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HITACHI

UK ABWR

Document ID	:	GA10-9101-0101-10000
Document Number	:	LE-GD-0035
Revision Number	:	A

UK ABWR Generic Design Assessment

Generic PCSR Chapter 10 : Civil Works and Structures

Hitachi-GE Nuclear Energy, Ltd.

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10.1 Introduction

This section provides the safety requirements and the design principles of the UK ABWR civil structures within the GDA scope.

In order to ensure that UK ABWR is safe under the all operating and fault conditions, the UK ABWR civil structures shall be designed to fulfil the following safety functions:

a. For Normal Operating Condition;

- To support SSCs for the normal operating loads
- To maintain environment appropriate for SSCs inside the structures
- To contain radioactive material to limit release to the external environment
- To shield from radiation to lower the level

b. For Fault Conditions

- To support SSCs, which deliver safety functions, for Design Basis (DB) loads
- To maintain environment appropriate for SSCs, which deliver safety function within the structure, for DB condition
- To contain radioactive material to limit release to the external environment.
- To protect SSCs, which deliver safety functions, from design basis natural phenomena and external hazards
- To protect SSCs, which deliver safety functions, from design basis condition by internal hazards, including the effects of fire, missiles, pipe whipping and discharging fluids, etc.
- To protect SSCs, which deliver safety functions, from propagation effect of structural collapse

The UK ABWR civil structures are designed according to the safety function categorisation, the classification of the SSCs and the seismic categorisation based on the SSCs housed in the structure. The following requirements are incorporated in the civil structures design;

- Appropriate design codes and standards
- Site environmental conditions stated in the Chapter 2 “Generic Site Envelope” of this PCSR
- Appropriate design conditions and loading for the required safety functions
- The Categorisation of Safety Functions, the Classification of SSCs and the Seismic Categorisation for earthquake events are stated in PCSR Chapter 5.4.

Conditions during construction and decommissioning, and CDM regulations are also considered appropriately in the design.

The safety requirements and the design principles for the scope of the civil structures in GDA are described in the following sections.

10.2 Scope of Structures

This section provides the scope of UK ABWR civil structures to be assessed in the GDA process.

The safety class 1 and 2 structures or Seismic Category 1 and 1A structures of which design is predominantly independent of the site specific conditions have been chosen as the civil structures to be assessed in the GDA process, which are as follows;

- Reactor Building (R/B)
- Reinforced Concrete Containment Vessel (RCCV)
- Control Building (C/B)
- Heat Exchanger Building (Hx/B)
- Turbine Building (T/B)
- Radwaste Building (Rw/B)
- Backup Building (B/B) and B/B tunnel
- Main Stack
- Light Oil Storage Vault and Tunnel
- CST Basement and Tunnel
- RCW tunnel

Refer to the Chapter 9.2.1 of this PCSR for the generic site layout of these structures.

10.3 Safety Requirements and Design Principles on Civil Structures

This section provides the safety requirements and the design principles on each civil structure listed in Section 10.2.

10.3.1 Safety Requirements and Design Principles on Reactor Building

10.3.1.1 Safety Requirements

This section provides the safety class, seismic category and safety functions of the Reactor Building as its safety requirements.

10.3.1.1.1 Safety Categorization of Civil Structures

The UK ABWR civil structures such as Reactor Building and Control Building provide a part of or whole of the safety functions below;

- To contain radioactive material to limit a potential release to the environment
- To shield radiation to an acceptable level
- To house SSCs to mitigate natural phenomena and external hazard
- To separate SSCs to protect them from internal hazard from other compartments
- To support SSCs to maintain those functions when those functions are required

Each civil structure can be categorized and classified into Category A, B or C and Class 1, 2 or 3 by their safety functions and contribution to the nuclear safety. The Chapter 5.4 of this PCSR "Categorization / Classification of SSCs" describes relations of safety categories, classes and safety functions.

The first function (to contain radioactive material to limit a potential release to the environment) directly delivers its safety function. The second function is part of ALARP to reduce plant personnel exposure. The other functions indirectly maintain functions in related SSCs.

Safety Classes related to the first four safety functions depend on the Class of SSCs which are housed in a structure. The Safety Class of a structure is Class 2, when its safety function is Safety Category B and the structure is one of the principal provisions to deliver the function. The Safety Class of a structure is Class 1, when its safety function is Safety Category A and part of the

structure principally delivers this function. According to the categorisation concept above, the R/B is a Safety Category A, Safety Class 1 structure.

10.3.1.1.2 Seismic Categorisation

The R/B is classified as Seismic Category 1. Refer to Chapter 5.4.5 of this PCSR for seismic categorisation.

10.3.1.1.3 Safety Function of the Reactor Building

The Reactor Building houses Safety Class 1 SSCs, including Reactor, Primary Containment Vessel, ECCS and other supporting systems. Furthermore, the R/B has a safety function as the secondary containment and shielding function for site boundary radiation level and operating personnel exposure. Safety functions of the UK ABWR R/B are shown below;

a. Normal Operating Conditions

- To support SSCs for the normal operating loads.
- To maintain environment appropriate for SSCs inside the R/B.
- To contain radioactive material to limit a potential release to the environment.
- To shield radiation to an acceptable level.

b. Fault Conditions

- To support SSCs, which deliver safety functions, for Design Basis (DB) loads.
- To maintain environment appropriate for SSCs, which deliver safety function within the R/B, for DB condition.
- To contain radioactive material to limit a potential release to the environment: The R/B potentially contains released radioactive material with the effect of Stand-by Gas Treatment System (SGTS) for the DB condition.
- To protect SSCs, which deliver safety functions, from design base natural phenomena and external hazards.
- To protect SSCs, which deliver safety functions, from design base condition by internal hazards, including the effects of fire, missiles, pipe whipping and discharging fluids etc.

10.3.1.2 Design Principles

This section provides the structural form and the design requirements of the Reactor Building as its design principles.

10.3.1.2.1 Structural Form

The R/B is constructed of reinforced concrete and structural steel with a steel frame and reinforced concrete roof. The R/B has four stories above the ground level and three stories below. The R/B encloses the Primary Containment Vessel. The secondary containment, together with the clean zone, comprises the R/B. It completely surrounds the containment (RCCV) except for the basement. The R/B and the secondary containment share structural walls and slabs. The R/B slabs and fuel pool girders are constructed monolithically with the RCCV. The R/B, together with the RCCV and the RPV pedestal, are supported by a common basement.

The R/B is a 63.0 m x 61.0 m reinforced concrete structure that is 42.6 m high above grade. The total building embedment is 25.7 m. The basement is 5.5 m thick. The exterior walls have enough thickness to protect the structure against the external hazards. The roof slab is also thick and consists of an arch structure. A series of arched steel frames are installed to support the roof structure. The steel frames are supported by columns above the operating floor. The R/B has six reinforced concrete floors which are monolithically connected to the primary containment. The operating floor at elevation FL 19.4 m is connected to the fuel pool girders which are supported by the primary containment and the R/B. Inside the R/B, there are 18 columns supporting the floors.

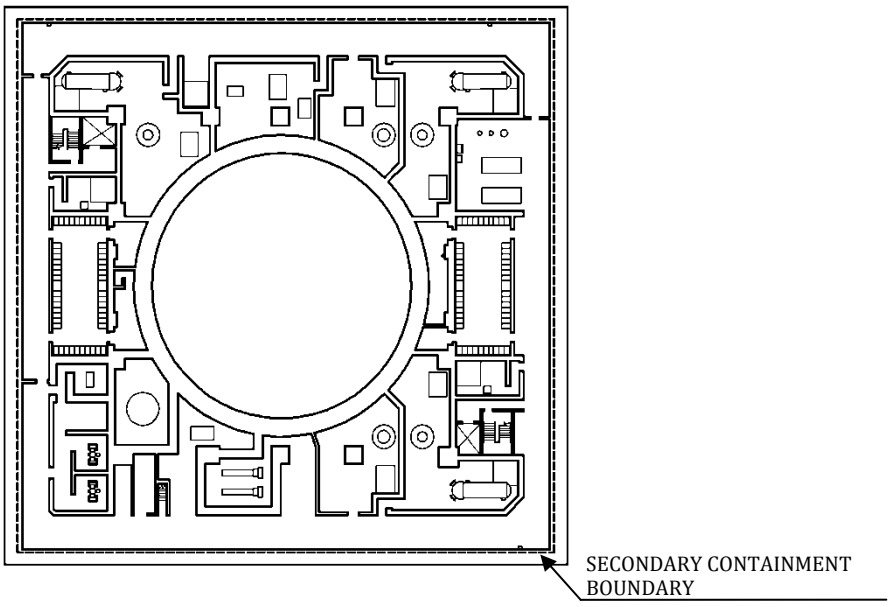

Figure 10.3-1: Plan Bottom Floor, R/B

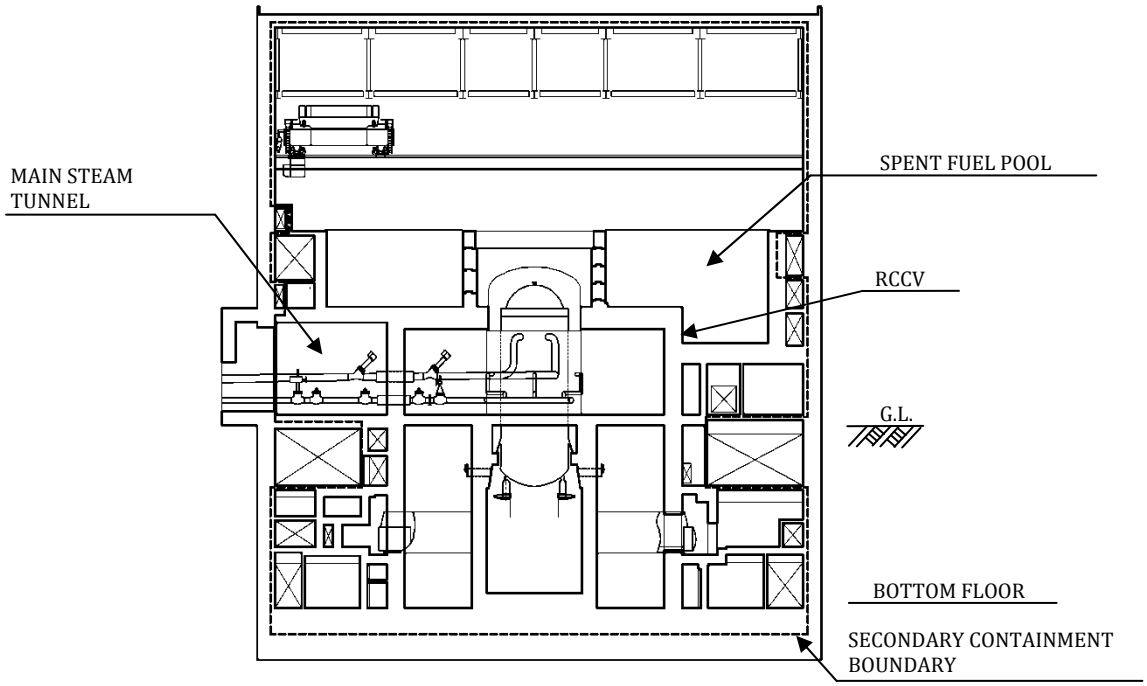

Figure 10.3-2: Section, R/B

10.3.1.2.2 Design Requirements of Normal Operating Conditions

In order to meet the safety functions for the normal operating as conditions described in 10.3.1.1.3, the following design requirements are incorporated in the R/B design;

- Support Function

  To support the SSCs for the normal operating loads, the R/B is designed with the following loading conditions.

  - Dead loads
  - Live loads
  - Temperature effects / loads
  - Equipment loads
  - Dynamic and static piping loads
  - Disassembled parts loads at the operating deck
  - Disassembled parts loads at unloading pathways
  - Building crane with lifting loads
  - Pool water loads
  - Monorail and lifting loads
  - Vibration effect of heavy pumps and motors
  - Temporary loadings during construction and decommissioning

- Environmental Condition

  To maintain environment and atmosphere appropriate for SSCs inside the R/B, the R/B avoids effects from winds, precipitation, snow, and ingress of groundwater by the exterior walls and slabs, and maintains temperature and humidity as comfortable conditions together with the HVAC system. The lightning protection system avoids adverse effects to the SSCs inside the building from lightning strike.

- Limiting Release

  To contain radioactive material to limit a potential release to the external environment during a normal operating condition, the R/B provides air-tight boundaries by concrete walls and slabs which provide the secondary containment. The HVAC system maintains inside of the secondary containment at negative pressure.

- Shielding

  To shield radiation to lower the level, the R/B provides shielding by concrete walls and slabs. The shielding walls and slabs are arranged around higher radiation areas to reduce worker's exposure. The external walls and slabs provide shielding to reduce dose rate at the site boundary.

10.3.1.2.3 Design Requirements of Fault Conditions

In order to meet the safety functions for the fault conditions as described in Section 10.3.1.1.3, the following design requirements are incorporated in the R/B design;

- Support Function

  To support SSCs, which deliver safety functions, for Design Basis loads, the R/B is designed as Seismic Class 1 building and meets the Design Basis Earthquake requirements.

- Environmental Condition

  To maintain environment and atmosphere appropriate for SSCs inside the R/B, which deliver safety functions, the R/B avoids effects from winds, precipitation, snow, and ingress of groundwater by the exterior walls and slabs, and maintains temperature and humidity as comfortable conditions together with the HVAC system. The lightning protection system avoids adverse effects to the SSCs inside the building from lightning strike.

- External Hazards

  To protect SSCs which deliver safety functions from design base natural phenomena and external hazard, the R/B provides massive exterior walls, slabs and roof to protect SSCs inside the building. The walls, slabs and roof shall resist structural failure against the design base events. As noted in PCSR Chapter 6 (External Hazards), the postulated external hazards that impose design basis requirements on the civil structures are listed below;

  a. Air temperature
  b. Wind (include tornado wind)
  c. Rainfall and Ice
  d. Snow
  e. External flooding (include climate change)
  f. Seismic Activity
  g. Aircraft Impact (accident and intentional)

h. External Fire
i. External Missiles (include tornado generated missiles)
j. External Explosion

The walls, slabs and roof are designed to provide coutermeasures against an aircraft impact to prevent or mitigate their physical impact and fire and vibration effect.

- Internal Hazards

To protect SSCs which deliver safety functions from design base internal hazards, the R/B provides divisional separation barriers between the safety trains by concrete walls and slabs. These separations shall prevent damage from one division propagating to another safety division during a fault condition. The divisional separation barriers can maintain their structural integrity against a postulated internal hazard. As noted in PCSR Chapter 7 (Internal Hazards), the postulated internal hazards that impose design basis requirements on the civil structures are listed below;

a. Internal Fire
b. Internal Flooding
c. Pipe Whip and Jet Impact
d. Dropped Load
e. Internal Missiles
f. Internal Explosion
g. Consequential Events

- Limiting Release

To contain radioactive material to limit release to the external environment during a fault condition, the R/B provides air-tight boundaries as the secondary containment by using concrete walls and slabs to maintain negative pressure together with the SGTS system during postulated accidental conditions.

The assessment of external and internal hazards is presented in Chapter 6 and 7 of this PCSR.

10.3.2 Safety Requirements and Design Principles on RCCV

The RCCV is treated as a single system and the strategy for dealing with the RCCV is as noted below.

The RCCV is divided into three main sections which are covered by the following principal design standards;

- Reinforced Concrete (RC) and Liner : ASME B&PV Code Section III, Division 2
- Metal Containment (MC) components : ASME B&PV Code Section III, Division 1

  Where, the MC components are the Drywell Head, Equipment Hatch, Personnel Airlock and Suppression Chamber (S/C) Hatch of Figure 10.3-3:.
- Internal Structures : ANSI/AISC N690

  (ASME B&PV Code Section III, Division 2 is applied to Diaphragm Floor.)

  Where, the Internal Structures are the Reactor Pressure Vessel (RPV) Pedestal, Diaphragm Floor (D/F) and Access Tunnel of Figure 10.3-3:.

These three main sections are fully described in this chapter and the Chapter 13 (Engineered Safety Features) describes the Engineering Safety for the whole RCCV System.

Because the RCCV is connected to the reactor building and the internal structures, the RCCV is evaluated by using the analysis model that integrated them including the RCCV Liner in the structural evaluation. Results of the analysis model are used for not only the evaluation of the RCCV, but also the evaluation of the RCCV Liner, Internal Structures and so on. The coherent evaluation of the RCCV and Internal Structures can be done by such an evaluation way.

10.3.2.1 Safety Requirements

This section provides the safety requirements of the RCCV.

10.3.2.1.1 Safety Class of Structures

The RCCV is classified as a Safety Class 1, Safety Category A structure.

10.3.2.1.2 Seismic Categorisation

The RCCV is classified as Seismic Category 1.

10.3.2.1.3 Safety Function of the RCCV

The RCCV is part of the Primary Containment around the Reactor Pressure Vessel (RPV). The RCCV constitutes a part of the R/B and is connected with the floor of the R/B. The RCCV consists of a steel liner inside the concrete and metal components such as the Drywell Head and penetrations.

The RCCV, which is a pressure suppression type, consists of a Drywell (D/W) that contains nuclear reactor primary system; a S/C that stores water; a vent pipe that connects the D/W and S/C; and a Vacuum Breaker (VB).

The D/W is a release space for coolant of the nuclear reactor in an accident condition where the primary piping may break. The D/W then has a function to act as a leaktight barrier against accidentally released radioactive material.

The pool water of the S/C is able to condense the released steam to suppress the pressure. The space in the S/C stores non-condensing gas coming from the D/W, to suppress the excessive pressure rise if a Loss of Coolant Accident (LOCA) condition occurs.

Vent pipes serve as the route for the mixture of coolant and non-condensing gas released to the D/W into the pool water of the S/C.

VB connects the S/C and D/W to maintain the integrity of the RCCV, by eliminating the negative pressure when the D/W pressure is decreased due to overflow stream caused by injection water in emergency core cooling system (ECCS) or due to water spray in the Primary Containment Vessel. The RCCV is designed so that the following major functions are achieved:

- To maintain integrity against pressure and temperature which may arise from the maximum assumed energy release if LOCA occurs.
- To endure the dynamic loads expected to be exerted on the S/C in abnormal transient conditions or if LOCA occurs.
- To endure the pressure rise and temperature rise due to decay heat of the core if LOCA occurs and where heat could be generated by a reaction between water and metal.
- To act as a leaktight barrier against the leakage of FP released if LOCA occurs.
- To provide a structure that resists the jet force exerted on the RCCV if a LOCA occurs.
- The RCCV is designed to guard against the possible generation (internal hazards) of missiles.

- The structure is designed so that the integrity of the RCCV is not impaired, by providing the suitable restraints against pipe whip if LOCA occurs.

10.3.2.2 Design Principles

This section provides the design principles of the RCCV

10.3.2.2.1 Structural Form

The primary containment of the UK ABWR is a RCCV with an internal steel liner and MC components (Drywell Head and so on). The RCCV is integrated with the reinforced concrete R/B. The structure includes various penetrations, Equipment Hatches and Personnel Airlocks. This containment provides an essentially leaktight barrier against the uncontrolled release of radioactivity to the environment. The internal structures of the containment provide equipment support, radiation protection, and components for operation of the ABWR pressure suppression containment.

The conceptual arrangement of the containment systems is shown in Figure 10.3-3:. The inside diameter of the RCCV is 29m, and the height from the upper surface of the foundation to the upper surface of the drywell head is 36m.

Stainless steel is used to provide corrosion protection on the normally wetted portion and above the area which contacts with pool water. Carbon steel with protective coating (paint) is used on the dry portion of the S/C.

10.3.2.2.1.1 RCCV

The thickness of the RCCV shell is 2m, which includes the steel liner thickness.
The steel-lined reinforced concrete containment structure is supported by a reinforced concrete basement to provide the primary containment pressure barrier of the RCCV and is classified as ASME B&PV Code Section III, Division 2, Concrete Containment.

10.3.2.2.1.2 MC Components

Penetrations through the containment pressure boundary include the Drywell Head, Equipment Hatches to both upper and lower D/W regions, Personnel Airlocks into upper and lower D/Ws, a combined personnel access and equipment hatch (S/C Hatch) into the S/C, and piping and

electrical penetration sleeves. These containment penetrations are steel structures classified as ASME B&PV Code Section III, Division 1, Class MC.

10.3.2.2.1.3 RCCV Internal Structures

The RPV Pedestal and the D/F partition the containment volume into D/W and S/C regions.
The RPV pedestal forms the lower D/W region and consists of two concentric steel cylinders joined together radially by vertical steel diaphragms and filled with concrete. It is anchored to the basement and supports the RPV through a support ring girder. The pedestal also supports the reactor shield wall.

The pressure suppression venting lines are an integral part of the pedestal structure, which includes
(1) Drywell Connecting Vents; the ducts which interconnect the lower and upper D/W regions,
(2) Vent Pipes; the vertical downcomers from the interconnecting ducts to the horizontal vents, and
(3) Horizontal Pipes; the horizontal vents that direct steam into the suppression pool.
The Horizontal Pipes consist of 30 pipes uniformly spaced around the perimeter of the pedestal in ten stacks of three each. In the event of a LOCA, a mixture of steam and water is discharged in the D/W and is led to the S/C pool through the vent lines, where the steam is cooled and condensed. This can effectively suppress the increase of pressure within the RCCV.

Vacuum relief between the D/W volumes and the S/C gas space is provided by vacuum breaker valves on piping sleeves penetrating the pedestal wall.

Vent Pipes, Horizontal Pipes and Vacuum breaker valves are applied to ASME, and they are not parts of RCCV Internal Structures.

The reinforced concrete D/F, separating the upper D/W and the S/C gas spaces, has a steel liner plate on the underside. The steel liner plate prevents the bypass flow of steam from the upper D/W to the S/C air space during a potential LOCA condition.

Other major internal structures within the containment include the reactor shield wall and the lower drywell personnel and equipment access tunnels.

These internal structures are made from stainless steel or carbon steel cladded with stainless steel.

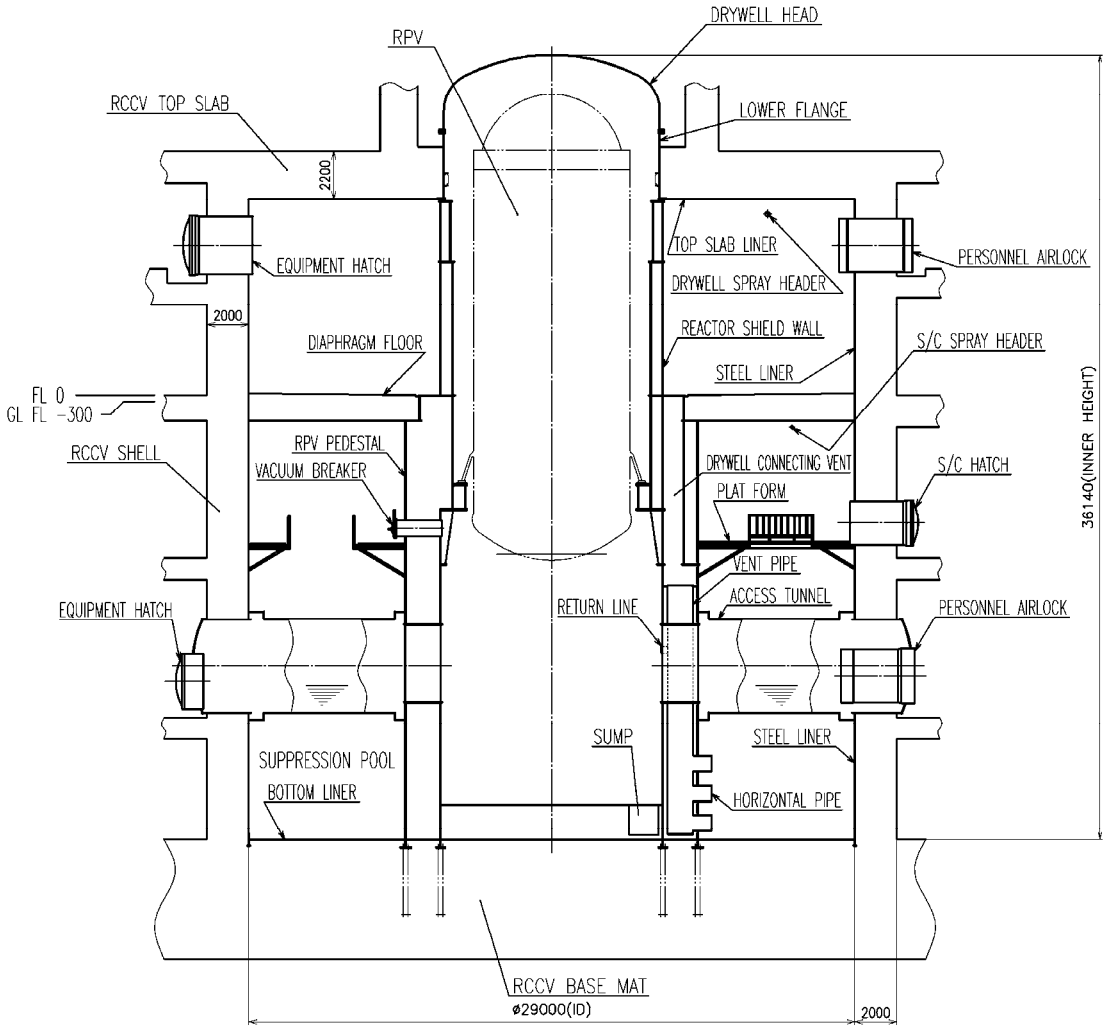

Figure 10.3-3: Conceptual Arrangement of RCCV

10.3.2.2.2 Design Description

The RCCV provides the pressure suppression Primary Containment System, which comprises the D/W, S/C and supporting systems. The RCCV is designed to have the following functional capabilities and the following conditions shall be satisfied:

a. Pressure suppression

Any steam of RCCV released from a possible pipe rupture in the primary system will be condensed by the suppression pool, and will suppress any significant pressure rise.

b. Pressure resistance and heat resistance

The RCCV can withstand maximum excessive pressure and temperature caused by any LOCA events including worst piping break such as instantaneous, complete and double-ended guillotine break of the feedwater piping.

c.Airtightness

The air leakage ratio of RCCV is 0.4 %/d or less of free volume of the containment at ordinary temperature and with a 90% of the maximum design pressure.

d. Structural strength

The RCCV has a structural strength that maintains integrity when assumed static load and dynamic load generated in normal operation, transient and accident conditions are appropriately combined with seismic load.

e. Cooling capacity

To maintain the integrity of RCCV, pool water of the S/C is cooled by a heat exchanger (of the residual heat removal system) in normal operation, and the atmosphere inside the RCCV is cooled by spraying the pool water in the RCCV if an accident occurs.

f. Explosion-proof capacity

A Flammability Control System ensures that concentration levels of hydrogen and oxygen are safely maintained below flammability limits, in the RCCV, in the event of an accident.

g. Iodine removal capacity

Iodine in the RCCV is removed if an accident occurs and if radioactive material leaks into the R/B from the RCCV. The atmosphere in the R/B is cleaned so that release of radioactive material is suppressed to a sufficiently low level.

h. Isolation valve

Isolation valve is designed to prevent the leakage of radioactive material from RCCV if an accident occurs.

i. Prevention of brittle fracture

As for the steel components in RCCV, brittle fracture is prevented by taking the lowest design temperature (10°C) into consideration.

j. Protection from piping rupture

The system can withstand the forces exerted by a jet blast due to outflow of coolant from a possible pipe-break if LOCA occurs. The RCCV is not damaged by pipe-whipping reaction forces of the jet and the piping will be suitably restrained.

k. Strength against dynamic load

During a LOCA and events such as Safety Relief Valve (SRV) operation, steam released from the primary system would flow into the suppression pool where it would condense. Such events would impose various dynamic loading conditions on the containment system structures.

The RCCV and structures within the RCCV have sufficient structural strength to maintain integrity against the following hydro-dynamic loads:

- Gas / steam release.
- Pool swell.
- Steam condensation (oscillation / chugging loads).
- Annulus Pressurisation.

l. Single failure and emergency power supply

Active components are designed so that they have multiplicity considering single failure and power can be obtained from the emergency power supply.

10.3.3 Safety Requirements and Design Principles on Control Building

10.3.3.1 Safety Requirements

This section provides the safety requirements and the design principles of the Control Building (C/B).

10.3.3.1.1 Safety Class and Seismic Categorisation

The Control Building houses Safety Class 1 SSCs, including Main Control Room (MCR). The C/B is a Safety Category A, Safety Class 1 structure and is classified as Seismic Category 1.

10.3.3.1.2 Safety Function of the Control Building

Safety functions of the UK ABWR C/B are shown as follows;

a. Normal Operating Condition;

- To support SSCs for the normal operating loads
- To maintain environment appropriate for SSCs inside the C/B and for the operators inside the MCR
- To shield radiation from the main steam tunnel

b. Fault Conditions

- To support SSCs, which deliver safety functions, for Design Basis (DB) loads
- To maintain environment appropriate for SSCs, which deliver safety function within the C/B, for the DB condition
- To shield radiation to lowest levels for accident management activities inside the MCR.
- To protect plant operators and SSCs, which deliver safety functions, from design base natural phenomena and external hazards
- To protect SSCs, which deliver safety functions, from design base condition by internal hazards, including the effects of fire, missiles, pipe whipping and discharging fluids, etc.

10.3.3.2 Design Principles

This section provides the structural form and the design requirements of the Control Building as its design principles.

10.3.3.2.1 Structural Form

The C/B is constructed of reinforced concrete and structural steel with a steel frame and reinforced concrete roof. The C/B is 33.1 m × 59.4 m reinforced concrete structure that is 16.7m high above grade (top roof level excluding shafts). The total building embedment is 25.7m. The basement is 3.0 m thick. The C/B has four reinforced concrete floors. Inside the C/B, there are 10 columns supporting the floors.

Within the C/B, the main steam tunnel, located on the ground floor of the C/B, provides an independent open space between the R/B and the T/B. The tunnel is closed at the R/B end and open at the T/B. The steam tunnel is designed to withstand pressurization effects that occur in the steam tunnel as a result of postulated rupture of pipes containing high energy fluid. The tunnel has no penetrations from the steam tunnel into other areas of the C/B. The concrete thickness of the steam tunnel walls, floor and ceiling are designed to minimize the potential dose rate to operators.

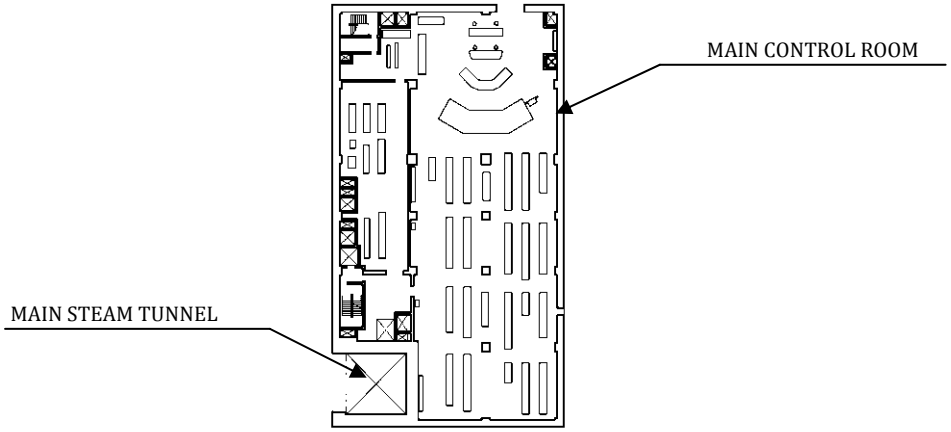

Figure 10.3-4: Plan 2F, C/B

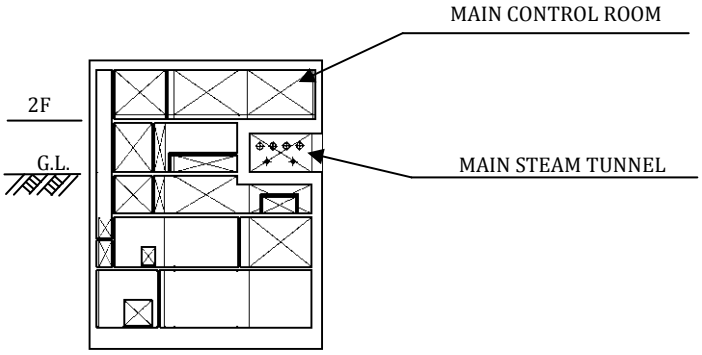

Figure 10.3-5: Section, C/B

10.3.3.2.2 Design Requirements of Normal Operating Conditions

In order to meet the safety functions for the normal operating conditions as described in Section 10.3.3.1.2, the following design requirements are incorporated in the C/B design;

- Support Function

  To support the SSCs for the normal operating loads, the C/B is designed with following loading conditions.

  - Dead Loads
  - Live Loads
  - Temperature Effects/Loads
  - Equipment loads
  - Dynamic and static piping loads
  - Disassembled parts loads at unloading pathways
  - Monorail and lifting loads
  - Temporary loadings during construction and decommissioning

- Environmental Condition

  To maintain environment appropriate for SSCs inside the C/B and for workers inside the MCR, the C/B avoids effects from winds, precipitation and snow, and ingress of groundwater by the exterior walls and slabs, and maintains temperature and humidity as comfortable conditions together with the HVAC system. The lightning protection system avoids adverse effects to the SSCs inside the building from lightning strike.

- Shielding

  To shield radiation from the main steam tunnel, the C/B provides shielding by concrete walls and slabs. The shielding walls and slabs are arranged around the MS and FDW piping to reduce worker's exposure remaining at rest of the main steam tunnel within the C/B. The shielding walls and slabs also provide shielding to reduce the potential dose rate at the site boundary.

10.3.3.2.3 Design Requirements of Fault Conditions

In order to meet the safety functions for the fault conditions as described in Section 10.3.3.1.2, the following design requirements are incorporated in the C/B design;

- Support Function

  To support SSCs, which deliver safety functions, for design base loads, the C/B is designed as Seismic Category 1 building and meets the Design Basis Earthquake requirements.

- Environmental Condition

  To maintain environment and atmosphere appropriate for plant operators and SSCs which deliver safety functions inside the C/B and for workers inside the MCR, the C/B avoids effects from winds, precipitation, snow and ingress of groundwater by the exterior walls and slabs, and maintains temperature and humidity as comfortable conditions together with the HVAC system. The lightning protection system avoids adverse effects to the SSCs inside the building from lightning strike.

- MCR Dose Condition

  To shield radiation to lower for accident management activities inside the MCR, the C/B provides shielding walls and slabs on the perimeter of the MCR. The shielding walls maintain their shielding function against postulated fault conditions.

- External Hazards

  To protect SSCs which deliver safety functions from design base external hazard, the C/B provides walls and slabs which protect the SSCs. The walls, slabs and roof shall resist structural failure against the design base events. The C/B is also shielded by the R/B and T/B on the North/South axis and the Rw/B and S/B on East/West axis. As noted in PCSR Chapter 6 (External Hazards), the postulated external hazards that impose design basis requirements on the civil structures are listed below;

  a. Air temperature
  b. Wind (include tornado wind)
  c. Rainfall and Ice
  d. Snow
  e. External flooding (include climate change)
  f. Seismic Activity
  g. Aircraft Impact (accident and intentional)
  h. External Fire
  i. External Missiles (include tornado generated missiles)
  j. External Explosion

- Internal Hazards

  To protect SSCs which deliver safety functions from design base internal hazards, the C/B provides divisional separation barriers between the safety trains by concrete walls and slabs. These separations shall prevent damage from one division propagating to another safety

division during a fault condition. The divisional separation barriers can maintain their structural integrity against a postulated internal hazard. As noted in PCSR Chapter 7 (Internal Hazards), the postulated internal hazards that impose design basis requirements on the civil structures are listed below;

a. Internal Fire
b. Internal Flooding
c. Pipe Whip and Jet Impact
d. Dropped Load
e. Internal Missiles
f. Internal Explosion
g. Consequential Events

The assessment of external and internal hazards is presented in Chapter 6 and 7 of this PCSR.

10.3.4 Safety Requirements and Design Principles on Heat Exchanger Building

This section provides the safety requirements and the design principles of the Heat Exchanger Building.

10.3.4.1 Safety Requirements

10.3.4.1.1 Safety Class and Seismic Categorisation

The Hx/B houses Safety Class 1 SSCs, including pumps and heat exchangers of the RCW system. The Hx/B is a Safety Category A, Safety Class 1 structure and is classified as Seismic Category 1.

10.3.4.1.2 Safety Function of the Heat Exchanger Building

Safety functions of the UK ABWR Hx/B are shown as follows;

a. Normal Operating Condition;

- To support SSCs for the normal operating loads
- To maintain environment appropriate for SSCs inside the building

b. Fault Conditions

- To support SSCs, which deliver safety functions, for Design Basis (DB) loads
- To maintain environment appropriate for SSCs, which deliver safety function within the Hx/B, for the DB condition
- To protect SSCs, which deliver safety functions, from design base natural phenomena and external hazard
- To protect SSCs, which deliver safety functions, from design base internal hazards

10.3.4.2 Design Principles

10.3.4.2.1 Structural Form

The Heat Exchanger Building (Hx/B) is a structure which houses portions of the Reactor Building Cooling Water (RCW) System and Turbine Building Cooling Water (TCW) System. The Hx/B is located adjacent to the intake point of the plant cooling water.

The Hx/B is a 62.0m x 44.0m, reinforced concrete and structural steel structure. The structure has two stories above ground and one story below. Design of the intake pond within the Hx/B would

be a site specific aspect. The mechanical portion of the Hx/B consists of four separate divisional areas, for mechanical and electrical equipment comprised of three RCW trains and one TCW train.

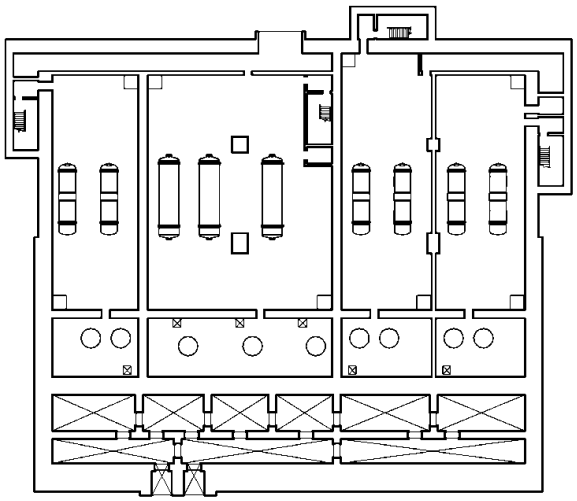

Figure 10.3-6: Plan B1F, Hx/B

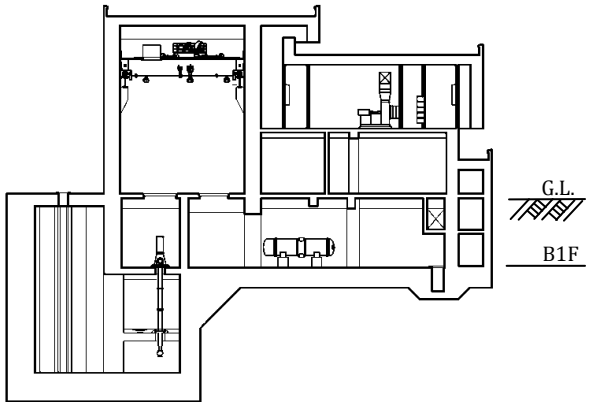

Figure 10.3-7: Section, Hx/B

10.3.4.2.2 Design Requirements of Normal Operating and Fault Conditions

In order to meet the safety functions for the normal operating and fault conditions as described in Section 10.3.4.1.2, the following design requirements are incorporated in the Hx/B design;

a. Normal Operating Condition;

- Support Function

  To support the SSCs for the normal operating loads, the Hx/B is designed with the following loading conditions.

- Dead Loads
- Live Loads
- Temperature Effects/Loads
- Equipment loads
- Dynamic and static piping loads
- Disassembled parts loads at unloading pathways
- Building crane with lifting loads
- Cooling water load
- Monorail and lifting loads
- Temporary loadings during construction and decommissioning

- Environmental Condition

  To maintain environment and atmosphere appropriate for SSCs inside the building, the Hx/B avoids winds, precipitation, snow, and ingress of groundwater by the exterior walls and slabs, and maintains temperature and humidity as comfortable conditions together with the HVAC system. The lightning protection system avoids adverse effects to the SSCs inside the building from lightning strike.

b. Fault Conditions

- Support Function

  To support SSCs, which deliver safety functions, for Design Basis (DB) loads, the Hx/B is designed as Seismic Category 1 building and meets the Design Basis Earthquake requirements.

- Environmental Condition

  To maintain environment and atmosphere appropriate for SSCs, which deliver safety functions within the Hx/B, for DB condition, the Hx/B avoids effects from winds, precipitation, snow and ingress of groundwater by the exterior walls and slabs, and maintains temperature and humidity as comfortable conditions together with the HVAC system. The lightning protection system avoids adverse effects to the SSCs inside the building from lightning strike.

- External Hazards

  To protect SSCs, which deliver safety functions, from design basis external hazards, the Hx/B provides massive exterior walls, slabs and roof to protect SSCs inside the building.

The walls, slabs and roof shall resist structural failure against the design base events. As noted in PCSR Chapter 6 (External Hazards), the postulated design basis external hazards that impose design requirements on the civil structures are listed below;

a. Air temperature
b. Wind (include tornado wind)
c. Rainfall and Ice
d. Snow
e. External flooding (include climate change)
f. Seismic Activity
g. Aircraft Impact (accident and intentional)
h. External Fire
i. External Missiles (include tornado generated missiles)
j. External Explosion

- Internal Hazards

To protect SSCs, which deliver safety functions, from design base internal hazards, the Hx/B provides divisional separation barriers between the safety trains by concrete walls and slabs. These separations shall prevent damage from one division propagating to another safety division during a fault condition. The divisional separation barriers can maintain their structural integrity against a postulated internal hazard. As noted in PCSR Chapter 7 (Internal Hazards), the postulated internal hazards that impose design basis requirements on the civil structures are listed below;

a. Internal Fire
b. Internal Flooding
c. Pipe Whip and Jet Impact
d. Dropped Load
e. Internal Missiles
f. Internal Explosion
g. Consequential Events

The assessment of external and internal hazards is presented in Chapter 6 and 7 of this PCSR.

10.3.5 Safety Requirements and Design Principles on Turbine Building

This section provides the safety requirements and the design principles of the Turbine Building.

10.3.5.1 Safety Requirements

10.3.5.1.1 Safety Class and Seismic Categorisation

The Turbine Building (T/B) houses the main turbine generator and other power conversion cycle equipment and auxiliaries. The T/B is located adjacent to the Safety Class 1 Control Building. The T/B is the Safety Category B, Safety Class 2 structure and is classified as Seismic Category 1A.

10.3.5.1.2 Safety Function of the Turbine Building

Safety functions of the UK ABWR T/B are shown as follows;

a. Normal Operating Condition;

- To support SSCs for the normal operating loads
- To maintain environment appropriate for SSCs inside the building
- To shield radiation to an acceptable level

b. Fault Conditions

- To support SSCs, which deliver safety functions, for Design Basis (DB) loads
- To protect SSCs, which deliver safety functions, from propagation effect of structural collapse

10.3.5.2 Design Principles

10.3.5.2.1 Structural Form

The T/B is a 114.5m × 69.6m, reinforced concrete and structural steel structure. The structure has three stories above ground and two stories below. The T/B is located adjacent to the Safety Class 1 Control Building.

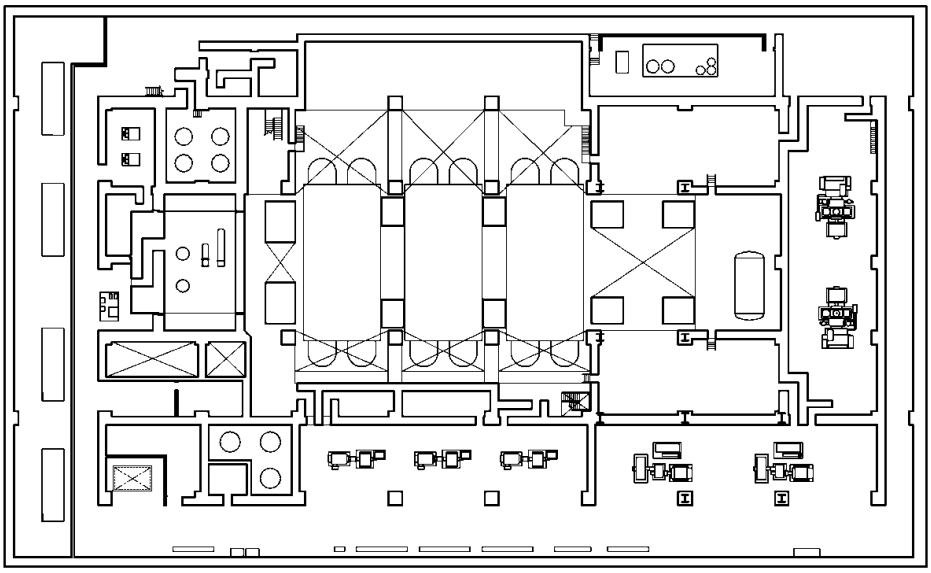

Figure 10.3-8: Plan B1F, T/B

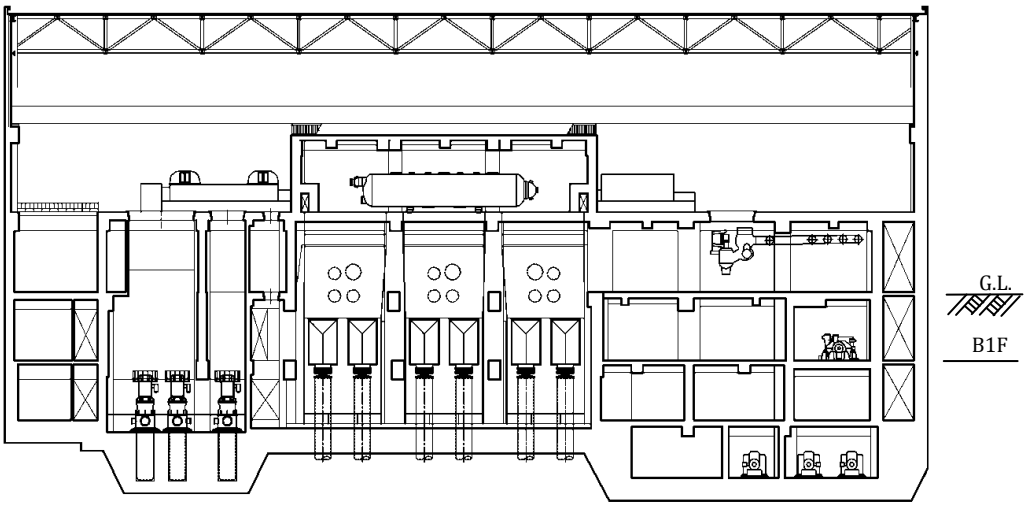

Figure 10.3-9: Section, T/B

10.3.5.2.2 Design Requirements of Normal Operating and Fault Conditions

In order to meet the safety functions for the normal operating and fault conditions as described in Section 10.3.5.1.2, the following design requirements are incorporated in the T/B design;

a. Normal Operating Condition;

- Support Function

  To support the SSCs for the normal operating loads, the T/B is designed with following loading conditions.

  - Dead Loads
  - Live Loads
  - Temperature Effects / Loads
  - Equipment loads
  - Dynamic and static piping loads
  - Disassembled parts loads at the operating deck
  - Disassembled parts loads at unloading pathways
  - Building crane with lifting loads
  - Monorail and lifting loads
  - Vibration effect of heavy pumps and motors
  - Temporary loadings during construction and decommissioning

- Environmental Condition

  To maintain environment and atmosphere appropriate for SSCs inside the building, the T/B avoids effects from winds, precipitation, snow and ingress of groundwater by the exterior walls and slabs, and maintains temperature and humidity as comfortable conditions together with the HVAC system. The lightning protection system avoids adverse effects to the SSCs inside the building from lightning strike.

- Shielding

  To shield radiation to lower the level, the T/B provides shielding by concrete walls and slabs. The shielding walls and slabs are arranged around higher radiation areas to reduce worker's exposure. The external walls and slabs provide shielding to reduce dose rate at the site boundary.

b. Fault Conditions

- Support Function

To support SSCs, which deliver safety functions, for Design Basis (DB) loads, the T/B is designed as Seismic Category 1A building and meets the Design Basis Earthquake requirements.

- Prevention of Propagation Effect

  To protect SSCs inside the C/B, that is the Safety Class 1 structure, from propagation effect of T/B structural collapse, the T/B is designed to avoid a collapse onto the C/B under the Design Base Earthquake.

10.3.6 Safety Requirements and Design Principles on Radwaste Building

This section provides the safety requirements and the design principles of the Radwaste Building.

10.3.6.1 Safety Requirements

10.3.6.1.1 Safety Class and Seismic Categorisation

The Radwaste Building (Rw/B) houses all equipment associated with the collection and processing of solid and liquid radioactive waste generated by the plant. The Rw/B is a Safety Category B, Safety Class 2 Structure and is classified as Seismic Category 2.

10.3.6.1.2 Safety Function of the Radwaste Building

Safety functions of the UK ABWR Rw/B are shown as follows;

a. Normal Operating Condition;

- To support SSCs for the normal operating loads
- To maintain environment appropriate for SSCs inside the building
- To shield radiation to an acceptable level

b. Fault Conditions

- To support SSCs, which deliver safety functions, for Design Basis (DB) loads
- To maintain environment appropriate for SSCs, which deliver safety function within the Rw/B, for DB condition

10.3.6.2 Design Principles

10.3.6.2.1 Structural Form

The Rw/B is a 39.8m x 52.0m, reinforced concrete and structural steel structure. The structure has three stories above ground and three stories below.

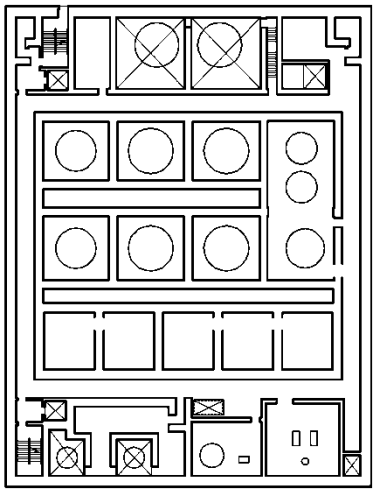

Figure 10.3-10: Plan B2F, Rw/B

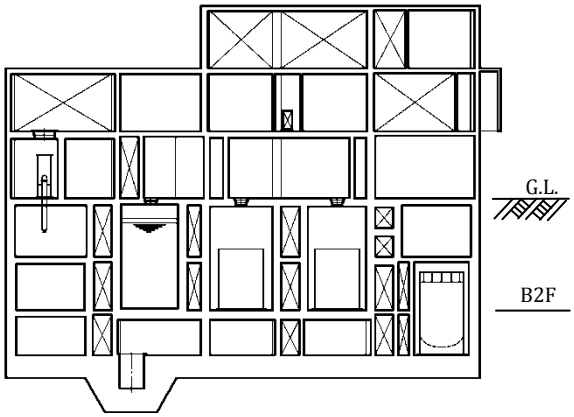

Figure 10.3-11: Section, Rw/B

10.3.6.2.2 Design Requirements of Normal Operating and Fault Conditions

In order to meet the safety functions for the normal operating and fault conditions as described in Section 10.3.6.1.2, the following design requirements are incorporated in the Rw/B design;

a. Normal Operating Condition;

- Support Function

To support the SSCs for the normal operating loads, the Rw/B is designed with following loading conditions.

- Dead Loads
- Live Loads
- Temperature Effects/Loads
- Equipment loads
- Dynamic and static piping loads
- Disassembled parts loads at unloading pathways
- Monorail and lifting loads
- Temporary loadings during construction and decommissioning

- Environmental Condition

  To maintain environment and atmosphere appropriate for SSCs inside the building, the Rw/B avoids effects from winds, precipitation, snow and ingress of groundwater by the exterior walls and slabs, and maintains temperature and humidity as comfortable conditions together with the HVAC system. The lightning protection system avoids adverse effects to the SSCs inside the building from lightning strike.

- Shielding

  To shield radiation to lower the level, the Rw/B provides shielding by concrete walls and slabs. The shielding walls and slabs are arranged around higher radiation areas to reduce worker's exposure. The external walls and slabs provide shielding to reduce dose rate at the site boundary.

b. Fault Conditions

- Support Function

  To support SSCs, which deliver safety functions, for Design Basis (DB) loads, the Rw/B is designed as Seismic Category 2 building.

- Environmental Condition

  To maintain environment and atmosphere appropriate for SSCs, which deliver safety function within the Rw/B, for DB condition, the Rw/B avoids effects from winds, precipitation, snow and ingress of groundwater by the exterior walls and slabs, and maintains temperature and humidity as comfortable conditions together with the HVAC

system. The lightning protection system avoids adverse effects to the SSCs inside the building from lightning strike.

10.3.7 Safety Requirements and Design Principles on Backup Building and Tunnel

This section provides the safety requirements and the design principles of the Backup Building (B/B) and its tunnel.

10.3.7.1 Safety Requirements

10.3.7.1.1 Safety Class and Seismic Categorisation

The B/B houses accident management facilities for beyond design based external hazards. The B/B is a Safety Category A, Safety Class 2 structure and is classified as Seismic Category 1A.

10.3.7.1.2 Safety Function of the Backup Building

Safety functions of the UK ABWR B/B are shown as follows;

a. Normal Operating Condition;

- To support SSCs for the normal operating loads
- To maintain environment appropriate for SSCs inside the building

b. Fault Conditions

- To support accident management facilities, for Design Basis (DB) loads
- To maintain environment appropriate for accident management facilities for DB condition
- To maintain function of the accident management facilities against an intentional airplane impact to the main structures such as R/B and C/B
- To protect accident management facilities from design base external flooding

10.3.7.2 Design Principles

10.3.7.2.1 Structural Form

The Backup Building is a robust structure to protect accident management facilities, such as water injection facilities, AC power source and I&C facilities, from beyond design based external events or human-induced events. This building is located away from the other safety related buildings in order to enhance redundancy of core and spent fuel pool cooling capability against potential risks of damage to the main buildings such as the R/B, C/B and Hx/B.

10.3.7.2.2 Design Requirements of Normal Operating and Fault Conditions

In order to meet the safety functions for the normal operating and fault conditions as described in Section 10.3.7.1.2, the following design requirements are incorporated in the B/B design;

a. Normal Operating Condition;

- Support Function

  To support SSCs for the normal operating loads, the B/B is designed with following loading conditions.

  - Equipment loads
  - Dynamic and static piping loads
  - Disassembled parts loads at unloading pathways
  - Cooling water load
  - Monorail and lifting loads
  - Temporary loadings during construction and decommissioning

- Environmental Condition

  To maintain environment and atmosphere appropriate for SSCs inside the building, the B/B avoids effects from winds, precipitation, snow and ingress of groundwater by the exterior walls and slabs, and maintains temperature and humidity as comfortable conditions together with the HVAC system. The lightning protection system avoids adverse effects to the SSCs inside the building from lightning strike.

b. Fault Conditions

- Support Function

  To support accident management facilities, the B/B is designed as Seismic Category 1A building and meets the Design Basis Earthquake requirements.

- Environmental Condition

  To maintain environment and atmosphere appropriate for accident management facilities, the B/B avoids effects from winds, precipitation, snow and ingress of groundwater by the exterior walls and slabs, and maintains temperature and humidity as comfortable conditions together with the HVAC system. The lightning protection system avoids adverse effects to the SSCs inside the building from lightning strike.

- Independence of the Function

  To maintain function of the accident management facilities against an intentional airplane impact to the main structures such as R/B and C/B, the B/B is located away from the R/B.

- External Hazards

  To protect accident management facilities from design base external flooding, the ground level of the B/B is set above the design base external flooding level. Openings under the design base external flooding level have water proof sealing.

The assessment of external and internal hazards is presented in Chapter 6 and 7 of this PCSR.

10.3.8 Safety Requirements and Design Principles on Main Stack

This section provides the safety requirements and the design principles of the Main Stack.

10.3.8.1 Safety Requirements

10.3.8.1.1 Safety Class and Seismic Categorisation

The Main Stack provides raised vent of the radiation control area within the plant. The Main Stack also supports the Safety Class 1 SGTS piping.

The Main Stack is a Safety Category A, Safety Class 1 structure and is classified as Seismic Category 1.

10.3.8.1.2 Safety Function of the Main Stack

Safety functions of the UK ABWR Main Stack are shown as follows;

a. Normal Operating Condition;

- To support SSCs for the normal operating loads

b. Fault Conditions

- To support SSCs, which deliver safety functions, for Design Basis (DB) loads
- To protect SSCs, which deliver safety functions, from propagation effect of structural collapse

10.3.8.2 Design Principles

10.3.8.2.1 Structural Form

The plant Main Stack is located on the Reactor Building. The stack vents the R/B, T/B, Rw/B, and a small portion of the Control and Service Buildings.

10.3.8.2.2 Design Requirements of Normal Operating and Fault Conditions

In order to meet the safety functions for the normal operating and fault conditions as described in Section 10.3.8.1.2, the following design requirements are incorporated in the Main Stack design;

a. Normal Operating Condition;

- Support Function

To support SSCs for the normal operating loads, the Main Stack is designed with the piping loads.

b. Fault Conditions

- Support Function

  To support SSCs, which deliver safety functions, for Design Basis (DB) loads, the Main Stack is designed as Seismic Category 1 building and meets the Design Basis Earthquake requirements.

- Prevention of Propagation Effect

  To protect SSCs inside the R/B, that is the Safety Class 1 structure, from propagation effect of the Main Stack structural collapse, the Main Stack is designed to avoid a collapse onto the R/B under the Design Base Earthquake.

10.3.9 Safety Requirements and Design Principles on Light Oil Storage Vault and Tunnel

This section provides the safety requirements and the design principles of the Light Oil Storage Vault and its tunnel.

10.3.9.1 Safety Requirements

10.3.9.1.1 Safety Class and Seismic Categorisation

The Light Oil Storage Vault and Tunnel support the Safety Class 1 Light Oil Tank for Emergency Diesel Generator. The Light Oil Storage Vault and Tunnel are Safety Category A, Safety Class 1 structures and is classified as Seismic Category 1.

10.3.9.1.2 Safety Function of the Light Oil Storage Vault and Tunnel

Safety functions of the UK ABWR Light Oil Storage Vault and Tunnel are shown as follows;

a. Normal Operating Condition;

- To support SSCs for the normal operating loads

b. Fault Conditions

- To support SSCs, which deliver safety functions, for Design Basis (DB) loads
- To protect SSCs which deliver safety functions from design base internal hazards

10.3.9.2 Design Principles

10.3.9.2.1 Structural Form

The Light Oil Storage Vault is a structure which houses a light oil storage tank and fuel oil pump as a portion of oil storage and transfer system. The UK ABWR has three trains of the system with two individual structures. One vault is an independent structure for one train. And the other vault houses two trains with divisional separation barrier by concrete walls. The structure is completely buried to avoid adverse effect by natural phenomena and external hazards.

10.3.9.2.2 Design Requirements of Normal Operating and Fault Conditions

In order to meet the safety functions for the normal operating and fault conditions as described in Section 10.3.9.1.2, the following design requirements are incorporated in the Light Oil Storage Vault and Tunnel design;

a. Normal Operating Condition;

- Support Function

  To support SSCs for the normal operating loads, the Light Oil Storage Vault and Tunnel are designed with the equipment loads and piping loads.

b. Fault Conditions

- Support Function

  To support SSCs, which deliver safety functions, for Design Basis (DB) loads, the structure is designed as Seismic Category 1 and meets the Design Basis Earthquake requirements.

- Internal Hazards

  To protect SSCs which deliver safety functions from design base internal hazards, the structure provides divisional separation barrier between the safety trains by concrete walls. These separations would prevent damage to one division propagating other safety division during a fault condition. The separation can maintain their structural integrity against a postulated internal hazard. The postulated internal hazards that impose design basis requirements on the civil structures are listed below;

  a. Internal Fire
  b. Internal Flooding
  c. Pipe Whip and Jet Impact
  d. Dropped Load
  e. Internal Missiles
  f. Internal Explosion
  g. Consequential Events

The assessment of internal hazards is presented in Chapter 7 of this PCSR.

10.3.10 Safety Requirements and Design Principles on CST Basement and Tunnel

This section provides the safety requirements and the design principles of the CST Basement and its tunnel.

10.3.10.1 Safety Requirements

10.3.10.1.1 Safety Class and Seismic Categorisation

The CST Basement and tunnel support the Safety Class 2 CST and connecting piping. The CST Basement and Tunnel are Safety Category B, Safety Class 2 Structure and is classified as Seismic Category 2.

10.3.10.1.2 Safety Function of the CST Basement and Tunnel

Safety functions of the UK ABWR CST Basement and tunnel are shown as follows;

a. Normal Operating Condition;

- To support SSCs for the normal operating loads
- To shield radiation to an acceptable level

b. Fault Conditions

- To support SSCs, which deliver safety functions, for Design Basis (DB) loads

10.3.10.2 Design Principles

10.3.10.2.1 Structural Form

The Condensate Storage Tank (CST) provides condensate quality water for both normal and emergency operations. CST is a water source for systems which require condensate makeup water. It also provides water to High Pressure Core Flooder System (HPCF) and Reactor Core Isolation Cooling System (RCIC).

10.3.10.2.2 Design Requirements of Normal Operating and Fault Conditions

In order to meet the safety functions for the normal operating and fault conditions as described in Section 10.3.10.1.2, the following design requirements are incorporated in the CST Basement and Tunnel design;

a. Normal Operating Condition;

- Support Function

  To support SSCs for the normal operating loads, the CST Basement is designed with the equipment loads and piping loads.

- Shielding

  To shield radiation to lower the level, the CST Basement provides shielding by concrete walls. The shielding walls are arranged around the CST to reduce worker's exposure.

b. Fault Conditions

- Support Function

  To support SSCs, which deliver safety functions, for Design Basis (DB) loads, the structure is designed as Seismic Category 2 structure..

10.3.11 Safety Requirements and Design Principles on RCW Tunnel

This section provides the safety requirements and the design principles of the RCW Tunnel.

10.3.11.1 Safety Requirements

10.3.11.1.1 Safety Class and Seismic Categorisation

The RCW tunnel supports the Safety Class 1 RCW piping. The RCW Tunnel is a Safety Category A, Safety Class 1 structure and is classified as Seismic Category 1.

10.3.11.1.2 Safety Function of the RCW Tunnel

Safety functions of the UK ABWR RCW tunnel are shown as follows;

a. Normal Operating Condition;

- To support SSCs for the normal operating loads

b. Fault Conditions

- To support SSCs, which deliver safety functions, for Design Basis (DB) loads
- To protect SSCs which deliver safety functions from design base internal hazards

10.3.11.2 Design Principles

10.3.11.2.1 Structural Form

The tunnel provides protected and separated pathways for power cables, and C&I cables. The RCW Tunnel is used to route the RCW system piping and cabling from the R/B to the Hx/B, including allowances for segregation and separation for resilience and diversity of services. The structure is completely buried to avoid adverse effect by natural phenomena and external hazards.

10.3.11.2.2 Design Requirements of Normal Operating and Fault Conditions

In order to meet the safety functions for the normal operating and fault conditions as described in Section 10.3.11.1.2, the following design requirements are incorporated in the RCW Tunnel design;

a. Normal Operating Condition;

- Support Function

  To support SSCs for the normal operating loads, the RCW tunnel is designed with the piping loads.

b. Fault Conditions

- Support Function

  To support SSCs, which deliver safety functions, for Design Basis (DB) loads, the structure is designed as Seismic Category 1 and meets the Design Basis Earthquake requirements.

- Internal Hazards

  To protect SSCs which deliver safety functions from design base internal hazards, the structure provides divisional separation barrier between the safety trains by concrete walls. These separations would prevent damage to one division propagating other safety division during a fault condition. The separation can maintain their structural integrity against a postulated internal hazard. The postulated internal hazards that impose design basis requirements on the civil structures are listed below;

  a. Internal Flooding
  b. Pipe Whip and Jet Impact
  c. Consequential Events

The assessment of internal hazards is presented in Chapter 7 of this PCSR.

10.4 Codes and Standards

This section provides the Codes and Standards, which are applied to the civil structural design of the safety-related structures of the UK ABWR. They are basically designed based on the US codes and standards, which are recognized internationally for nuclear facilities, considering the conformity with the UK requirements. The most current edition is applied. When the older edition of the code is applied, its technical justification is needed.

10.4.1 Seismic Analysis and Design

a. ASCE 4-98: ASCE Standard for Seismic Analysis of Safety Related Nuclear Structures
b. ASCE 43-05: Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities
c. NUREG-0800: USNRC Standard Review Plan for Review of Safety Analysis Reports for Nuclear Power Plants-LWR Edition, Revision 4
   Section 3.7.1, Seismic Design Parameters, Revision 4
   Section 3.7.2, Seismic System Analysis, Revision 4
   Section 3.7.3, Seismic Subsystem Analysis
d. RG 1.61: Damping Values for Seismic Design of Nuclear Power Plants, Revision 1
e. RG 1.92: Combining Modal Responses and Spatial Components in Seismic Response Analysis, Revision 2
f. EUR Volume 2:General Nuclear Island Requirements, Chapter4 Design Basis, Revision D
g. BS EN 1998-1:2004 Design of structures for earthquake resistance, with UK National Annex to Eurocode 8
h. IAEA NS-G-3.6:2004 Geotechnical Aspects of Site Evaluation and Foundations for Nuclear Power Plants

10.4.2 Building Design

Codes and Standards of building structural design are shown as follows;

a. ACI 349-M06: Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary
b. ANSI/AISC N690-12: Specification for the Design, Fabrication and Erection of Steel Safety-Related Structures for Nuclear Facilities
c. ASCE 4-98: Seismic Analysis of Safety-Related Nuclear Structures and Commentary

d. ASCE 7-05: ASCE Standard for Minimum Design Loads for Buildings and Other Structures

e. ACI 350.3-06: Seismic Design of Liquid-Containing Concrete Structures

f. NUREG-0800: USNRC Standard Review Plan for Review of Safety Analysis Reports for Nuclear Power Plants-LWR Edition;
Section 3.3.2 Tornado Loads, Revision 3
Section 3.7.2 Seismic System Analysis, Revision 4
Section 3.8.4: Other Seismic Category I Structures, Revision 4
Section 3.8.5: Foundations, Revision 4

g. RG 1.92: Combining Modal Responses and Spatial Components in Seismic Response Analysis, Revision 2

h. RG 1.142: Safety-Related Concrete Structures for Nuclear Power Plants (Other Than Reactor Vessels and Containments) , Revision 2

10.4.3 RCCV and MC Components Design

Codes and Standards of RCCV and MC Components design are shown as follows;
Refer to the Section 10.3.2.2.1 for description of RCCV and MC components.

a. ASME Boiler & Pressure Vessel Code, Section III, Division 2, Subsection CC: Code for Concrete Containments, 2013 Edition

b. ASME Boiler & Pressure Vessel Code, Section III, Division 1, Subsection NE: Class MC Components, 2013 Edition

c. NUREG-0800: USNRC Standard Review Plan for Review of Safety Analysis Reports for Nuclear Power Plants-LWR Edition;
Section 3.8.1, Concrete Containment, Revision 4
Section 3.8.2, Steel Containment, Revision 3

d. RG 1.136: Design Limits, Loading Combinations, Materials, Construction, and Testing of Concrete Containments, Revision 3

e. RG 1.57: Design Limits and Loading Combinations for Metal Primary Reactor Containment System Components, Revision 2

10.4.4 RCCV Internal Structures Design

Codes and Standards of RCCV internal structures design are shown as follows;
Refer to the Section 10.3.2.2.1 for description of RCCV internal structures.

a. ASME Boiler & Pressure Vessel Code, Section III, Division 2, Subsection CC: Code for Concrete Containments, 2013 Edition

b. ACI 349-M06: Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary

c. ANSI/AISC N690-12: Specification for the Design, Fabrication and Erection of Steel Safety-Related Structures for Nuclear Facilities

d. NUREG-0800: USNRC Standard Review Plan for Review of Safety Analysis Reports for Nuclear Power Plants-LWR Edition;
Section 3.8.1, Concrete Containment, Revision 4
Section 3.8.3, Concrete and Steel Internal Structures of Steel or Concrete Containments, Revision 4

10.4.5 Reference Standards for Materials

The materials which conform to the European Standards listed below are used considering the procurement in the UK supply chain. As for the materials of the RCCV liner, MC components and internal structures, ASME and/or ASTM code are used to keep the consistency of the design.

a. BS EN 1991-1-1:2002 Actions on structures - Part 1-1: General actions - Densities, self-weight, imposed loads for buildings, with the UK National Annex to Eurocode 1
b. BS EN 1992-1-1:2004 Design of concrete structures - Part 1-1: General rules and rules for buildings, with the UK National Annex to Eurocode 1
c. BS EN 206-1:2000 Concrete - Part 1: Specification, performance, production and conformity.
d. BS EN 10080:2005 Steel for the reinforcement of concrete - Weldable reinforcing steel – General.
e. BS 4449:2005 Specification for carbon steel bars for the reinforcement of concrete
f. BS EN 10025-2:2005 Hot rolled products of structural steels - Part 2: Technical delivery conditions for non-alloy structural steels.

g. BS EN 10025-4:2004 Hot rolled products of structural steels - Part 4: Technical delivery conditions for thermomechanical rolled weldable fine grain structural steels.

h. BS EN 14399-3:2005 High strength structural bolting assemblies for preloading - Part 3: System HR - Hexagon bolt and nut assemblies

i BS EN 14399-10:2009 High strength structural bolting assemblies for preloading -Part 10: System HRC - Bolt and nut assemblies with calibrated preload

j ASME SA-240, 2013 Edition: Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications

k ASME SA-516, 2013 Edition: Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower- Temperature Service

l ASME SA-36, 2013 Edition: Carbon Structural Steel

m ASME SA-264, 2013 Edition: Stainless Chromium-Nickel Steel -Clad Plate

n ASME SA-320, 2013 Edition: Alloy Steel and Stainless Steel Bolting Materials for Low-Temperature Service

o ASME SA-193, 2013 Edition: Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature or High Pressure Service and Other Special Purpose Applications

p ASME SA-437, 2013 Edition: Alloy Steel Turbine-Type Bolting Material Specially Heat Treated for High-Temperature Service

q ASME SA-194, 2013 Edition: Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both

r ASTM A-633-13: Standard Specification for Normalized High-Strength Low-Alloy Structural Steel Plates

s ASTM A709-13a: Standard Specification for Structural Steel for Bridges

t ASTM A572-13a: Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel

u ASTM A533-09e1: Standard Specification for Pressure Vessel Plates, Alloy Steel, Quenched and Tempered, Manganese-Molybdenum and Manganese-Molybdenum-Nickel

v ASTM A325-10e1: Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

w ASTME A490-12: Standard Specification for Structural Bolts, Alloy Steel, Heat Treated, 150 ksi Minimum Tensile Strength

x ASTM A540-11: Standard Specification for Alloy-Steel Bolting for Special Applications

y ASTM A36-12: Standard Specification for Carbon Structural Steel

z ASTM A992/A992M-11: Standard Specification for Structural Steel Shapes