Revision	Approved by	Number of Pages
000		43
Approval Date	12/11/2018	

General Nuclear System Ltd.

UK HPR1000 GDA Project

Document Reference:	HPR/GDA/PCSR/0025

Title:

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

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MODIFICATION RECORD

Revision	Section	Page	Modification
000	ALL	ALL	First Issue

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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
ERIC	Eliminate, Reduce, Inform, Control
GDA	Generic Design Assessment
EDF E	EDF energy (UK)
GPP	General Principles of Prevention
GNS	General Nuclear System Limited
HSE	Health and Safety Executive (UK)
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
PCSR	Pre-Construction Safety Report
RGP	Relevant Good Practice
RRO	Regulatory Reform (Fire Safety) Order
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. Fire-fighting Water Production System (JAC [FWPS]).

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 Practice (UK) (ACoP), and guidance documents, 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 a specific element of the UK HPR1000 nuclear power plant during the lifecycle. Information is provided for aspects of the design that might impact on conventional health and safety during construction, commissioning, operation, maintenance, and decommissioning of the UK HPR1000 nuclear power plant, and for compliance with the general requirements of UK legislation, including *the Health and Safety at Work etc. Act 1974*, Reference [1], *the Construction (Design and Management) (CDM) Regulations 2015*, Reference [2], *the Control of Major Accident Hazards (COMAH) regulations*, Reference [3], *the Building Regulations 2010*, Reference [4] and *the Regulatory Reform (Fire Safety) Order (RRO) 2005*, Reference [5], etc.

Reducing risks, protecting people 2001, Reference [6] 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.

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 the ***Claim 4.2*** derived from the high level ***Claim 4***.

Claim 2*: The UK HPR1000 design will be developed in an evolutionary manner, using 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, Inform, 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.*

This chapter includes two areas: Conventional Health and Safety and Conventional Fire Safety.

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

a) ***Sub-claim 1****: The design of the UK HPR1000 is being developed to eliminate, reduce 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 nuclear power plant.*

   1) ***Argument 1.1****: 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 1.1.1****: The design teams are being provided with training covering the UK conventional health and safety acts, regulations, ACoPs, and guidance documents. The training and the skills, knowledge and experience assessment arrangements are described in the Construction Design Management Strategy document, Reference [7].*

   2) ***Argument 1.2****: Suitable design management arrangements with regard 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 CDM duty holders to help them deliver the outcome stated in the high level claim.*

      - ***Evidence 1.2.1:*** *The management arrangements with regard to conventional health and safety for this project are outlined in the Construction Design Management Strategy document, Reference [7].*

   3) ***Argument 1.3****: 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 1.3.1****: The monitor, inspection, audit and review arrangements of the management arrangements implementation are described in the Construction Design Management Strategy document, Reference [7].*

   4) ***Argument 1.4****: The information about the health and safety risks is provided*

and communicated to all relevant parties and the suitable and sufficient health and safety advice relative to the risk is provided to all relevant parties.

- ***Evidence 1.4.1:*** *The interface arrangements are in place, which are described in the Construction Design Management Strategy document, Reference [7].*

5) ***Argument 1.5****: Designers have complied with CDM 2015 Regulation 9 (Designers Duties) when they prepare the design of the UK HPR1000.*

- ***Evidence 1.5.1:*** *How the Designers comply with CDM 2015 Regulation 9 (Designers Duties) when they prepare the design of the UK HPR1000 is described in the Construction Design Management Strategy document, Reference [7].*

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

1) ***Argument 2.1****: the UK HPR1000 design follows the applicable UK codes and standards for fire safety.*

- ***Evidence 2.1.1****: The fire safety requirements of UK codes and standards are identified, see Sub-chapter 25.4.2.*

- ***Evidence 2.1.2****: The fire fighting strategy stated reflects the UK context requirements, see Sub-chapter 25.4.3.*

2) ***Argument 2.2****: In the UK HPR1000 design, where a departure occurs, a fire engineering approach or another legitimately equivalent method will be used to determine whether the risk is ALARP or not, if not the design will be modified.*

- ***Evidence 2.2.1:*** *Gaps from BS9999 will be identified and assessed through an effective methodology, see Sub-chapter 25.4.4.*

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 purpose and the scope of this chapter.

c) Sub-chapter 25.3 Conventional Health and Safety

This section lists the applicable acts, regulations, ACoPs, and guidance documents for conventional health and safety, outlines how the UK HPR1000 Generic Design Assessment (GDA) project intends to meet the relevant requirements for the UK conventional health and safety, and presents the COMAH assessment.

d) Sub-chapter 25.4 Conventional Fire Safety

This section lists the applicable codes and standards used in the conventional fire safety area, describes the requirements of conventional fire safety drawn from UK legislation and the fire safety strategy for the UK HPR1000 which complies with the requirements.

e) Sub-chapter 25.5 Concluding Remarks.

This section provides the concluding remarks

f) 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 evidence to support relevant high level claims that are presented in Chapter 1.
Chapter 4 General Safety and Design Principles	Chapter 4 provides the general principles for application of laws, regulations, codes and standards. Chapter 25 is compliant with them.
Chapter 9 Electric Power	Chapter 25 provides the conventional health and safety risk management techniques and general prevention principles in the electrical power area.
Chapter 10 Auxiliary Systems	Chapter 25 provides the conventional health and safety risk management techniques and general prevention principles in auxiliary systems.

PCSR Chapter	Interface
	Sub-chapter 10.7 of Chapter 10 provides information of fire protection system related to fire safety strategy in Chapter 25.
Chapter 15 Human Factors	Chapter 25 and Chapter 15 have an interface which assists with compliance 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 19 Internal Hazards	Chapter 25 provides the general personnel safety protection measures against toxic and corrosive substances hazard. 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.
Chapter 20 MSQA and Safety Case Management	The organisational arrangements and quality assurance arrangements for Management of Safety and Quality Assurance (MSQA) set out in Chapter 20 are implemented in the design process and in the production of Chapter 25.
Chapter 21 Reactor Chemistry	Chapter 25 provides the hazardous substances and explosive hazard management techniques and general prevention measures in reactor chemistry area.
Chapter 24 Decommissioning	Chapter 25 provides the conventional health and safety risk management techniques and general prevention principles during the decommissioning stage.
Chapter 28 Fuel Route and Storage	Chapter 25 provides the conventional health and safety risk management techniques and the general prevention principles in the fuel handling and

PCSR Chapter	Interface
	storage area.
Chapter 30 Commissioning	Chapter 25 provides the conventional health and safety risk management techniques and general prevention principles during the commissioning stage.
Chapter 33 ALARP Evaluation	Chapter 25 demonstrates that the conventional health and safety risks and fire safety risks are ALARP, which supports the overall ALARP demonstration addressed in Chapter 33.

The table above lists the interfaces between Chapter 25 and other chapters, but it is understood that the requirement to use the GPP to eliminate, reduce or control the conventional health and safety risks cuts across all areas and all stages of the UK HPR1000 design.

25.3 Conventional Health and Safety

25.3.1 Applicable Acts, Regulations, ACoPs, and Guidance Documents

The general principles for identification of the applicable acts, regulations, ACoPs, and guidance documents to conventional health and safety are described in Chapter 4 and *General Principles for Application of Laws, Regulations, Codes and Standards*, Reference [8].

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

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

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

No.	Standard No.	Title	Date Issued	Topic
5	SI 2015 No. 51	The Construction (Design and Management) Regulations 2015	2015	CDM
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

No.	Standard No.	Title	Date Issued	Topic
23	SI 1992 No. 2966	The Personal Protective Equipment at Work Regulations 1992	1992	Personal Protective Equipment
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	The Supply of Machinery (Safety) (Amendment)	2011	Machinery

No.	Standard No.	Title	Date Issued	Topic
	No. 2157	Regulations 2011		
41	SI 1996 No. 1656	The Work in Compressed Air Regulations 1996	1996	Pressure
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

No.	Standard No.	Title	Date Issued	Topic
58	HSG268	The health and safety toolbox: How to control risks at work	2014	General
59	HSG 274	Legionnaires' disease: Technical guidance Part1: The control of legionella bacteria in evaporative cooling systems	2013	Microbiological Hazards
60	HSG 274	Legionnaires' disease Part 2: The control of legionella bacteria in hot and cold water systems	2014	Microbiological Hazards
61	HSG 274	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

Note: Entries 20 and 21 in table T-25.3-1 are not relevant to the UK HPR1000 project. The use of asbestos and lead paint is not permitted.

The list of acts, regulations, ACoPs, and guidance documents 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 documents for conventional health and safety.

25.3.2 Implementation of UK Legislation

The applicable UK acts, regulations, ACoPs and guidance documents for conventional health and safety are used during the GDA stage 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 CDM Regulations 2015. 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 stage. 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* document, Reference [7].

The implementation of the management arrangements is being monitored, inspected, audited and reviewed to verify 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, 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.

Topic reports for health risk, work at height, lifting operation and confined spaces provide evidences to demonstrate that the conventional health and safety risk management process 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.

25.3.2.1 Organisation for the Project

The UK HPR1000 GDA is being carried out by General Nuclear System (GNS) on behalf of its shareholders China General Nuclear Power Corporation (CGN) and EDF energy (UK) (EDF E). GNS 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 [9], and *the CDM Regulations 2015*, Reference [2], there is a fundamental responsibility on duty holders to eliminate, reduce or control conventional health and safety risk, so far as is reasonably practicable.

The CDM duty holders, relevant to the GDA stage, are the Client, the Principal Designer and the Designer, Reference [2]. The arrangements to comply with the CDM regulations relevant to the GDA stage are outlined in the *UK HPR1000 Construction Design Management Strategy* document, Reference [7].

a) Client

GNS enacts the client duty holder role during the UK HPR1000 GDA stage. 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 carry out their duties;

5) Welfare facilities are provided;

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

b) Principal Designer

GNS enacts the Principal Designer duty holder role during the UK HPR1000 GDA stage. 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 designers carry out their duties.

c) Designer

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

1) Construction and commissioning;

2) Operation and maintenance ;

3) Decommissioning of the nuclear power plant.

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 stage of this project.

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

The overview of the arrangements describing how GNS, CGN and EDF E enact the Client, Principal Designer and Designer role is described in Reference [7].

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 is assessing the skills, knowledge and experience of the organisations and individuals that are appointed on the UK HPR1000 project through the process described in Reference [7].

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 secures health and safety. Records of training are required to be kept.

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 as follows:

a) The UK acts, regulation, ACoPs and guidance documents are noted 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, 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.

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

25.3.2.4 Conventional Health and Safety Risks Identification

The design risk management 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 activity or element of the design which has the potential to arise 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 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* document, Reference [7].

The conventional health and safety risks of the UK HPR1000 nuclear power plant are likely to include high temperature and high pressure, fire and explosions, hazardous substances, noise, vibration, electrical hazards, mechanical hazards, work at height, vehicle movement, drowning, lifting operation, manual handling, microbiological hazards, and 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 risk, so far as is reasonably practicable.

a) GPP

The GPP are as follows, Reference [10]:

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) Inform (provide information on remaining risks in a systematic way);

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 reviews 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 document, Reference [7].

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.

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 [11].

The microbiological hazards are being considered to comply with *the Control of Substances Hazardous to Health Regulations*, Reference [12], *the REACH Enforcement Regulations*, Reference [13], *Approved Code of Practice and guidance on Legionnaires' disease*, Reference [14], and the guidance on control of Legionnaires' disease, Reference [15], [16], [17] at the design stages.

There are more detailed but potentially significant requirements at later stages in the design, such as the health and safety requirements with respect to people movement, for segregation of pedestrians and traffic, and for the avoidance of slips, trips and falls, as well as 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 as follows:

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) and 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 [18], 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 as follows:

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 use of correctly 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 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, 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, ceiling and floors of workplaces which need to use hazardous compounds, use materials and coatings to provide corrosion resistance, and are non-absorbent.

c) Electrical hazards

The applied hazard prevention measures for electrical hazards are as follows:

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, temperature or pressure, wet, dusty or corrosive conditions, 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 voltage and low 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.

d) Mechanical hazards

The applied hazard prevention measures for mechanical hazards are as follows:

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 for 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 suitable maintenance, testing and inspection programmes to ensure mechanical reliability is maintained;

5) Set fixed barriers and warning signs;

6) All plant systems are being 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 conditions, 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, ensuring that all personnel, operators and others are protected from revolving / moving parts, ensuring appropriate guards, interlocks and alarms are designed;

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.

e) Work at height

The applied hazard prevention measures for work at height are as follows:

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 in 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, and through 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 (for maintenance, etc.), 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 as follows:

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 specify 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 as follows:

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 as follows:

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 as follows:

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 all kinds of 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 [19].

j) Confined spaces

According to *the Confined Spaces Regulations*, Reference [20], 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 the nuclear power plant include closed containers, trenches, basements, underground warehouses, sub-drains, tunnels, sumps and galleries. The applied hazard prevention measures for confined spaces are as follows:

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, enable use of temporary ventilation if not practicable;

11) The additional requirements of *the Confined Spaces Regulations*, Reference [20] 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 as follows:

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 or 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, and 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 COMAH 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 [3]. The COMAH 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;

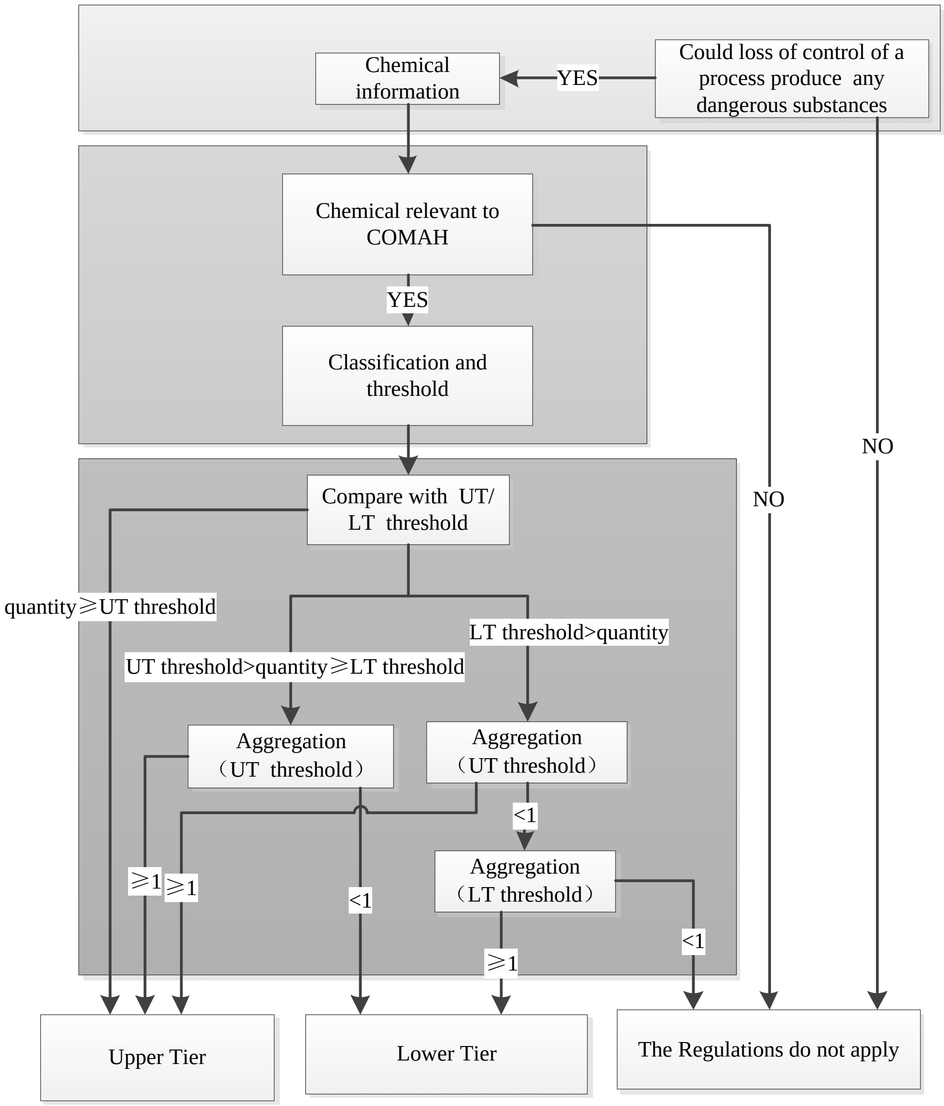
b) If the quantity of a dangerous substance onsite is more than the UT threshold, the site is classified as an UT COMAH establishment.

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 nuclear power plant safely and efficiently. The quantities of chemicals presented at the UK HPR1000 site is described in the *Chemical Inventory for UK HPR1000*, Reference [21]. At the GDA stage, 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 site specific stage, 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. It is therefore difficult to present the storage capacity accuracy for each chemical substance during the GDA stage. Information provided in Reference [21] 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 [22] includes the following steps:

a) Collect information on chemicals likely 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 [23], then determine the threshold of each dangerous substance according to the Schedule 1 of *the COMAH regulations 2015* in Reference [3];

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 COMAH regulations 2015* in Reference [3].

   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 [3], 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 [3], 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 [3]):

1) Health hazards - dangerous substances falling within section H, entries H1 to H3 in Part 1of Schedule 1 of the COMAH regulations 2015 in Reference [3].

2) Physical hazards - dangerous substances falling within section P, entries P1 to P8 in Part 1of Schedule 1 of the COMAH Regulations 2015 in Reference [3].

3) Environmental hazards - dangerous substances falling within section E, entries E1 and E2 in Part 1of Schedule 1 of the COMAH regulations 2015 in Reference [3].

Aggregation is applied using the following formula:

$q_1/Q_{U1} + q_2/Q_{U2} + q_3/Q_{U3} + q4/Q_{U4} + q_5/Q_{U5} + \ldots$

- 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 the COMAH Regulations 2015 in Reference [3], and

- 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 COMAH Regulations 2015 in Reference [3].

- If the sum of the health hazards, physical hazards, or environmental hazards is equal to or in excess of 1, 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 shall demonstrate that an adequate safety management system is in place to prevent major accidents. The competent authority shall be sent a notification, including the name of the operator, the full address of the establishment, the registered place of business, the name and position of the person in charge of the establishment, sufficient information to identify the dangerous substances or category of dangerous substances involved or likely to be present, the quantity and physical form of the dangerous substances involved or likely to be present, and 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 [3].

The findings of the COMAH assessment are described in *COMAH Assessment for UK HPR1000*, Reference [24]. The quantity of hydrazine present in the UK HPR 1000 is to be 1.14 tonnes, which is above the LT threshold of 0.5 tonnes, but does not exceed the UT threshold of 2 tonnes. Then the aggregation rule is applied to confirm whether the UK HPR1000 is likely to be an UT establishment. If the sum for the health hazards, or the physical hazards, or the environmental hazards is equal to or in excess of 1, the UK HPR 1000 is classified as an UT establishment, if not, it is a LT establishment. As none of the sum is equal to or greater than 1, therefore, the UK HPR1000 is a LT establishment.

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, RGP in the conventional health and safety area has been sufficiently identified.

Reducing risks, protecting people 2001, Reference [6] 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 Construction Design Management Strategy* document, Reference [7]. Reference [7] outlines how the UK HPR1000 GDA project intends to meet the relevant requirements of the CDM Regulations 2015. The design risk management methodology is being used during the UK HPR1000 design process to eliminate, reduce or control conventional health and safety risks 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 and Regulatory Reform (Fire Safety) Order (RRO)* which presents the general requirements for conventional fire safety.

Nuclear power plants are also required to comply with these UK legislations where practicable, although due to their own inherent characteristics (large and complex), gaps may still exit. As a result, *The Building Regulations* and RRO are considered as benchmarks of design assessment, and protection of human life shall align with their objectives.

In the UK, there are two main guidance documents, *Approved Document B (ADB)* and *BS9999: Code of Practice for Fire Safety in the Design, Management and Use of Buildings*, which both provide guidance for meeting UK expectations for 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 fire safety requirements. However, ADB is not suitable for complex buildings. 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. BS9999 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 a Nuclear Site.

BS9999 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 may be used to compensate and justify the condition. BS9999 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 to BS9999 and guidance is provided in BS7974 as a structured approach to fire safety engineering.

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

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

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.

25.4.2 General Requirements

25.4.2.1 Management Requirements

The high standard of fire safety management will contribute to the reduction of risk associated with fire. According to the requirements in RRO and the assessment method for risk profile in BS9999, the management requirements are as follows:

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 the facility.

25.4.2.2 Design Requirements

As previously discussed, the application of BS9999 is considered to be an applicable method of meeting *The Building Regulations* and RRO. Therefore, the functional requirements of the BS9999 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.

25.4.2.2.1 Fire Alarm and Warning

The buildings should be designed and constructed so that there are appropriate provisions for the early warning of fire, Reference [4].

Automatic fire alarm and detection systems do not provide any degree of fire containment. However such systems, in addition to giving an alarm, can be used to initiate such functions as, Reference [25]:

a) Closing down ventilation and air conditioning plant;

b) Operating fire suppression and/or smoke control systems;

c) Releasing passive fire protection equipment;

d) Activating ventilation systems.

25.4.2.2.2 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 [4].

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 [25].

According to BS9999, 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.

25.4.2.2.3 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 [4].

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 [25].

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 [4]:

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

b) Installation of suitable automatic fire suppression systems.

25.4.2.2.4 External Fire Spread

According to Reference [4], 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.

25.4.2.2.5 Access and Facility for Fire-fighting

Reasonable provisions should be made to enable fire services to gain access to the buildings, and buildings must be constructed to provide reasonable facilities to assist fire fighters in the protection of human life, Reference [4].

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 environmental damage, Reference [25]:

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.

25.4.3 Fire Safety Strategy

Following the recommendations of BS 9999 is an acceptable way to meet the functional requirements in *The Building Regulation* and RRO. As a code of practice, BS9999 contains elements of good fire safety practice and provides a more advanced approach. BS9999 is widely applied in other GDA projects.

Prior to commencing the fire and protection of human life review, following BS9999, consideration must be given to fire prevention and risk reduction. Therefore, Sub-chapter 25.4.3.1 presents the considerations for fire safety management, and Sub-chapter 25.4.3.2 includes the measures or designs for meeting the requirements of

BS9999 based on the fire risk assessment level in Sub-chapter 25.4.3.1.

25.4.3.1 Fire Safety Management

Due to the importance of fire safety throughout the lifetime of a nuclear power plant, a strict fire safety management strategy is necessary. In UK HPR1000 design, there are lots of specific criteria and examples of good practice relating to the requirements mentioned in Sub-chapter 25.4.2.1:

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 operate 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.

25.4.3.2 Fire Safety Design

The following Sub-chapters describe the fire safety design to satisfy the requirements mentioned in Sub-chapter 25.4.2.2, the detailed information is shown in the High Level Fire Safety Strategy, Reference [26].

25.4.3.2.1 Fire Alarm and Warning

The Fire Alarm System (JDT [FAS]) can continuously monitor the plant through use of fire detectors placed in appropriate locations of the plant. The system can quickly detect fire, automatically alarm, provide the location of the fire and monitor the development of a fire. The JDT [FAS] can initiate automatic actions when necessary. The JDT [FAS] is designed in accordance with the relevant UK standards. Further design information is presented in Sub-chapter 10.7.3 of Chapter 10.

25.4.3.2.2 Means of Escape

a) The distance an occupant must travel before reaching a fire escape route is within the permissible limits;

b) The number and width of required escape routes depends on the size of the workforce involved (outside the construction period). This workforce is divided by floor in order to determine the size of the crowd moving towards the exits from the furthest points. Additionally, the protected escape routes consider the emergency requirements for the use of fire extinguishers, stretchers, etc.;

c) The escape routes lead to the outside or protected escape routes;

d) Along the escape routes, the doors remain functional even in the event of loss of power and controlled facilities, such as the turnstiles, can be operated during evacuation;

e) Rooms containing more than 60 persons have a second exit opposite to the first one, directly, or through other rooms, to a protected rescue route;

f) Evacuation doors are easy to open and, if practicable, will be designed to open in the direction required to aid emergency services access (i.e. in the same direction of travel). An exception may be made for doors used by rooms with less than 60 persons.

25.4.3.2.3 Internal Fire Spread

a) The internal linings of the structure limit the propagation of fire, where applicable;

b) The buildings are divided into different fire compartments based on the principles of ETC-F 2010, the compartment boundaries, i.e. walls and floors, have an appropriate level of fire resistance, suitable for their function;

c) Fire resistant wall and floor junctions are adequately sealed in order to maintain their fire resistance;

d) Services penetrations (ducts, cable trays, holes, etc.) through fire boundaries are sealed using appropriate methods to suit the level of fire resistance of the boundaries 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 performance of the structure is evaluated according to the following criteria, Reference [27]:

a) R - Loadbearing capacity: the ability of the construction element to withstand fire exposure under specified mechanical actions, on one or more faces, for a period of time, without any loss of structural stability;

b) E - Integrity: the ability of the construction element with a separation function, to withstand fire exposure on one side only, without the transmission of fire to the unexposed side as a result of the passage of flames or hot gases;

c) I - Thermal Insulation: the ability of the construction element to withstand fire exposure on one side, without the transmission of fire as a result of significant transfer of heat from the exposed side to the unexposed side.

25.4.3.2.4 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.

25.4.3.2.5 Access and Facilities for Fire-fighting

a) Adequate access to a building is provided through an external entry point. Protected escape routes are used as fire-fighting shafts, including fire-fighting stairwells and fire-fighting lobbies provided with a fire main. The boundaries of fire-fighting shafts will have sufficient fire resistance;

b) 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 the relevant UK standards. Further design information of is presented in Sub-chapter 10.7.4 of Chapter 10;

c) 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. 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;

d) The fixed fire-fighting systems are installed for the rooms presenting a flashover risk according to fire hazard analysis. The fixed fire-fighting systems are designed in accordance with the relevant UK standards. Detailed design information is presented in Sub-chapter 10.7.4 of Chapter 10.

25.4.4 Gap Management

It has been recognised that design gaps may exist between the current UK HPR1000 design and the requirements 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 UK HPR1000 meets the requirements of UK acts, regulations, codes and standards. If gaps exist, justification is provided to demonstrate that the requirements of fire safety can still be met.

Gaps between the current design and the recommendations of BS9999 are identified through an overall design review. The gaps identified will be assessed and subject to the optioneering and decision-making process during GDA Step 3 and Step 4.

25.4.5 ALARP Assessment

As mentioned in above, conventional fire safety requirements from UK legislation have been sufficiently identified, and BS9999 is used as the design guidance and applied in UK HPR1000 conventional fire safety design where practicable.

Priority is given to building arrangement to provide appropriate means of escape. For the UK HPR1000, buildings are appropriately divided into different fire compartments with a sufficient fire resistance. This provides relative safety areas and aids evacuation. Fire safety management and other mitigation measures also contribute to reducing the risk of fire.

Where compliance with BS9999 is not practicable, systematic gap management will be carried out to provide a robust ALARP solution. Appropriate options will be selected to minimise or eliminate gaps and reduce risk to ALARP.

A series of fire safety strategies for each building will be developed to present the detailed design and demonstrate that the risk is ALARP.

25.5 Concluding Remarks

This chapter has provided information on the methodology of implementing UK legislation, in particular the CDM Regulations 2015 which require the designer to eliminate, reduce 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 Construction Design Management Strategy document, Reference [2]. 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 to ensure the UK HPR1000 complies with the UK health and safety legislation.

As mentioned in Sub-chapter 25.4.3, the overall fire safety design of UK HPR1000 complies with the recommendations of BS9999 and provides an equivalent level of fire safety required by UK legislation.

25.6 References

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