-A4-E1:*** *The interface arrangements are in place, which are described in the UK HPR1000 Construction Design Management Strategy, Reference [10] and the CDM Design Risk Management Work Instruction, Reference [11].*

5) ***Argument 4.2.SC25.1-A5****: Designers have complied with CDM regulations 2015 Regulation 9 (Designers Duties) when they prepare the design of the UK HPR1000.*

   − ***Evidence 4.2.SC25.1-A5-E1:*** *How the Designers comply with CDM 2015 Regulation 9 (Designers Duties) when they prepare the design of* *the UK HPR1000 is described in the UK HPR1000 Construction Design Management Strategy, Reference [10] and the CDM Design Risk Management Work Instruction, Reference [11].*

b) ***Sub-claim 4.2.SC25.2****: Conventional fire safety is managed in accordance with UK Requirements from Relevant Good Practice (RGP) and the risk is as low as reasonably practicable (ALARP).*

1) ***Argument 4.2.SC25.2-A1****: The fire safety requirements of UK codes and standards are identified.*

- ***Evidence 4.2.SC25.2-A1-E1****: The applicable codes and standards in conventional fire safety area are identified and listed in Sub-chapter 25.4.1.*

- ***Evidence 4.2.SC25.2-A1-E2****: The general requirements of fire management and fire safety design are presented in Sub-chapter 25.4.3.*

2) ***Argument 4.2.SC25.2-A2****: The fire safety strategy presents the approach to meet the requirements of UK codes and standards.*

- ***Evidence 4.2.SC25.2-A2-E1****: The management and design measures relative to conventional fire safety which comply with UK codes and standards are considered as the fire safety strategy and presented in Sub-chapter 25.4.4.*

3) ***Argument 4.2.SC25.2-A3****: The gap management process is carried out to identify the gaps from the requirements and determine the appropriate options.*

- ***Evidence 4.2.SC25.2-A3-E1:*** *Gaps in the Reactor Building, Safeguard Building and Fuel Building are identified through the overall design review against BS 9999.*

- ***Evidence 4.2.SC25.2-A3-E2:*** *Options for the gaps identified are selected through the optioneering process.*

25.2.2 Chapter Structure

The general structure of this chapter is presented as below:

a) Sub-chapter 25.1 List of Abbreviations and Acronyms

This section lists the abbreviations and acronyms that are used in Pre-Construction Safety Report (PCSR) Chapter 25.

b) Sub-chapter 25.2 Introduction

This section briefly introduces the contents of this chapter, including the sub-claims, arguments and evidences of this chapter and the interfaces with other chapters.

c) Sub-chapter 25.3 Conventional Health and Safety

This section lists the applicable acts, regulations, ACoPs, and guidance for conventional health and safety, and outlines how the UK HPR1000 Generic Design Assessment (GDA) project intends to meet the relevant requirements for UK conventional health and safety. In addition this section also presents the Control of Major Accident Hazards (COMAH) assessment approach and findings.

d) Sub-chapter 25.4 Conventional Fire Safety

This sub-chapter provides an overview of conventional fire safety design for the UK HRP1000.

1) Sub-chapter 25.4.1 lists the applicable codes and standards in the conventional fire safety area;

2) Sub-chapter 25.4.2 presents the scope of conventional fire safety design;

3) Sub-chapter 25.4.3 presents the fire safety requirements from UK codes and standards;

4) Sub-chapter 25.4.4 presents the fire safety strategy requirements which the UK HPR1000 is to comply with;

5) Sub-chapter 25.4.5 presents the gap management process and the results for step 3;

6) Sub-chapter 25.4.6 presents the ALARP demonstration for conventional fire safety area.

e) Sub-chapter 25.5 Concluding Remarks

This section provides the concluding remarks.

Sub-chapter 25.6 References

This section lists the supporting references of this chapter.

25.2.3 Interfaces with Other Chapters

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

T-25.2-1 Interfaces between Chapter 25 and other Chapters

PCSR Chapter	Interface
Chapter 1 Introduction	Chapter 1 provides the fundamental objective, Level 1 Claims and Level 2 Claims. Chapter 25 provides chapter claims, arguments and evidences to support relevant high level claims that are

PCSR Chapter	Interface
	presented in Chapter 1.
Chapter 4 General Safety and Design Principles	Chapter 25 follows the general principles for application of laws, regulations, codes and standards presented in Chapter 4.
Chapter 6 Reactor Coolant System	Chapter 25 provides the conventional health and safety risk management techniques and general prevention principles for the reactor coolant system. Chapter 6 provides the design information to demonstrate the conventional health and safety risk management techniques and general prevention principles are applied in the design process of the reactor coolant system.
Chapter 7 Safety Systems	Chapter 25 provides the conventional health and safety risk management techniques and general prevention principles for the safety systems. Chapter 7 provides the safety system design information and the consideration about conventional health and safety risk management.
Chapter 8 Instrumentation and Control	Chapter 25 provides the conventional health and safety risk management techniques and general prevention principles for the instrumentation and control system. Chapter 8 provides the design information to demonstrate the conventional health and safety risk management techniques and general prevention principles are applied in the design process of the instrumentation and control systems design process.
Chapter 9 Electric Power	Chapter 25 provides the conventional health and safety risk management techniques and general prevention principles for the electrical power system. Chapter 9 provides the design information to demonstrate the conventional health and safety risk

PCSR Chapter	Interface
	management techniques and general prevention principles are applied in the design process of the electrical power system.
Chapter 10 Auxiliary Systems	Chapter 25 provides the conventional health and safety risk management techniques and general prevention principles for the auxiliary systems. Chapter 10 provides the design information to demonstrate the conventional health and safety risk management techniques and general prevention principles are applied in the design of the auxiliary systems. Chapter 25 provides the requirements of life safety for the fire protection systems design (fire alarm system, fire-fighting system and smoke control system). Sub-chapter 10.7 of Chapter 10 provides information of fire protection system related to fire safety strategy in Chapter 25.
Chapter 11 Steam and Power Conversion System	Chapter 25 provides the conventional health and safety risk management techniques and general prevention principles for the steam and power conversion system. Chapter 11 provides the design information to demonstrate the conventional health and safety risk management techniques and general prevention principles are applied in the design process of the steam and power conversion system.
Chapter 15 Human Factors	Chapter 25 and Chapter 15 have an interface which assists in complying with some conventional health and safety legislative requirements.
Chapter 16 Civil Works & Structures	Chapter 25 and Chapter 16 have an interface in terms of design safety of civil structures and protective barriers, and CDM requirements for building design risk management.
Chapter 17 Structural Integrity	Chapter 25 provides the conventional health and

PCSR Chapter	Interface
	safety risk management techniques and general prevention principles in the structural integrity area. Chapter 17 provides the design information to demonstrate the conventional health and safety risk management techniques and general prevention principles which are applied in the design process of the structural integrity.
Chapter 19 Internal Hazards	Chapter 19 identifies the internal hazard "Toxic and Corrosive Materials and Gases". Specific personnel safety protection against this hazard is described in Chapter 25. Chapter 25 and Chapter 19 have an interface in terms of internal fire protection design, especially in the design of fire areas, evacuation routes, and fire-fighting systems. Internal fire in Chapter 19 focuses on the nuclear safety while Chapter 25 is for life safety in the event of fire. Chapter 25 applies the fire zoning drawings provided by Chapter 19 to demonstrate that the requirements of escape route protection and internal fire spread control are achieved.
Chapter 21 Reactor Chemistry	Chapter 25 provides the hazardous substances and explosive hazard management techniques and general prevention measures in the reactor chemistry area. Chapter 21 provides the design information to demonstrate the conventional health and safety risk management techniques and general prevention principles are applied in the design process of the reactor chemistry.
Chapter 23 Radioactive Waste Management	Chapter 25 provides the conventional health and safety risk management techniques and general prevention principles in the radioactive waste management. Chapter 23 provides the design information to

PCSR Chapter	Interface
	demonstrate the conventional health and safety risk management techniques and general prevention principles are applied in the design process of the radioactive waste management.
Chapter 24 Decommissioning	Chapter 25 provides the conventional health and safety risk management techniques and general prevention principles during the decommissioning stage. Chapter 24 presents application of the conventional health and safety risk management techniques and general prevention principles in the development of decommissioning safety case.
Chapter 28 Fuel Route and Storage	Chapter 25 provides the conventional health and safety risk management techniques and the general prevention principles for the fuel handling and storage system.
Chapter 29 Interim Storage of Spent Fuel	Chapter 25 provides the conventional health and safety risk management techniques and the general prevention principles for spent fuel interim storage. Chapter 29 provides the design information to demonstrate the conventional health and safety risk management techniques and general prevention principles are applied in the design process of spent fuel interim storage.
Chapter 30 Commissioning	Chapter 25 provides the conventional health and safety risk management techniques and general prevention principles during the commissioning stage. Chapter 30 provides arrangements and requirements for commissioning which consider these requirements of conventional safety and fire safety.
Chapter 33 ALARP Evaluation	Chapter 25 demonstrates that the conventional health and safety risks and conventional fire safety risks are ALARP, which supports the overall

PCSR Chapter	Interface
	ALARP demonstration addressed in Chapter 33.

The table above lists the interfaces between Chapter 25 and other chapters, but it is understood that the requirements to use the GPP to eliminate, reduce, isolate or control the conventional health and safety risks cut across all areas and all stages of the UK HPR1000 design. The requirements to ensure life safety in case of fire also should be applied to all areas and all stages of the UK HPR1000 design.

25.3 Conventional Health and Safety

25.3.1 Applicable Codes and Standards

The general principles for identification of the applicable acts, regulations, ACoPs, and guidance relating to conventional health and safety are described in Chapter 4 and *General Principles for Application of Laws, Regulations, Codes and Standards*, Reference [12].

During GDA step 3, the suitable analysis of applicable codes and standards for conventional safety has been carried out, the analysis process and results are presented in Reference [13].

The applicable health and safety acts and regulations for the design of the UK HPR1000 at the GDA phase include those listed in table T-25.3-1. The associated ACoPs and guidance for health and safety are taken into account in the design of the UK HPR1000 at the GDA phase, which are also included in the table.

The list of acts, regulations, ACoPs, and guidance for conventional health and safety is not exhaustive and will be expanded in due course to cover all associated UK acts, regulations, ACoPs, and guidance for conventional health and safety.

T-25.3-1 List of Applicable Acts, Regulations, ACoPs, and Guidance

No.	Standard No.	Title	Date Issued	Topic
1	——	Health and Safety at Work etc. Act 1974	1974	General
2	——	Energy Act, 2013	2013	General
3	SI 1999 No. 3242	The Management of Health and Safety at Work Regulations 1999	1999	General
4	SI 2006 No. 438	The Management of Health and Safety at Work (Amendment) Regulations 2006	2006	General
5	SI 2015 No. 51	The Construction (Design and Management) Regulations 2015	2015	CDM

No.	Standard No.	Title	Date Issued	Topic
6	SI 2005 No. 735	The Work at Height Regulations 2005	2005	Work at Height
7	SI 2007 No. 114	The Work at Height (Amendment) Regulations 2007	2007	Work at Height
8	SI 1998 No. 2307	The Lifting Operations and Lifting Equipment Regulations 1998	2000	Lifting Operation
9	SI 1992 No.3004	The Workplace (Health Safety and Welfare) Regulations 1992	1992	Workplace
10	SI 2005 No.1643	The Control of Noise at Work Regulations 2005	2005	Noise
11	SI 2005 No. 1093	The Control of Vibration at Work Regulations 2005	2016	Vibration
12	SI 1998 No. 2306	The Provision and Use of Work Equipment Regulations 1998	1998	Work Equipment
13	SI 2002 No. 2677	The Control of Substances Hazardous to Health Regulations 2002	2002	Hazardous Substances
14	SI 2002 No. 2776	The Dangerous Substances and Explosive Atmosphere Regulations 2002	2002	Fire and Explosives
15	SI 1997 No. 1713	The Confined Spaces Regulations 1997	1997	Confined Spaces
16	SI 1989 No. 635	The Electricity at Work Regulations 1989	1989	Electricity
17	SI 1992 No. 2793	The Manual Handling Operations Regulations 2002	2002	Manual Handling
18	SI 2015 No. 483	The Control of Major Accident Hazards Regulations 2015	2015	COMAH
19	SI 2015 No. 627	The Planning (Hazardous Substances) Regulations 2015	2015	COMAH
20	SI 2012 No. 632	The Control of Asbestos Regulations 2012	2012	Asbestos
21	SI 2002 No. 2676	The Control of Lead at Work Regulations 2002	2002	Hazardous substances
22	SI 1996 No. 341	The Health and Safety (Safety Signs and Signals) Regulations 1996	1996	Safety Signs and Signals
23	SI 1992 No. 2966	The Personal Protective Equipment at Work Regulations 1992	1992	Personal Protective Equipment

No.	Standard No.	Title	Date Issued	Topic
24	SI 2002 No.1144	The Personal Protective Equipment Regulations 2002	2002	Personal Protective Equipment
25	SI 1999 No. 2001	The Pressure Equipment Regulations 1999	1999	Pressure
26	SI 2002 No. 1267	The Pressure Equipment (Amendment) Regulations 2002	2002	Pressure
27	SI 2015 No. 399	The Pressure Equipment (Amendment) Regulations 2015	2015	Pressure
28	SI 2000 No. 128	The Pressure System Safety Regulations 2000	2000	Pressure
29	SI 1984 No. 1244	The Classification, Packaging and Labelling of Dangerous Substances Regulations 1984	1984	Hazardous Substances
30	SI 1986 No. 1922	The Classification, Packaging and Labelling of Dangerous Substances (Amendment) Regulations 1986	1986	Hazardous Substances
31	SI 1988 No. 766	The Classification, Packaging and Labelling of Dangerous Substances (Amendment) Regulations 1988	1988	Hazardous Substances
32	SI 1989 No. 2208	The Classification, Packaging and Labelling of Dangerous Substances (Amendment) Regulations 1989	1989	Hazardous Substances
33	SI 1990 No. 1255	The Classification, Packaging and Labelling of Dangerous Substances (Amendment) Regulations 1990	1990	Hazardous Substances
34	SI 2014 No. 1638	The Explosives Regulations 2014	2014	Explosives
35	SI 2016 No. 588	The Control of Electromagnetic Fields at Work Regulations 2016	2016	Electricity
36	SI 2016 No. 1093	The Lifts Regulations 2016	2016	Lifting Operation
37	SI 2016 No. 1186	The Lifts (Amendment) Regulations 2016	2016	Lifting Operation
38	SI 2016 No. 1107	The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016	2016	Fire and Explosives
39	SI 2008 No. 1597	The Supply of Machinery (Safety) Regulations 2008	2008	Machinery
40	SI 2011 No. 2157	The Supply of Machinery (Safety) (Amendment) Regulations 2011	2011	Machinery
41	SI 1996 No. 1656	The Work in Compressed Air Regulations 1996	1996	Pressure

No.	Standard No.	Title	Date Issued	Topic
42	SI 1981 No. 917	Health and Safety (First-Aid) Regulations 1981	1981	First-Aid
43	SI 2010 No.1140	Control of Artificial Optical Radiation at Work Regulations	2010	Radiation
44	SI 2017 No.1075	The Ionising Radiation Regulations	2017	Radiation
45	SI 2008 No.2852	The REACH Enforcement Regulations	2008	Hazardous Substances
46	L113	Safe use of lifting equipment: Lifting Operations and Lifting Equipment Regulations 1998	2014	Lifting Operation
47	L24	Workplace (Health, Safety and Welfare) Regulations 1992	2013	Workplace
48	L5	Control of substances hazardous to health: The Control of Substances Hazardous to Health Regulations 2002.	2013	Hazardous Substances
49	L8	Approved Code of Practice and guidance on Legionnaires' disease	2013	Microbiological Hazards
50	L23	Manual handling - Manual Handling Operations Regulations 1992 - Guidance on Regulations	2016	Manual Handling
51	L74	First aid at work: The Health and Safety (First-Aid) Regulations 1981. Guidance on Regulation	2013	First-Aid
52	L96	A guide to the Work in Compressed Air Regulations 1996	1996	Pressure
53	L111	The Control of Major Accident Hazards Regulations 2015: guidance on regulations	2015	COMAH
54	L153	Managing health and safety in construction: Construction (Design and Management) Regulations 2015 guidance on regulations	2015	CDM
55	L150	Explosives Regulations 2014: safety provisions guidance on regulations	2014	Explosives
56	HSG65	Managing for health and safety	2013	General
57	HSG136	A guide to workplace transport safety	2014	Transport Safety
58	HSG268	The health and safety toolbox: How to control risks at work	2014	General
59	HSG 274 Part 1	Legionnaires' disease: Technical guidance Part1: The control of legionella bacteria in evaporative cooling systems	2013	Microbiological Hazards

No.	Standard No.	Title	Date Issued	Topic
60	HSG 274 Part 2	Legionnaires' disease Part 2: The control of legionella bacteria in hot and cold water systems	2014	Microbiological Hazards
61	HSG 274 Part 3	Legionnaires' disease: Technical guidance Part 3: The control of legionella bacteria in other risk systems	2013	Microbiological Hazards
62	INDG401	Working at height: a brief guide	2014	Work at Height
63	INDG136	Working with substances hazardous to health: a brief guide to COSHH	2012	Hazardous Substances
64	INDG244	Workplace health, safety and welfare: A short guide for managers	2012	Workplace
65	INDG362	Noise at work: A brief guide to controlling the risks	2012	Noise
66	INDG451	Heat stress in the workplace: A brief guide	2013	Heat Stress
67	INDG225	Preventing slips and trips at work	2012	Slips and Trips
68	INDG291	Providing and using work equipment safely: A brief guide	2013	Work Equipment
69	EH40	Workplace exposure limits: Containing the list of workplace exposure limits for use with the Control of Substances Hazardous to Health Regulations 2002 (as amended)	2011	Exposure Limits
70	HSR25	The Electricity at Work Regulations 1989	2015	Electricity
71	INDG 411	Need building work done? A short guide for clients on the Construction (Design and Management) Regulations 2015	2015	CDM

25.3.2 Implementation of UK Legislation

The applicable UK acts, regulations, ACoPs and guidance for conventional health and safety are used during the GDA phase of the UK HPR1000 when conventional health and safety risk identification, and associated design risk management techniques are applied.

The management arrangements for conventional health and safety of the UK HPR1000 are developed to ensure full implementation of *the Health and Safety at Work etc. Act 1974*, Reference [1], *the Management of Health and Safety at Work Regulations*, Reference [2], and *the Construction (Design and Management) Regulations 2015*, Reference [3]. The management arrangements include the organisation for the project, training and competence information, health and safety information communication in addition to the processes and procedures of design risk management for conventional health and safety during the GDA phase. The processes and procedures of design risk management cover design decisions, regular design team meetings, design risk assessment and status of the design progress, design risk register and design gateway reviews. The design arrangements are described in the *UK HPR1000 Construction Design Management Strategy*, Reference [10] and the *CDM Design Risk Management Work Instruction*, Reference [11].

The implementation of the management arrangements is being monitored, inspected, audited and reviewed to verify that the design of the UK HPR1000 is compliant with UK requirements for conventional health and safety.

Training is being provided on the management arrangements to ensure that the GPP are used to eliminate, reduce, isolate or control conventional health and safety risks during the design process and then to ensure suitable information is provided to those that need it for any remaining risks.

The designers use the skills and knowledge acquired and the tools of design risk management, such as hazard checklist, hazard identification workshop and risk assessment steps, in the UK HPR1000 to identify and assess the conventional health and safety risks, as well as eliminate, reduce, isolate and control them by design mitigations. The processes are recorded in conventional health and safety design risk register. The conventional health and safety design risk registers for each system and each building in GDA scope are being developed and will be continually developed throughout the lifetime of the design.

Health Risks Topic Report, Reference [14], *Work at Height Topic Report*, Reference [15], *Lifting Operation Topic Report*, Reference [16] and *Confined Space Topic Report*, Reference [17] are samples of the processes of design risk management in the UK HPR1000. They provide examples and evidences to demonstrate that the conventional health and safety risk management process of the UK HPR1000 is robust. These topic reports also provide evidences to demonstrate that the design of the UK HPR1000 is compliant with UK conventional health and safety legislation.

In these topic reports, lots of examples have been chosen to show how the conventional health and safety risks are managed in the UK HPR1000 project. These examples come from a cross section of work activities that are required for the delivery of the UK HPR1000 GDA project and from activities throughout the lifecycle of the UK HPR1000 NPP.

25.3.2.1 Organisation for the Project

The UK HPR1000 GDA is being carried out by General Nuclear System Limited on behalf of its shareholders China General Nuclear Power Corporation (CGN) and EDF Energy (UK) (EDF E). General Nuclear System Limited is managing the UK HPR1000 GDA supported by its shareholders.

Under *the Health and Safety at Work Act 1974*, Reference [1], *the Energy Act 2013*, Reference [18] and *the Construction (Design and Management) Regulations 2015*, Reference [3], there is a fundamental responsibility on duty holders to eliminate, reduce, isolate or control conventional health and safety risk, so far as is reasonably practicable.

The CDM duty holders, relevant to the GDA phase, are the Client, the Principal Designer and the Designer, Reference [3]. The arrangements to comply with the CDM regulations relevant to the GDA phase are outlined in the *UK HPR1000 Construction Design Management Strategy*, Reference [10].

a) Client

General Nuclear System Limited enacts the Client duty holder role during the UK HPR1000 GDA phase. The Client ensures the arrangements are in place for managing and organising the project, which include:

1) Other duty holders are appointed;

2) Sufficient time and resource are allocated;

3) Relevant information is prepared and provided to duty holders;

4) The Principal Designer carries out their duties;

5) Welfare facilities are provided;

6) Construction Phase Plan is available prior to construction commencing.

b) Principal Designer

General Nuclear System Limited enacts the Principal Designer duty holder role during the UK HPR1000 GDA phase. The Principal Designer plans, manages, monitors and co-ordinates health and safety in the pre-construction stage of the project. The duties of Principal Designer include:

1) Identifying, eliminating or controlling foreseeable risk;

2) Ensuring the Designers carry out their duties.

c) Designer

CGN and EDF E enact the Designer duties. The Designer eliminates, reduces, isolates or controls foreseeable hazards that may arise during:

1) Construction and commissioning;

2) Operation and maintenance;

3) Decommissioning of the NPP.

The Principal Contractor and Contractors have duties to manage the risks on site and these duties are not included in the GDA scope. It is understood that if the Principal Contractor or Contractors are carrying out design works they will also hold the duties of the Designer but this is not expected during the GDA phase of this project.

All duty holders have responsibilities to co-operate and communicate with each other and with the Principal Designer. Particular importance for the GDA phase of the project is that the Designers must co-ordinate their work to ensure all conventional health and safety risks are identified.

The overview of the arrangements describing how General Nuclear System Limited, CGN and EDF E enact the Client, Principal Designer and Designer role is described in Reference [10].

25.3.2.2 Training and Competence Information

There is a requirement to appoint the right people and organisations at the right time. The Client assesses the skills, knowledge and experience of the organisations and individuals that are appointed on the UK HPR1000 project through the process described in Reference [10].

All duty holder organisations are required to make sure that individuals are provided the right information, instruction, training and supervision to carry out their jobs in a way that ensures health and safety. Records of training are required to be kept.

The general conventional health and safety legislation training and the training on the management arrangements are provided to the project managers and all of the designers. The Institute of Occupational Safety and Health (IOSH) and Association for Project Safety Accredited Principal Designer and Design Risk Management Course have been provided to the key members in the CGN design team. There is a good understanding of the requirements for the Designer to identify, eliminate, reduce, isolate and control risks through good design.

These courses are provided to the Designers in CGN to ensure that the GPP are used to eliminate, reduce, isolate or control conventional health and safety risks during the design process and then to ensure suitable information is provided to those that need it for any remaining risks.

25.3.2.3 Health and Safety Information Communication

Once fully developed, the project arrangements are communicated and the guidance is provided to ensure that those carrying out works on the project are able to do so in a way that secures health and safety. Examples of health and safety information that is communicated are:

a) The UK acts, regulations, ACoPs and guidance that may be of assistance in delivering the requirements of duty holders;

b) The GPP, ERIC principles and how they are used during the design process to eliminate, reduce, isolate or control conventional health and safety risks;

c) Information about remaining risks that may assist other designers or be needed to pass to the Principal Contractor or user of the building.

The health and safety risk information is provided and shared to all relevant parties in a systematic way that is easily accessible to all and clearly documented to ensure the UK HPR1000 project is completed safely. A 3D model is being developed to generate, share and store health and safety risk information for the UK HPR1000. The 3D model is being used in the following ways:

a) Identification of space to be reserved for maintenance activities;

b) Clash detection;

c) Access routes for construction and/or maintenance equipment;

d) Identification of lifting envelopes for construction/maintenance tasks;

e) Review of construction sequences for buildability issues, etc.

CGN are working closely with the General Nuclear System Limited Principal Designer CDM Advisor to implement specific project processes such as Design Risk Register Reviews and Design Gateway Reviews. There are regular meetings between General Nuclear System Limited Principal Designer and CGN Designers to ensure co-ordination of the design and procedures to document the evaluation of a number of options where there are complex issues to be considered.

Health and safety information is included in the Health and Safety File so that the information is available for operations, construction, maintenance and decommissioning.

25.3.2.4 Conventional Health and Safety Risks Identification and Assessment

The design risk identification process of the UK HPR1000 ensures that foreseeable risks to health and safety are identified by:

a) Identifying the construction, commissioning, operation, maintenance, or decommissioning activities, or the element of the design, which has the potential to result in a conventional health or safety risk;

b) Identifying what consequence is likely to arise from the hazard, and who is affected.

The hazard identification tools include but are not limited to:

a) Hazard checklists;

b) Hazard identification workshop for more complex packages of work.

The risk assessment method of the UK HPR1000 ensures that the foreseeable risks are assessed and the most suitable design solutions are implemented, Reference [2]. The steps of risk assessment are listed as follows:

a) Identify the potential hazards;

b) Identify who might be at risk;

c) Evaluate the risk;

d) Assess the existing design solution and consider if this is ALARP;

e) Record the risk assessment on the design risk register.

The key factors which are considered are listed when the risk assessment is carried out:

a) The activity that needs to be carried out;

b) The number of people required to do the task;

c) The equipment that will be required (size/weight/laydown space for spare parts etc.) and the tools that need to be used;

d) The intended frequency of the activity;

e) The location and surrounding environment, such as lighting, ventilation, temperature, humidity, obstacles, floor conditions and space available.

The conventional health and safety risk identification and risk management techniques are being carried out against each system and designated area within the design of the UK HPR1000 to allow conventional health and safety risks to be considered during the design process. The significant health and safety risks are being identified and prioritised during the design process.

The conventional health and safety Design Risk Register is being used during the risk identification process which contains details of all identified significant risks, and is regularly reviewed. The Design Risk Register is described in the *UK HPR1000 Construction Design Management Strategy*, Reference [10] and the *CDM Design Risk Management Work Instruction*, Reference [11].

The conventional health and safety risks of the UK HPR1000 NPP are likely to include:

a) High temperature and high pressure;

b) Fire and explosions;

c) Hazardous substances;

d) Noise;

e) Vibration;

f) Electrical hazards;

g) Mechanical hazards;

h) Working at height;

i) Vehicle movement;

j) Drowning;

k) Lifting operations;

l) Manual handling;

m) Microbiological hazards;

n) Confined spaces.

25.3.2.5 Conventional Health and Safety Risk Management

Conventional health and safety risk management is following the GPP and ERIC Principles, and prioritises the significant risks.

The UK HPR1000 design is eliminating, reducing or controlling conventional health and safety risks, so far as is reasonably practicable.

a) GPP

The GPP are as follows, Reference [2]:

1) Avoiding risks;

2) Evaluating the risks which cannot be avoided;

3) Combating the risks at source;

4) Adapting the work to the individual, especially regarding the design of workplaces, the choice of work equipment and the choice of working and production methods, with a view, in particular, to alleviating monotonous work, work at a predetermined work-rate and to reducing their effect on health;

5) Adapting to technical progress;

6) Replacing the dangerous with the non-dangerous or the less dangerous;

7) Developing a coherent overall prevention policy which covers technology, organisation of work, working conditions, social relationships and the influence of factors relating to the working environment;

8) Giving collective protective measures priority over individual protective measures;

9) Giving appropriate instructions to workers.

b) ERIC

The process of ERIC Principles is as follows:

1) Eliminate (hazards, so far as is reasonably practicable);

2) Reduce (hazards where it is not reasonably practicable to eliminate them);

3) Isolate (isolate people from the hazard – consider physical barriers/engineering);

4) Control (manage those remaining risks).

The conventional health and safety design review is embedded into the existing design review processes and therefore it ensures that design prevention is considered in the design progresses along with any design changes.

The Design Gateway Review assesses the status of Design Risk Management activities and decides whether the project can pass through the gate from the current stage to the next. The Design Gateway Review is carried out at defined milestones within the project schedule to ensure adequate Design Risk Management activities within the Design Stage are reviewed and all risks, so far as is reasonably practicable, are designed out. The Design Gateway Review is described in the *UK HPR1000 Construction Design Management Strategy*, Reference [10] and the *CDM Design Risk Management Work Instruction*, Reference [11].

Record documents shall be provided to ensure that design prevention measures are taken and can be referenced and shared. The record documents will allow any important health and safety information required by others to be identified so that it can be provided in Pre-Construction Information or within the Health and Safety File, Reference [10].

25.3.2.5.1 General Design Strategies

There are a number of general design strategies adopted for the UK HPR1000:

a) Control of Dangerous/Hazardous Substances

All specified substances are reviewed to identify less dangerous/hazardous alternatives if they reduce associated risk so far as is reasonably practicable and meet the required performance.

Asbestos products are prohibited.

b) Construction Feasibility and Maintenance Safety

The design pays close attention to construction feasibility, in-service inspection accessibility, as well as regular test and maintenance feasibility.

c) Working Environment and Health Facilities

The design ensures the provision of a working environment that is, so far as is reasonably practicable, safe, without risks to health, and adequate as regards facilities and arrangements for their welfare at work.

The design principles encourage the use of engineering controls to minimise the use of personal protective equipment.

All equipment complies with *the Provision and Use of Work Equipment Regulations*, Reference [19].

The microbiological hazards are being considered to comply with the following requirements at the design stages:

a) *The Control of Substances Hazardous to Health Regulations*, Reference [20];

b) *The REACH Enforcement Regulations*, Reference [21];

c) *Approved Code of Practice and guidance on Legionnaires' disease*, Reference [22];

d) The guidance on control of Legionnaires' disease, Reference [23], [24] and [25] .

There are more detailed but potentially significant requirements at later stages in the design, such as the health and safety requirements with respect to:

a) People movement, for segregation of pedestrians and traffic, and for the avoidance of slips, trips and falls;

b) Goods and material movement for the avoidance of manual handling, so far as is reasonably practicable.

These are being taken account of during the design development.

25.3.2.5.2 Hazard Prevention Measures

The likely significant health and safety risks are being identified, and the potential hazard prevention measures are also being applied for each identified significant risk in accordance with the principles of prevention, so far as is reasonably practicable.

The applied hazard prevention measures for each identified significant risk are as follows:

a) High temperature, high pressure, fire and explosive hazards

The applied hazard prevention measures for high temperature, high pressure, fire and explosive hazards are:

1) Design for safe construction, operation, commissioning, maintenance and decommissioning;

2) Avoid areas where operators are regularly present when routing high-temperature and high-pressure pipes;

3) Provide heat insulation design, corresponding shielding and physical isolation for high-temperature pipes;

4) Provide suitable and sufficient ventilation;

5) Install visual and audible alarm devices and fire-fighting measures to avoid accumulation of flammable and explosive gases;

6) Design to reduce the need for entry of personnel in high-temperature areas, and avoid worker 'heat stress' in high temperature areas;

7) Where dangerous substances are used, steps are taken to eliminate areas where potentially explosive atmospheres may occur, (e.g. by use of welded pipework joints rather than flanged connections where reasonably practicable to avoid leak sources).Where this is not possible, avoid potential ignition sources and ensure the use of correctly certified electrical equipment for each zone on the basis of requirements set out in *the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations*, Reference [26], unless the risk assessment finds otherwise;

8) Automatic alarms are provided for dangerous substances where identified by risk assessment;

9) Where potentially explosive atmospheres may occur, the control measures include provision of antistatic personal protective equipment for the workers involved, as well as proper electrical earthing;

10) The risks from the sudden uncontrolled release of energy are avoided, through robust design incorporating suitable and sufficient safety devices, including over-pressurisation safety devices and back up devices;

11) The risk from corrosion failure is being avoided through the selection of suitable materials and the application of suitable surface protective systems, by robust written schemes of examination;

12) The risk of corrosion under lagging is being given due attention in the design stage;

13) The prevention measures for fire risk are described in Sub-chapter 25.4.

b) Hazardous substances

The applied hazard prevention measures for hazardous substances are:

1) Design for safe construction, operation, commissioning, maintenance and decommissioning;

2) Preferential use of non-hazardous substances instead of hazardous, using advanced production processes and technology, and non-hazardous raw materials, in order to eliminate hazardous substances hazards;

3) The effects of incompatible materials coming into contact and producing harmful by-products are being considered during the design process;

4) The thresholds/calculations for COMAH are being considered and steps are being taken to design-out or reduce COMAH substances wherever possible;

5) For the processes and equipment which use or produce hazardous substances (including outage process equipment), adopt mechanisation and automation, local exhaust ventilation and scrubber systems in order to avoid direct manual operation and reduce the potential of exposure to hazardous substances;

6) Automatic alarms are provided for hazardous substances where identified by risk assessment;

7) Emergency ventilation and leakage alarm devices are interlocked with an emergency exhaust system. Equipment and protective systems for use in hazardous areas must be of the correct certified electrical equipment class;

8) To prevent hazardous materials spilling and leaking, the equipment and pipelines adopt effective sealing, containment, low loss coupling and devices to reduce the risk of unloading into the wrong tank, are combined with ventilation and purification measures. For example, all the acid and alkali solution tanks are sealed containers and located to reduce heat loading. There is integrated absorption equipment (acid mist absorber) at the exhaust port of the solution tank;

9) Design for hygiene and emergency facilities;

10) Avoid use of hazardous materials. Where hazardous substances are unavoidable, internal structures and surfaces such as walls, ceilings and floors of workplaces which need to use hazardous compounds, employ materials and coatings to provide corrosion resistance (and are non-absorbent).

c) Electrical hazards

The applied hazard prevention measures for electrical hazards are:

1) Design for safe working practices on operation and maintenance of electrical equipment, so far as is reasonable practicable;

2) Implement high voltage protection measures to ensure separation of high voltage equipment from operating areas and personnel;

3) Implement safe working maintenance practices for high voltage equipment;

4) Use reliable insulation for electric parts, implement isolation, use fire retardant products for switch cabinets, use anti-spark protection in potentially flammable atmospheres, and employ reliable earth leakage protection;

5) Lightning protection measures for buildings;

6) Anti-static protection measures to prevent static accumulation;

7) Choose correctly certified electrical equipment classes for use in hazardous areas and specify high-temperature resistant equipment;

8) Provide a suitable means for cutting supply and for isolation of electrical equipment, where appropriate;

9) Electrical systems are designed, so far as is reasonably practicable, to reduce risk;

10) Electrical equipment that may be exposed to mechanical damage, natural hazards, excessive temperatures or pressures, wet, dusty or corrosive environments, flammable or explosive substances including dusts, vapours or gasses is suitably rated for the applicable Index of Protection;

11) Using suitably-rated electrical equipment;

12) Suitable measures such as earthing or other suitable means are taken to reduce risk arising when conductors (other than circuit conductors) become charged;

13) Suitable measures are provided for protecting against current surges and spikes for every part of the electrical system;

14) Develop Permit to Work processes that provide suitable controls for working on and testing high and low voltage voltage circuits and equipment, and build in practical isolation solutions. The training and authorisation process for implementation of the permit process shall be developed at a later stage in the project.

d) Mechanical hazards

The applied hazard prevention measures for mechanical hazards are:

1) Design for safe construction, operation, commissioning, maintenance and decommissioning;

2) Selection of mechanical equipment with the appropriate reliabilities;

3) Provide a suitable means for supply, removal and isolation of plant equipment, so far as is reasonably practicable, to reduce risk. The functions

for isolation, venting, draining and purging are provided where required. Ensure operators are protected from revolving/moving parts and ensure appropriate interlocks and alarms are available;

4) Implementation of suitable maintenance, testing and inspection programmes to ensure mechanical reliability is maintained;

5) Set fixed barriers and warning signs;

6) All plant systems are designed, so far as is reasonably practicable, to prevent danger. Equipment that may be exposed to mechanical damage, natural hazards, temperature or pressure, wet, dusty or corrosive environments, flammable or explosive substances including dusts, vapours or gasses is suitably rated for the applicable hazard;

7) All plant systems are designed to allow safe construction, operation commissioning, maintenance and decommissioning. Plant systems are designed ensuring that all personnel, operators and others are protected from revolving/moving parts by ensuring appropriate guards, interlocks and alarms are implemented;

8) Develop Permit to Work processes that provide suitable controls for working on and testing of plant and rotating machinery and build practical isolation solutions. The training and authorisation process for the permit system shall be developed at the appropriate stage of the project.

e) Work at height

The applied hazard prevention measures for work at height are:

1) Design for safe construction, operation, commissioning, maintenance and decommissioning, recognising that there is a need for mobile platforms scaffolding or other access devices during construction and decommissioning;

2) Consider the need to work at height during the design stage;

3) Eliminate the need for work at height so far as is reasonably practicable through use of equipment that can be operated from a position of safety, e.g.

   - Use of automated process equipment such as valve actuators;
   - Installing air conditioning units at ground level as opposed to locating them on roofs, and design of safe access solutions;
   - Use of staircase systems as opposed to fixed ladders;
   - Specifying load bearing roof skylights instead of fragile components where reasonably practicable;

- Provision of adequate collective fall prevention guardrails in all situations where there is a foreseeable risk of a fall.

4) Design of roof mounted services that require access (e.g. for maintenance), with provision for safe access (e.g. barriers);

5) Early installation of permanent means of access, and prefabricated staircases with hand rails;

6) Provide personal fall protection systems (as a last resort);

7) Prevention of falling objects is also addressed in design, where reasonably practicable, e.g. by minimising gaps on working platforms.

f) Vibration and noise

The applied hazard prevention measures for vibration and noise are:

1) Design for low noise and low vibration levels during operation and maintenance;

2) High noise levels are considered for elimination at the design stage and engineered out so far as is reasonably practicable;

3) Reduce potential sources of noise by choosing appropriate equipment;

4) Design for monitoring vibration;

5) Identify the high noise working areas at the design stage and provide control requirements for the personnel working time within the working area;

6) Give due regard to expected noise levels in all areas of the plant and take steps to meet specific noise reduction requirements at an early stage of design and in procurement;

7) Personal hearing protectors are available to workers who are exposed to noise at or above the exposure action value.

g) Dust hazard and particulate exposure

The applied hazard prevention measures for dust hazard and particulate exposure are:

1) Design for safe construction, operation, commissioning, maintenance and decommissioning;

2) Employ automatic processes as much as possible to avoid personnel contact with dusts and address related exposure risks;

3) Conduct closed operations in areas where the dust hazard exists;

4) Provide appropriate ventilation to reduce dust concentration.

h) Drowning

The applied hazard prevention measures for drowning are:

1) Design for safe construction, operation, commissioning, maintenance and decommissioning;

2) Design in protective barriers and railings, paying attention to stairways, cranes and fuel handling;

3) Ensure guardrails in the presence of all drowning risk areas;

4) Reduce the need for areas with deep water and control personnel access to these areas.

i) Vehicle movement

The applied hazard prevention measures for vehicle movement are:

1) Design for safe construction, operation, commissioning, maintenance and decommissioning;

2) Site traffic routes shall allow for one-way systems and vehicular traffic segregation from pedestrians;

3) Reduce vehicle access generally, and reduce the need for on-site transport containers for the operational phase;

4) Traffic routes are designed to avoid reversing, to avoid blind bends, and to avoid potential clash with plant, including overhead power lines;

5) Access controls shall be set up to segregate vehicles from pedestrians, and to act as a hold point to check and ensure that drivers are aware of site health and safety rules before entry;

6) A detailed vehicle management plan shall be developed for the construction phase, outage maintenance and operations, giving due regard to Health and Safety Executive (HSE) guidance document: *A guide to workplace transport safety*, Reference [27].

j) Confined spaces

According to *the Confined Spaces Regulations*, Reference [28], a confined space means any place, including any chamber, tank, vat, silo, pit, trench, pipe, sewer, flue, well or other similar space in which, by virtue of its enclosed nature, arises a reasonably foreseeable specified risk. The typical confined spaces in NPPs include closed containers, trenches, basements, underground warehouses, sub-drains, tunnels, sumps and galleries. The applied hazard prevention measures for confined spaces are:

1) Design for safe construction, operation, commissioning, maintenance and

decommissioning, particularly for use in confined areas;

2) Design to eliminate confined spaces (addressing all issues of potential asphyxia);

3) Where unavoidable, provide locking devices and entry controls;

4) Develop permit control systems;

5) Design and be constructed in such a way to eliminate the need for persons to enter confined spaces, so far as is reasonably practicable;

6) Develop Permit to Work processes that provide suitable controls for entry into confined spaces, where this in unavoidable;

7) Ensure that all confined space entry points are large enough to allow rescuers to wear self-contained breathing apparatus;

8) Design to restrict access to confined spaces by securing entry points, and providing relevant hazard warning signage;

9) Provide suitable isolation points that allow the hazard to be removed;

10) Install fixed ventilation and detection facilities, and enable use of temporary ventilation if not practicable;

11) The additional requirements of *the Confined Spaces Regulations*, Reference [28] will be developed at detailed design stages.

k) Lifting Equipment and Lifting Operation

The applied hazard prevention measures for lifting equipment and lifting operation, including the lifting of personnel, are:

1) Design for safe construction, operation, commissioning, maintenance and decommissioning;

2) Lifting equipment used for lifting personnel has the necessary safeguards in place to prevent the operator from being crushed, trapped, struck or from falling from the carrier (such as a mobile elevated work platform);

3) Lifting equipment is positioned or installed in such a way that reduces to as low as is reasonably practicable the risk of the lifting equipment or a load striking a person;

4) Machinery and accessories for lifting loads are clearly marked to indicate their safe working loads;

5) Lifting equipment used for lifting persons is clearly marked in such a way that explicitly states the requirements and controls for safe use;

6) Lifting equipment shall be thoroughly examined after installation and before being put into service for the first time, after assembly and before being put into service at a new site or in a new location;

7) Lifting equipment and associated accessories for lifting persons shall be thoroughly examined at least every 6 months. Other lifting equipment shall be thoroughly examined at least every 12 months.

25.3.3 COMAH

The Control of Major Accident Hazards regulations 2015 apply to establishments where the dangerous substances are stored/used or generated through loss of control in quantities equal to or above the qualifying quantities thresholds listed in Reference [4]. *The Control of Major Accident Hazards regulations 2015* do not apply to radioactive materials.

There are two thresholds for each dangerous substance, known as Lower Tier (LT) and Upper Tier (UT).

a) If the quantity of a dangerous substance onsite is more than the LT threshold but less than the UT threshold, the site is classified as a LT COMAH establishment;

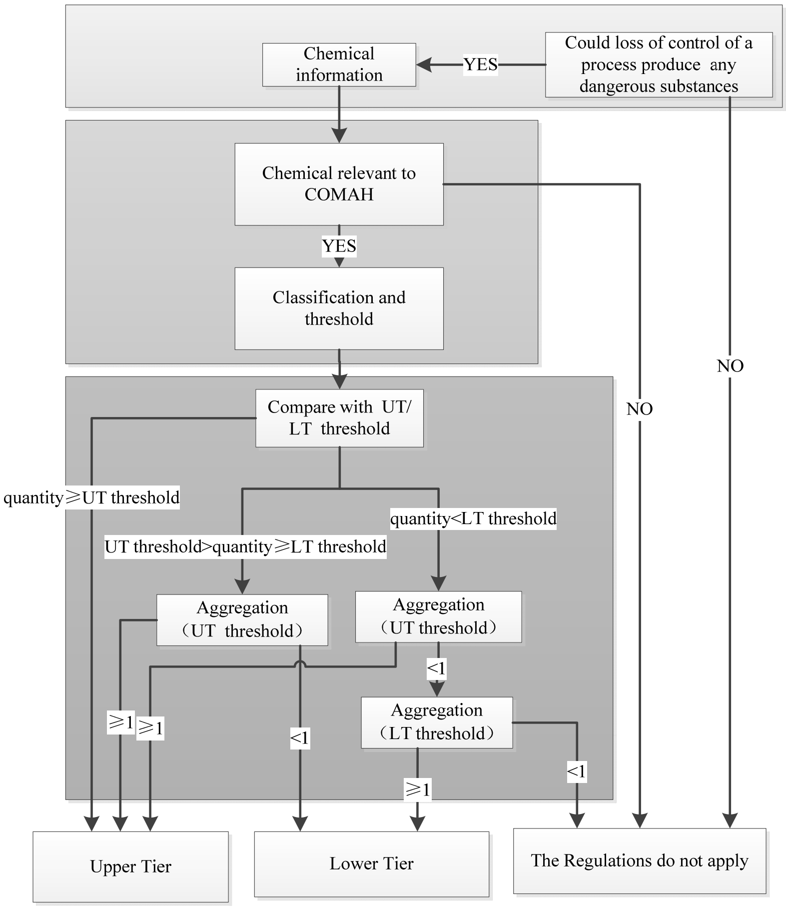
b) If the quantity of a dangerous substance onsite is more than the UT threshold, the site is classified as an UT COMAH establishment.

c) In the case of an establishment where no individual dangerous substance is present in a quantity above or equal to the relevant qualifying quantity, the rules of aggregation must be considered.

The UK HPR1000 project needs to use certain chemicals in order to operate, construct, maintain, commission, and decommission the NPP safely and efficiently. The quantities of chemicals presented at the UK HPR1000 site are described in the *Chemical Inventory for the UK HPR1000*, Reference [29]. At the GDA phase, the quantity of each chemical present in the UK HPR1000 has not been fixed. The quantities of chemicals present on site are operational decisions determined by the site operator at the nuclear site licensing phase, for example, the requirement for storage of bulk quantities of a chemical substance on site or receipt of regular deliveries of the chemical substance to the site. Therefore, it is difficult to present the storage capacity accuracy for each chemical substance during the GDA phase. Information provided in Reference [29] is based on the values estimated from existing CGN fleet feedback.

The UK HPR1000 is expected to have substantial inventories of chemicals that means it can, in some cases, become a LT or UT COMAH establishment. The COMAH assessment process shall be carried out to confirm whether the UK HPR1000 will be designated as an UT or a LT COMAH establishment.

The process of COMAH assessment has been split into three phases and a schematic diagram of the COMAH assessment process is outlined in F-25.3-1.



F-25.3-1 Schematic Diagram of the COMAH assessment

The COMAH assessment process in Reference [30] includes the following steps:

a) Collect information on chemicals which are present on site, and list the total quantity in tonnes;

b) Collate chemical inventory for the UK HPR1000, and classify the dangerous substances into different groups in accordance with the Classification, Labelling and Packaging Regulation, Reference [31], then determine the threshold of each dangerous substance according to the Schedule 1 of *the Control of Major Accident Hazards regulations 2015* in Reference [4];

c) Compare the quantity of a dangerous substance with the LT threshold and UT threshold defined within Part 1 of Schedule 1 and Part 2 of Schedule 1 of *the Control of Major Accident Hazards regulations 2015* in Reference [4].

   1) If a dangerous substance is present on a given establishment in a quantity equal to or in excess of the UT threshold in Reference [4], including through use of the aggregation rule laid down in paragraph d), it is classified as an UT establishment.

2) If a dangerous substance is present on a given establishment in a quantity equal to or in excess of the LT threshold, but less than the UT threshold in Reference [4], including though use of the aggregation rule laid down in paragraph d), it is classified as a LT establishment.

d) If an establishment has no single dangerous substance equal to or in excess of the UT threshold or LT threshold, it could still be a COMAH establishment. Therefore, the aggregation rule must be applied.

The aggregation rule is used three times, from the perspective of health hazards, physical hazards and environmental hazards, to assess the dangerous substance relevant to COMAH. The classification of health hazards, physical hazards and environmental hazards is as follows, Reference [4]:

1) Health hazards: Dangerous substances falling within section H, entries H1 to H3 in Part 1of Schedule 1 of *the Control of Major Accident Hazards regulations 2015* in Reference [4];

2) Physical hazards: Dangerous substances falling within section P, entries P1 to P8 in Part 1of Schedule 1 of *the Control of Major Accident Hazards regulations 2015* in Reference [4];

3) Environmental hazards: Dangerous substances falling within section E, entries E1 and E2 in Part 1of Schedule 1 of *the Control of Major Accident Hazards regulations 2015* in Reference [4].

Aggregation is applied using the following formula:

$$q_1/Q_{U1} + q_2/Q_{U2} + q_3/Q_{U3} + q_4/Q_{U4} + q_5/Q_{U5} + \dots \qquad (25.3\text{-}1)$$

1) Where q_x = the quantity of dangerous substance x (or category of dangerous substances) falling within Part 1 or Part 2 of Schedule 1 of t*he Control of Major Accident Hazards regulations 2015* in Reference [4];

2) Where Q_{UX} = the relevant qualifying quantity of dangerous substance or category x from Column 3 of Part 1 or from Column 3 of Part 2 of Schedule 1 of *the Control of Major Accident Hazards regulations 2015* in Reference [4];

3) If the sum of the health hazards, physical hazards or environmental hazards is equal to or in excess of 1.0, the establishment is an UT establishment.

The same aggregation approach is applied to determine whether an establishment is a LT establishment.

If the site is an UT or LT COMAH establishment, the operator of the establishments has a general duty to take all necessary measures to prevent major accidents, limit their consequences, and report any major accidents to the competent authority. They must prepare a Safety Report containing the Major Accident Prevention Policy for the UT establishment, or a Major Accident Prevention Policy for the LT establishment which demonstrates that an adequate safety management system is in place to prevent major accidents. The competent authority shall be sent a notification, including:

a) The name of the operator;

b) The full address of the establishment;

c) The registered place of business;

d) The name and position of the person in charge of the establishment;

e) The sufficient information to identify the dangerous substances or category of dangerous substances involved or likely to be present;

f) The quantity and physical form of the dangerous substances involved or likely to be present;

g) The activities or proposed activities of the installation or storage facilities.

Any changes in these details shall be notified to the competent authority. The notification must be sent to the competent authority within a reasonable period of time prior to the start of construction, Reference [4].

For a two unit site, the second unit will be built about ten months after the first one, so there are three stages from commissioning to operation:

a) Two units commissioning;

b) One unit commissioning and one unit operation;

c) Two unit operation.

The findings of the COMAH assessment are described in *COMAH Assessment for the UK HPR1000*, Reference [32].

No single dangerous substance equal to or in excess of the UT threshold or LT threshold, and none of the three quotient values of UT and LT threshold are equal to or greater than 1.0, therefore, the UK HPR1000 is not a COMAH establishment for the three stages outlined above.

The thresholds/calculations for COMAH are considered during the design process, and steps are being taken to design out or reduce COMAH classified chemicals wherever possible.

25.3.4 ALARP Assessment

As mentioned in Sub-chapter 25.3.1, the RGP in the conventional health and safety area has been sufficiently identified.

Reducing risks, protecting people 2001, Reference [7] is used as guidance by the designer throughout the design of the UK HPR1000. This document describes the philosophy of the UK regulatory approach to the assessment of risk.

The health and safety design risk management methodology for the UK HPR1000 is provided in *the UK HPR1000 Construction Design Management Strategy*, Reference [10] and the *CDM Design Risk Management Work Instruction*, Reference [11]. Reference [10] and Reference [11] outline how the UK HPR1000 GDA project intends to meet the relevant requirements of *the Construction (Design and Management) Regulations 2015*, Reference [3]. The design risk management methodology is being used during the UK HPR1000 design process to eliminate, reduce, isolate or control conventional health and safety risks to ALARP. The health and safety design risk management methodology is compliant with RGP.

Conventional health and safety is one element of the ALARP process. The relevant system and designated area design disciplines give consideration to conventional health and safety issues during the optioneering for each system/area design of the UK HPR1000. The implementation of the design risk management is being monitored, inspected, audited and reviewed at an agreed frequency, based on risk.

25.4 Conventional Fire Safety

25.4.1 Applicable Codes and Standard

In the UK, new constructions should follow the recommendations put forward by *The Building Regulations*, Reference [5], and *Regulatory Reform (Fire Safety) Order (RRO)*, Reference [6], which present the general requirements for conventional fire safety.

Complying with the conventional fire safety requirements of UK legislations by following a code of practice or approved guidance is a way of demonstrating that a reasonable standard of fire safety is provided in the design, and it provides a basis for reducing risk to ALARP.

In the UK, there are two main guidance, *Approved Document B (ADB)*, Reference [33], and *BS 9999: Code of Practice for Fire Safety in the Design, Management and Use of Buildings*, Reference [34], which both provide guidance for meeting UK expectations for conventional fire safety in the design of buildings. ADB provides an approved method to meet the functional requirements of RRO. ADB deals with fire safety and a building designed to satisfy the guidance within this document is deemed to satisfy the UK fire safety requirements. However, ADB is not suitable for complex buildings because it is used for simple conventional structures.

Therefore, under the goal-setting regulatory regime, designers and consultants are free to use alternative methods to meet these functional requirements (including fire engineering) and justify their fire safety strategy. BS 9999 provides a more advanced and flexible approach to develop a conventional fire safety strategy and it is considered to be the most appropriate guidance to evaluate and develop the fire strategy document for the UK HPR1000.

BS 9999 allows that "some variation from the recommendations might be necessary for certain special buildings or areas of buildings". Similarly, it allows for, where a gap may exist, an enhanced protection measure within a building to be used to compensate and justify the condition. BS 9999 provides a level of flexibility that allows the fire protection measures to enable reasonable practical solutions to be designed. Fire engineering is an acceptable way of justifying gaps against BS 9999 and guidance is provided in *BS 7974: Application of Fire Safety Engineering Principles to the Design of Buildings-Code of Practice*, Reference [35], as a structured approach to fire safety engineering.

Furthermore, whilst *EPR Technical Code for Fire Protection* (ETC-F), Reference [36], is predominantly for nuclear safety, it is applied during the design of protection against internal hazards, which includes the consideration for life safety.

To conclude, the applicable codes and standards used in the conventional fire safety area are:

a) BUILDING AND BUILDINGS, *The Building Regulations*, 2010 No.2214, 2010;

b) REGULATORY REFORM, *The Regulatory Reform (Fire Safety) Order*, 2005 No. 1541, 2005;

c) HM Government, *Approved Document B (Volume 2)*, 2006;

d) BSI, *BS9999: Code of Practice for Fire Safety in the Design, Management and Use of Buildings*, 2017;

e) BSI, *BS7974: Application of Fire Safety Engineering Principles to the Design of Buildings-Code of Practice*, 2001;

f) AFCEN, *EPR Technical Code for Fire Protection*, ETC-F 2010.

Detailed suitability analysis for the codes and standards is presented in *Suitability Analysis of Codes and Standards in Conventional Fire Safety*, Reference [37].

25.4.2 Scope

The items that should be assessed in Conventional Fire Safety are listed in T-25.4-1 which are consistent with the items considered in GDA scope according to *Scope for UK HPR1000 GDA Project* (HPR/GDA/REPO/0007, Rev. 001, 2019), Reference [38].

T-25.4-1 Item List for Conventional Fire Safety Area

No.	Building code	Building description
1	BDA	Emergency Diesel Generator Building A
2	BDB	Emergency Diesel Generator Building B
3	BDC	Emergency Diesel Generator Building C
4	BDU	SBO Diesel Generator Building for Train A
5	BDV	SBO Diesel Generator Building for Train B
6	BEX	Equipment Access Building
7	BFX	Fuel Building
8	BNX	Nuclear Auxiliary Building
9	BPX	Personnel Access Building
10	BRX	Reactor Building
11	BSA	Safeguard Building A
12	BSB	Safeguard Building B
13	BSC	Safeguard Building C
14	BWX	Radioactive Waste Treatment Building
15	BEJ	Extra Cooling System and Fire-fighting Water Supply System Building

According to *High Level Fire Safety Strategy*, Reference [39], five main aspects should be considered in conventional fire safety design:

a) Fire alarm warning

This aspect includes the provision of automatic fire alarm and detection systems which are used to detect the fire at an early stage, trigger the alarm and initiate other fire-fighting measures such as sprinklers.

b) Means of escape

This aspect includes the characteristic of occupancy, the evacuation strategy which describes how the staff evacuates in case of fire, the provision of escape routes and emergency lighting and signage.

c) Control of internal fire spread

This aspect includes the control management for the combustibles contained in the buildings, the fire zoning design including the fire area division and the fire resistance of structures both for load-bearing elements and compartment boundaries.

d) Control of external fire spread

This aspect includes the design requirements and principles of the external walls and roof of the building to resist external fire spread.

e) Access and facilities for fire-fighting

This aspect includes the provision of fire-fighting access within buildings, the provision of fire-fighting systems including fire mains, fire hydrants and sprinklers, and the provision of smoke control systems.

In GDA step 3, the conventional fire safety strategies for the Reactor Building, Fuel Building and Safeguard Buildings have been developed, which are detailed in Reference [40], [41] and [42], respectively.

25.4.3 General Requirements

25.4.3.1 Management Requirements

Fire safety management contributes to the reduction of risk associated with fire. According to the requirements in RRO and the assessment method for risk profile in BS 9999, the main management requirements are:

a) An effective fire emergency plan shall be established;

b) The use and storage of combustible materials in workplaces shall be under strict control;

c) All equipment and systems shall be kept in satisfactorily working condition through a robust maintenance and testing regime;

d) All personnel shall have appropriate training and be familiar with the use of fire-fighting facilities.

25.4.3.2 Design Requirements

As previously discussed, the application of BS 9999 is considered to be an applicable method of meeting *The Building Regulations* and RRO. Therefore, the functional requirements of the BS 9999 may be effectively used to inform the conventional fire safety requirements.

As the topic area of conventional fire safety primarily focuses on human life, the requirements of conventional fire safety design can be considered by assessing the aspects associated with fire. Each of these is listed in the sub-chapters below.

25.4.3.2.1 Fire Alarm and Warning

The buildings should be designed and constructed in such way that there are appropriate provisions for the early warning of fire, Reference [5].

Automatic fire alarm and detection systems do not provide any action for fire containment. However such systems, in addition to alarm, can also be used to initiate such functions as, Reference [34]:

a) Closing down ventilation and air conditioning system;

b) Operating fire protection systems;

c) Releasing passive fire protection equipment;

d) Activating pressurised systems.

25.4.3.2.2 Means of Escape

In the event of fire, buildings should be designed to provide an appropriate means of escape to a safe place, outside the buildings, which is capable of being safely and effectively used at all times, Reference [5].

The expected reaction and subsequent actions of those responsible for the management of the building should be assessed against the development of the fire in terms of threat and time, and the provision of adequate means of escape should be determined accordingly, Reference [34].

According to BS 9999, the design of means of escape should adequately consider the building risk profile depending on the occupancy characteristics and the fire growth rate associated with its use. The time to escape to a safe place should be less than the allowable travel time which is based on the risk profile.

25.4.3.2.3 Internal Fire Spread (linings and structures)

The buildings are constructed so as to inhibit the spread of fire through the use of appropriate construction materials, through the provision of fire zoning and fire separation, and by achieving a satisfactory level of structural fire resistance.

To inhibit the spread of fire within the building, the internal linings should have adequate resistance to the spread of flames over their surfaces and reasonable rate of heat release or fire growth, Reference [5].

To maintain the stability of affected buildings, the structure of a building should be able to withstand the effects of fire to an appropriate degree without loss of load-bearing capacity, Reference [34].

Where reasonably necessary, to inhibit the spread of fire within the building, measures should be taken, to an extent appropriate to the size and intended use of the building comprising either or both of the following, Reference [5]:

a) Sub-division of the building with fire resistant construction;

b) Installation of suitable automatic fire suppression systems.

25.4.3.2.4 External Fire Spread

According to Reference [5], to inhibit the external fire spread, the following requirements should be considered in the design:

a) The external walls of the building shall adequately resist the spread of fire over the walls and from one building to another, having regard to the height, the use and the position of the building;

b) The roof of the building shall adequately resist the spread of fire over the roof and from one building to another, having regard to the use and position of the building.

25.4.3.2.5 Access and Facility for Fire-fighting

Reasonable provisions should be made to enable fire services to gain access to buildings, and buildings must be constructed to provide reasonable facilities to assist fire fighters in the protection of human life, Reference [5].

Fire-fighting facilities should be selected and designed to assist the fire and rescue service in protecting life, protecting fire-fighters, reducing building losses, salvaging property and goods and minimising the environmental damage, Reference [34]:

a) Fire-fighting shafts should be provided as necessary and each should contain all of the appropriate facilities according to the type of buildings;

b) All premises should be provided with a supply of water for fire-fighting. Fire mains should be installed in any building provided with a fire-fighting shaft and should be capable of delivering a sufficient flow of water to enable effective fire-fighting to be undertaken;

c) Means should be provided to ventilate the fire-fighting shaft of smoke. Fire-fighting shafts should be provided with a pressure differential system which is designed and installed in accordance with relevant UK standards;

d) If possible, other mitigation measures should be provided to reduce the fire risk, such as fire suppression systems.

25.4.4 Fire Safety Strategy

Following the recommendations of BS 9999 is an acceptable way to meet the functional requirements as set in *The Building Regulation* and RRO. As a code of practice, BS 9999 contains elements of good fire safety practice. BS 9999 was also widely applied in other GDA projects.

Prior to commencing the fire and protection of human life review, following BS 9999, consideration must be given to fire prevention and risk reduction. Therefore, Sub-chapter 25.4.4.1 presents the considerations for fire safety management, and Sub-chapter 25.4.4.2 includes the measures or designs for meeting the requirements of BS 9999 based on the fire risk assessment level in Sub-chapter 25.4.4.1.

25.4.4.1 Fire Safety Management

Due to the importance of fire safety throughout the lifetime of a NPP, a strict fire safety management strategy is necessary. From operational experience feedback, there are lots of good practices relating to satisfying the requirements mentioned in Sub-chapter 25.4.3.1:

a) The workers or occupants in the buildings are trained appropriately, and familiar with the fire emergency plans and fire-fighting facilities;

b) Routine maintenance and testing are needed to ensure that the fire-fighting facilities can be operated correctly in the event of fire;

c) Combustible materials are kept to separate from possible ignition sources and safely stored in appropriate locations, so far as is reasonably practicable;

d) The use of combustible materials in workplaces is minimised and particular attention will be given to management of safety culture and behaviours.

25.4.4.2 Fire Safety Design

The following sub-chapters describe the fire safety design to satisfy the requirements mentioned in Sub-chapter 25.4.3.2, the detailed information is shown in *High Level Fire Safety Strategy*, Reference [39], and the fire safety strategy for each building.

25.4.4.2.1 Fire Alarm and Warning

The Fire Alarm System (JDT [FAS]) can continuously monitor the plant through fire detectors that are placed in appropriate locations of the plant. The JDT [FAS] can quickly detect fire, provide audible alarms and initiate automatic actions if necessary. .

Fire detectors are located in various locations. The detection range of smoke detectors is a circle with a radius of 5.80m. The layout of the detectors can ensure that the detection range covers the entire floor.

The type of detector at each location is chosen with regard to the particular fire phenomena applicable to the equipment or location being monitored (temperature, flame, smoke, combustion gas, etc.) and to the specific conditions of its installation (accessibility, atmosphere: humidity, temperature, ionizing radiation, corrosive or explosive gases and pressure at the location). Fire detectors of the following types are mainly used:

a) Smoke detector;

b) Flame detector;

c) Heat detector;

d) Line type heat fire detector;

e) Aspirating smoke detector;

f) Hydrogen detector.

Local audible and visible alarms are provided throughout the buildings. Normally, local alarms are located near the room exit. They are trigged automatically by the detectors and will warn people near the fire immediately once a fire has been detected.

Beside the local alarm, the broadcast alarm is sent manually by the operators to inform the personnel in other areas. There is an investigation period before the broadcast alarm is activated to avoid the influence of spurious alarms. The evacuation signal is broadcasted if a fire is confirmed or a second detector is activated.

The detailed information of the JDT [FAS] is presented in Sub-chapter 10.7.3 of Chapter 10.

25.4.4.2.2 Means of Escape

Except for diesel generator buildings, in the buildings within GDA scope, at least two protected staircases running through all the occupied floors are provided. In each diesel generator building, there is only one protected staircase. At least one protected staircase in the building is connected directly to the outside or other buildings and is used as the fire-fighting shaft.

There is no combustible material in the protected staircases except for the cables that serve the protected staircases themselves. A fire is not likely to occur inside a protected staircase. The barriers of protected staircases have a fire resistance rating not less than 1 hour according to ETC-F. The pressurised system is used to maintain positive pressure in the protected staircases in case of fire. A fire outside the protected staircase does not affect the availability of the protected staircases.

The corridors connecting to the staircases are also protected, where practicable. If physical segregation of the corridor is not practicable, additional measures are taken to reduce the fire load along the corridor, such as the cable wrapping.

The layout of the protected staircases and corridors ensure that, at most place in the nuclear island, two escape directions are available and the travel distance is less than the required value of BS 9999 for the correspondent risk profile. However, the situations of exceeding travel distance and inner-inner room still exist in the UK HPR1000. These situations are considered as gaps and have been identified. The optioneering process is applied to resolve these gaps. Detailed information is presented in Sub-chapter 25.4.5 and the gap management report for each building.

The exits, the staircases and the corridors are all wide enough taking the maximum people flow rate into account. The evacuation doors are designed to open in the same direction of travel.

The emergency escape lighting system provides lighting and escape route signs， for emergency exits and escape routes， to facilitate personnel evacuation. Escape lighting luminaries are laid in accordance with the relevant requirements of BS EN 1813 and BS 5266-1.

25.4.4.2.3 Internal Fire Spread

To limit internal fire spread, the buildings in the UK HRP1000 are divided into different fire compartments. The types of fire compartments are determined according to the plant layout and their functions. According to ETC-F 2010, the types of fire compartments applied in the UK HPR1000 are listed in T-25.4-2.

T-25.4-2 Types of Fire Compartments

Fire Compartment	Function
SFS	Protection of common mode failure
SFI	Facilitation of the intervention and limitation of unavailability
SFA	Protection of protected escape routes

SFS is used to limit the internal fire spread between different safety trains. They are created for nuclear safety, but they also contribute to conventional fire safety by providing a relative safe area in the building which reduces the travel distance and make horizontal progressive evacuation available.

SFI is created on the basis of the fire load inventory, to facilitate the intervention of fire-fighting crews. In the UK HPR1000, the rooms with a risk of flashover or a risk of localised fire are divided as SFI where practicable.

SFA is intended to enable the personnel to be evacuated in full safety in the event of fire and to provide access to the fire-fighting teams. In the UK HPR1000, the protected staircase, lobbies and corridors are divided as SFA.

The barriers of the compartments mentioned above have an appropriate level of fire resistance rating, suitable for their functions. The barriers of SFS have a fire resistance rating of 120 min; while the barriers of SFI and SFA have a fire resistance rating of 60 min.

Compartment barriers include concrete barriers (i.e. walls and floors), fire doors and penetrations. The thickness and cover of the concrete walls ensures that concrete barriers meet the requirement of fire resistance rating. Fire doors provide the same fire resistance requirements as concrete barriers, and this will need to be demonstrated by the suppliers. The service penetrations (ducts, cable trays, holes, etc.) through fire barriers are sealed using appropriate methods to suit the level of fire resistance of the barriers they penetrate, e.g. using fire dampers and fire sealing.

The stability of the structure supporting the fire-resisting boundary must be maintained for the required period. Therefore, the structure is constructed with materials that allow for a sustained performance under fire conditions for the designated time period.

The detailed fire zoning design is presented in the fire safety strategy for each building.

25.4.4.2.4 External Fire Spread

a) The external elevations of the buildings are designed with the appropriate limits on unprotected areas to prevent the spread of fire from the building of origin;

b) The entrance doors of the adjacent buildings are designed with an appropriate level of fire resistance;

c) Fire hydrants are distributed around the buildings appropriately, to ensure water supplies are easily accessible.

25.4.4.2.5 Access and Facilities for Fire-fighting

Adequate access to a building is provided through an external entry point. Protected staircases near the external entry points in each building are used as fire-fighting shafts. For safeguard buildings, fuel building, personnel access building and diesel generator buildings, the fire-fighting shafts are provided with fire-fighting lobbies. For other buildings where fire-fighting lobbies cannot be arranged due to limited space, additional fire protection measures, such as sprinklers and cable wrapping, are taken to ensure that the fire risk around the fire-fighting shafts is low and meet the requirement of ALARP. According to the risk profile and building layout characteristic, fire-fighting lifts are provided in the fuel building and the safeguard building A/B/C.

The fixed fire-fighting systems are installed for the rooms presenting a flashover risk according to fire hazard analysis. The types of fixed fire-fighting systems are determined according to the combustible material characteristic. Automatic sprinklers are used to extinguish electrical fire; while foam extinguishing systems are used to extinguish oil fire. Fire-fighting water supply is maintained using the Fire-fighting

Water Production System (JAC [FWPS]) and Fire-fighting Water System for Nuclear Island (JPI [FWSNI]). The JAC [FWPS] and the JPI [FWSNI] are designed in accordance with ETC-F 2010 and the relevant UK standards. Further design information is presented in Sub-chapter 10.7.4 of Chapter 10.

The Smoke Control System (DFL [SCS]), which includes the smoke exhaust system and over pressurised system, is provided to keep operational fire-fighting spaces acceptably clear of smoke. Smoke exhaust system is provided in the cabinet rooms with a risk of flashover or a risk of localised fire. An over pressurised system is provided in protected staircases and corridors to ensure positive pressure. The DFL [SCS] are designed in accordance with the relevant UK standards. Detailed design information is presented in Sub-chapter 10.7.5 of Chapter 10.

25.4.5 Gap Management

It has been recognised that design gaps may exist between the current UK HPR1000 design and the recommendation of UK legislations. It is therefore deemed appropriate to identify these gaps, and look to close them in line with RGP and the ALARP methodology.

The objective of gap management is to identify the gaps, determine and implement the appropriate fire safety options and demonstrate that the fire safety design for the UK HPR1000 meets the requirements of UK acts, regulations, codes and standards. If gaps exist, justification is provided to demonstrate that an equivalent level of fire safety will be provided.

At GDA step 3, the gap management methodology presented in Reference [43] is applied to identify and address the gaps in the Reactor Building, Fuel Building and Safeguard Buildings. The gap management process and gap assessment results are described in the following sub-chapters.

25.4.5.1 Gap Management Process

a) Gap Identification

The first step of gap management is to identify the gaps between the UK HPR1000 conventional fire safety design and the recommendations of BS 9999 through a holistic assessment. The building design is reviewed against a check list created from the guidance in BS 9999. Where an element of the current design does not meet the guidance and recommendations provided in BS 9999, a ‘gap’ is identified. The check list is presented in Appendix A of *Gap Management Report for Reactor Building*, Reference [44].

At this current stage of GDA, gaps in the Reactor Building, Fuel Building and Safeguard Buildings have been identified. The complete gap lists for the Reactor Building, Fuel Building and Safeguard Buildings are presented in Reference [44], [45] and [46], respectively.

b) Gap Grouping

After gap identification, the next step is to group the gaps identified. The grouping is based on the character and the influence of gaps. Those gaps which involve the same design aspect and may have similar potential options are grouped. For each group, the worst case is selected as the representation to be assessed. Typically, the gaps can be grouped into the following groups:

1) Excess of one-way travel distance;

2) Excess of two-way travel distance;

3) Inner-inner room condition;

4) Other specific cases, such as system design gaps.

The gaps identified in the Reactor Building, Fuel Building and Safeguard Buildings have been appropriately grouped. Grouping results of the gaps in these three buildings are detailed in Reference [44], [45] and [46], respectively.

c) Gap Assessment

The optioneering and decision making process is applied to assess and determine reasonably practicable options to close the gaps.

Information collection is the basis of gap assessment. For each gap, all relevant information is listed in a table to support the assessment, including plant layout, combustible distribution, fire-fighting systems design and occupancy characters. Both the information of original fire rooms and their escape route are collected.

To resolve the gaps, options of various types are considered, including layout modification, installation of additional fire protection measures and changes in the argument. For certain complex gaps, fire engineering analysis, presented in Reference [35], are applied to identify a range of fire engineering options which can achieve a similar level of safety and select the most appropriate option.

To comprehensively evaluate the impact of each option on various aspects, four evaluation criteria are considered: life safety, nuclear safety, cost and operation activity. The scoring and weighting multipliers are decided on a case-by-case basis by the fire safety team. The option with the highest score is selected. A comparison between the options is made to justify that the selected option is ALARP.

The assessment process for each gap group is detailed in Reference [44], [45] and [46].

25.4.5.2 Gap Assessment Results

Based on the assessment results for the Reactor Building, Fuel Building and Safeguard Buildings, most of the gaps can be addressed by a justification of the current design. The design justification takes all the favourable factors into account, such as high ceiling, local alarm and etc. Fire engineering approach is applied if necessary. The detailed information is presented in Reference [44], [45] and [46]. The weakness caused by these gaps can be compensated for by strengths in the following aspects:

a) Combustible material limitation, such as cable wrapping;

b) Personal training;

c) Access control;

d) Enhancement of fire detectors and fire alarm system design.

Design modification may be necessary for certain significant gaps. The modification options are determined according to the layout characteristics and the impact analysis. With the modification, the significant gaps can be eliminated to improve the level of life safety in a fire event.

T-25.4-3 presents the gaps which have been identified in the three main buildings. The optioneering work for the gaps mentioned in T-25.4-3 is complete. The detailed assessment is presented in Reference [44], [45] and [46]. The fire safety strategies of the Reactor Building, Fuel Building and Safeguard Buildings are developed by taking all the design modifications into account.

T-25.4-3 Gaps in Three Main Buildings

25.4.6 ALARP Demonstration

25.4.6.1 General Approach for the ALARP Demonstration

As present, in *ALARP Demonstration Report for Conventional Fire Safety*, Reference [47], the ALARP assessment includes identification of the gaps through a consistency review against RGP and a risk assessment for potential enhancement where necessary. In general, the ALARP assessment covers four steps:

a) Identification of RGP;

b) Consistency Review against RGP;

c) Potential Improvement Identification;

d) Risk Assessment for Potential Improvement.

25.4.6.2 RGP Identification

RGP in this context should comprise practices that have been approved for use in the nuclear reactor plant design by recognised authority bodies and are considered relevant and appropriate to the UK HPR1000 design.

As mentioned in Sub-chapter 25.4.1, the design should comply with the requirements of UK legislation. Complying with the conventional fire safety requirements of the UK legislation by following codes of practice or approved guidance is a way that demonstrates that a reasonable standard of fire safety is provided in its design and construction, and it provides a basis for reducing risks ALARP.

To conclude, the RGP considered in conventional fire safety area is listed in T-25.4-4.

T-25.4-4 Relevant Good Practice of Conventional Fire Safety Area

No.	Title	Version	Source
1	Building Regulations	2010	BUILDING AND BUILDINGS
2	Regulatory Reform (Fire Safety) Order	2005	REGULATORY REFORM
3	The Building Regulations – Fire Safety Approved Document B	2010	Secretary of State
4	BS 9999: Code of Practice for Fire Safety in The Design, Management and Use of Buildings	2017	British Standard Institution

No.	Title	Version	Source
5	BS 7974: Application of Fire Safety Engineering Principles to the Design of Buildings-Code of practice	2001	British Standard Institution
6	EPR Technical Code for Fire Protection	2010	AFCEN

25.4.6.3 Consistency Review against RGP

The consistency review is carried out to compare the UK HPR1000 design with the requirements from RGP. After the consistency review, the RGP that have been used are justified and confirmed where these have been applied in the UK HPR1000 design. Most of the requirements are considered in the conventional fire safety design of the UK HPR1000. Correspondent measures are taken to ensure that these requirements are met. Where there is non-compliance, the gaps are identified and assessed through the optioneering and decision making process to ensure that the design is ALARP. Detailed justification is provided in the gap management report for each building.

The consistency review result is detailed in *Compliance Analysis of Codes and Standards in Conventional Fire Safety*, Reference [48].

25.4.6.4 Potential Improvement Identification

Based on the conclusion of consistency review against RGPs, gaps or potential enhancements can be identified. As mentioned in Sub-chapter 25.4.5, at present, the gaps in the Reactor Building, Fuel Building and Safeguard Buildings have been identified and addressed. The potential improvements that have been identified are listed in T-25.4-3.

25.4.6.5 Risk Assessment for Potential Improvement

The purpose of risk assessment is to identify the design weakness, determine and implement the appropriate fire safety options. According to the results of the gap assessment for the Reactor Building, Fuel Building and Safeguard Buildings, the risks mainly come from the non-compliance of escape route design, including the long travel distance or the presence of inner-inner room. Since the plant layout is complex, these gaps are assessed on a case by case basis in Reference [44], [45] and [46].

The conventional fire safety assessment for these three buildings shows that the design of the UK HPR1000 can provide an equivalent level of conventional fire safety as required by the UK legislation despite the existing gaps. The residual risk of gaps has been reduced to ALARP through conservative justification, fire safety engineering analysis and design improvements.

25.5 Concluding Remarks

This chapter has provided information on the methodology of implementing the UK legislation, in particular *the Construction (Design and Management) Regulations 2015*, Reference [3], which requires the designer to eliminate, reduce, isolate or control health and safety risks ALARP. The health and safety design management arrangements in terms of how the UK HPR1000 GDA project intends to meet the relevant requirements of the UK health and safety legislation are detailed in the *UK HPR1000 Construction Design Management Strategy*, Reference [10]. The implementation of the management arrangements is being monitored to ensure their application and key people within the design teams are being provided with suitable knowledge to assist the design teams with their tasks in all stages and ensure that the UK HPR1000 complies with the UK health and safety legislation.

With the exception of gaps identified in T-25.4-1, the overall fire safety design of the UK HPR1000 complies with the recommendations of BS 9999 and provides an equivalent level of fire safety required by UK legislation. The gaps identified will be subject to an optioneering and decision making process during which further risk reduction methods will be assessed and risk reduction will be undertaken in line with the ALARP methodology.

It should be noted that design changes made during Step 3 have not been totally reflected in the present version of the Conventional Fire safety assessment reports due to the design development progress of the UK HPR1000. The relevant safety strategy reports of Conventional Fire Safety will be updated based on the latest version of UK HPR1000 design reference.

25.6 References

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