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UK ABWR

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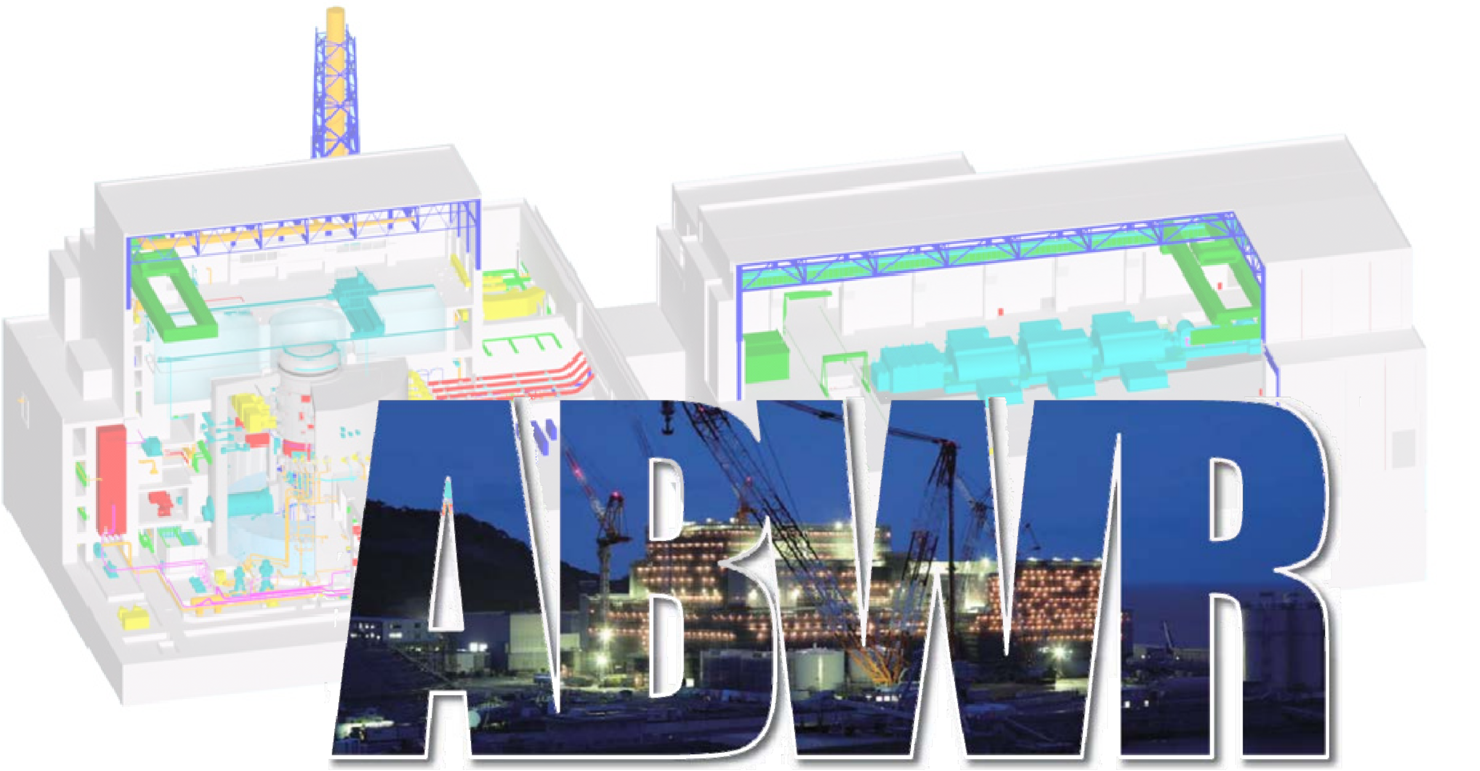
UK ABWR Generic Design Assessment

Preliminary Safety Report on Radiation Protection Section 2 Strategy to ensure that the exposure is ALARP



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Acronyms

Abbreviations and Acronyms Description	Description
ABWR	Advanced Boiling Water Reactor
ALARP	As Low As Reasonably Practicable
BSL	Basic Safety Level
BSO	Basic Safety Objective
BWR	Boiling Water Reactor
CBA	Cost Benefit Analysis
CUW	Reactor Water Clean-Up System
FMCRD	Fine Motion Control Rod Drive
FPC	Fuel Pool Cooling and Cleanup System
HSE	Health and Safety Executive
HVAC	Heating Ventilating and Air Conditioning System
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IRR99	Ionising Radiations Regulations 1999
LPRM	Local Power Range Monitor
MS	Main Steam System
MSIV	Main Steam Isolation Valve
MSV	Main Stop Valve
NEA	Nuclear Energy Agency
OG	Off-Gas System
PCSR	Pre-construction Safety Report
PSA	Probabilistic Safety Analysis
RHR	Residual Heat Removal System
RIP	Reactor Internal Pump
RPV	Reactor Pressure Vessel
SAP	Safety Assessment Principle
SFP	Spent Fuel Pool
SJAE	Steam Jet Air Ejector
SRV	Safety Relief Valve
TIP	Traversing In-Core Probe

1 General Description

UK Health and Safety Executive developed a suite of guidance documents consisting of six parts [1-1] as follows, explaining the concept “reasonably practicable” and providing guidance about what they should expect to see in dutyholders demonstrations that the risk has been reduced ‘as low as reasonably practicable’ (ALARP).

(1) Assessing compliance with the law in individual cases and the use of good practice
(2) Policy and guidance on reducing risks as low as reasonably practicable in design
(3) Principles and guidelines to assist HSE in its judgments that dutyholders have reduced risk as low as reasonably practicable
(4) HSE principles for Cost Benefit Analysis (CBA) in support of ALARP decisions
(5) Cost Benefit Analysis (CBA) Checklist
(6) ALARP "at a glance"

With respect to radiation protection, operators must demonstrate that radiation doses (all risks) to workers and members of the public from nuclear facilities are ALARP.

The primary scope of radiation protection to demonstrate that the exposure is ALARP consists of:

- Doses to workers during normal operation, which covers start-up conditions, steady-state and shutdown conditions as well as outages including maintenance. Furthermore, the conditions of transport and storage of radioactive and/or contaminated items including spent fuel are included.
- Doses to the public arising from direct and scattered radiation originating from the site during normal operation.

The scope of doses to the public is discussed in PCSR “Radiation Protection” Chapter.

In addition, the provisions adopted to keep exposures ALARP are also demonstrated from the aspect of hierarchy of control, e.g. the engineering means are used, and other options are only used when those means are not possible or cost-effective. The personal protective equipment is only used if no other means are available.

Also the events resulting from accident and fault conditions are not included in this section.

2 Radiation Protection Principles and Criteria

In accordance with UK Health and Safety Legislation as above, administrative programs and procedures of the UK ABWR, in conjunction with the facility's design, ensure that the occupational radiation exposure to personnel is kept ALARP.

Generally, design considerations and methods that are deployed to maintain in plant radiation exposures ALARP, have two objectives:

(1) Minimising the necessity for and the amount of time spent in radiation areas for personnel.
(2) Minimising radiation levels in routinely occupied plant areas and in the vicinity of plant equipment expected to require personnel attention.

Both equipment and facility designs are considered in occupational exposure ALARP during normal operation and outage including maintenance and repairs, as well as transport and storage of radioactive and/or contaminated items based on the above-mentioned two objectives.

Examples of features which will assist in maintaining low occupational exposures include the following:

(1) Provisions for draining, flushing, and decontaminating equipment and piping.
(2) Design of equipment to minimise the buildup of radioactive material and to facilitate flushing of contamination traps.
(3) Shielding which provides protection during maintenance or repairs.
(4) Provision for means and adequate space for utilization of movable shielding.
(5) Separation of more highly radioactive equipment from less radioactive equipment and provision for separate shielded compartments for adjacent items of radioactive equipment.
(6) Provision of design features such as the Reactor Water Clean-Up System (CUW) and the condensate demineraliser to minimise contamination buildup.
(7) Ventilation and containment systems as necessary to control airborne contamination.

In addition to the minimisation of radiation levels and necessary time to be spent in radiation areas, other features are incorporated to reduce personnel radiation exposure further.

Radiation zones are established in all areas of the plant as a function of both the access requirement and radiation sources in that area. Operating activities, inspection requirements of equipment and maintenance activities are considered in determining the appropriate zoning for a given area.

The primary objective of the radiation shielding is to protect operating personnel and the general public from radiation emanating from the reactor, the turbine systems, the radwaste management systems, and the other systems, while maintaining appropriate access for operation and maintenance. Radiation shielding is also designed to limit the radiation exposure of critical components within specified limits to assure that their performance and design life are maintained.

For all areas potentially having airborne radioactivity, the ventilation systems are designed such that during normal and maintenance operations, airflow is from an area of low potential contamination to an area of higher potential contamination. This is achieved by keeping specific zones at lower pressure as required, in respect to their adjacent compartments.

The area radiation monitoring system is provided to supplement the personnel and area radiation survey. The system measures continuously, indicates and records the gamma radiation levels at strategic locations, and activates alarms on high levels to warn the personnel to avoid unnecessary or inadvertent exposure.

The regulation of radiation protection in the UK is governed by the Ionising Radiations Regulations 1999 (IRR99) [2-1] and also the principles and criteria presented in The Health and Safety Executive (HSE) Safety Assessment Principles (SAPs) for Nuclear Facilities [2-2].

The HSE SAPs assign levels and objectives for radiation doses to individuals and groups; these are the basic safety levels (BSLs) and the basic safety objectives (BSOs), respectively. These encompass the legal limits defined in the Ionising Radiations Regulations. The employer (and so the designers and operators) must ensure doses are ALARP beyond the BSO. The specific UK individual dose criteria are presented in Table 2-1.

Table 2-1 Radiation Safety Criteria

Description	Annual dose (mSv)	
	BSL*	BSO*
Employees working with ionising radiation	20 (LL**)	1
Other employees on the site	2	0.1
Average to a group of employees working with ionising radiation	10	0.5
Any persons off the site from sources of ionising radiation on the site	1 (LL**)	0.02

* : BSL, BSO refer to HSE Safety Assessment Principles for Nuclear Facilities
**: LL – Legal Limit defined in Ionising Radiations Regulations, 1999

An important element of optimisation of protection is that the collective dose to individuals on and off site, as a result of operation of the nuclear facility, should be kept ALARP.

The engineering design procedures require that the component design engineer consider the applicable IAEA "Radiation Protection Aspects of Design for Nuclear Power Plants" No.NS-G-1.13 [2-3], ICRP "1990 Recommendations of the International Commission on Radiological Protection ICRP Publication 60" [2-4] and NEA "Occupational Radiological Protection Principles and Criteria for Designing New Nuclear Power Plants" No.6975 [2-5]. In this way, the radiation problems of a component or system are considered.

The design of the UK ABWR has adopted the design considerations described in the principles above to implement ALARP as much as possible.

The following sub-sections cite some examples of design considerations made to implement ALARP. The justification of the design considerations to implement ALARP is described in sub-section 8 Justification of ALARP with Annual Dose.

3 Equipment Design Considerations for ALARP Exposures

3.1 Equipment Design Considerations to Limit Time Spent in Radiation Areas

The equipment designs to limit time spent in radiation areas include the following:

(1) Equipment is designed to be operated and have its instrumentation and controls in accessible areas both during normal operation and outage.
(2) Equipment is designed to facilitate maintenance.
(3) Past experience has been factored into current designs.
(4) Life expectancy of equipment and minimising the requirement for replacement are considered.
(5) Segregation of maintainable parts from radiation areas is considered.

3.2 Equipment Design Considerations to Limit Radiation Levels of Components

The equipment designs to limit component radiation levels include the following:

(1) Equipment designs include provisions for limiting leaks of an inside fluid and radiation contamination of adjacent areas from an inside fluid.
(2) The materials are selected to reduce radiation level.
(3) The systems including filter and demineraliser are designed to limit the radioactive isotopes in the coolant.

4 Facility Layout General Design Considerations for ALARP Exposures

4.1 Minimising Personnel Time Spent in Radiation Areas

General design considerations of the facility to minimise the amount of time spent in radiation areas for personnel include the following:

(1) Locating equipment, instruments, and sampling stations, which require routine maintenance, calibration, operation, or inspection, for ease of access and minimum required occupancy time in radiation areas.
(2) Laying out plant areas to allow remote or mechanical operation, service, monitoring, or inspection of highly radioactive equipment.
(3) Providing appropriate means, where practicable, for transportation of equipment or components requiring service to a lower radiation area.

4.2 Minimising Radiation Levels in Plant Access Areas and Vicinity of Equipment

Generally, design considerations are directed toward minimising radiation levels in plant access areas and in the vicinity of equipment requiring personnel attention include the following:

(1) Separating radiation sources and occupied areas wherever practicable.
(2) Providing adequate shielding between radiation sources and access and service areas.
(3) Locating equipment, instruments, and sampling sites in the lowest practicable radiation zone.
(4) Providing central control panels to permit remote operation of all essential instrumentation and controls from the lowest radiation zone practicable.
(5) For package units, separating highly radioactive equipment from less radioactive equipment, instruments and controls, wherever practicable.
(6) Providing means and adequate space for utilizing and storing moveable shielding for sources within the service area when required.
(7) Providing space for pumps and valves outside of highly radioactive areas in principle.
(8) Providing backflushable filter systems for highly radioactive radwaste and cleanup systems.
(9) Providing labyrinth entrances or shielding doors to radioactive pump, equipment, and valve rooms.
(10) Providing adequate space in labyrinth entrances for easy access.
(11) Providing reactor water chemistry control to reduce radioactivity in reactor water and deposition.

4.3 Minimising Contamination Levels in Plant Access Areas

General design considerations are directed toward minimising contamination levels in plant access areas and in the vicinity of equipment requiring personnel attention include the following:

(1) Providing means to control contamination and to facilitate decontamination of potentially contaminated areas where practicable.
(2) Providing means for decontamination of service areas.
(3) Maintaining ventilation air flow patterns from areas of lower radioactivity to areas of higher radioactivity.

5 Operational Considerations for ALARP Exposures

Described below are several general considerations for normal operation and outage for ALARP exposures.

(1) Permanent shielding is used, where possible, with workers behind walls or in low-level radiation areas when not actively working in high radiation areas. Temporary shielding is used in some areas only if the total exposure, which includes exposure received during installation and removal, will be effectively reduced.

(2) Systems and equipment which are subject to crud buildup have been equipped with connections which can be used for flushing the system to eliminate potential hot-spot buildup.

(3) Prior to performing maintenance work, consideration will be given to flushing and/or chemical decontamination of the system or piece of equipment in order to reduce the crud levels and hence the personnel's exposure.

(4) Access control points will be established in low-level radiation areas because personnel may spend a significant amount of time in these areas changing protective clothing and respiratory equipment. These access points are set up to limit the spread of contamination to as small an area as possible.

(5) Contamination containments, i.e. glove bags, poly bottles, tents, etc., are used where practicable to allow personnel to work on highly contaminated equipment while minimising the spread of contamination during the work.

(6) Personnel will be assigned alarm dosimeters to allow the control of accumulated dose at any time during the work.

(7) Operational procedures will support the overall effort to keep occupational exposures ALARP.

6 Radiation Protection Design Features

6.1 Equipment Design

This subsection describes specific components, as well as system design features that support keeping the exposure of plant personnel during plant operation and maintenance ALARP.

(1) Pumps

- Pumps located in radiation areas are designed to minimise the time required for maintenance.
- The configuration of piping in the environment of pumps is designed to provide sufficient space for efficient pump maintenance.
- Provisions are made for flushing and in certain cases chemically cleaning pumps prior to maintenance.
- Where two or more pumps conveying highly radioactive fluids are required for operational reasons to be located adjacent to each other, shielding is provided between the pumps to maintain exposure levels ALARP.
- Pumps adjacent to other highly radioactive equipment are also shielded to reduce the maintenance exposure.
- Systems containing radioactive fluids are welded to the most practical extent to reduce leakage through flanged or screwed connections.

(2) Instrumentation

- Instruments are located in low radiation areas such as shielded valve galleries, corridors, or control rooms, whenever possible.
- Liquid service equipment for systems containing radioactive fluids is provided with vent and backflush provisions.

(3) Heat Exchangers

- The tubes of heat exchangers are constructed to minimise the possibility of failure and reduce maintenance requirements.
- The heat exchanger design allows for the complete drainage of fluids from the exchanger, avoiding pooling effects that could lead to radioactive crud deposition.

(4) Valves

- Wherever possible, valves in systems containing radioactive fluids are separated from those for “clean” services to reduce the radiation exposure from adjacent valves and piping during maintenance.
- Flushing and drain provisions are deployed in radioactive systems to reduce exposure to personnel during maintenance.
- Valves are designed to minimise the leakage through the packing.

(5) Piping

- Piping is selected to provide a service life equivalent to the design life of the plant, with consideration given to corrosion allowances and environmental conditions.
- Distinction is made between piping conveying radioactive and non-radioactive fluids.
- Piping containing radioactive fluids is designed to minimise the leakage through the piping or flanged connections.

(6) Lighting

- Lighting is designed to provide sufficient illumination in radiation areas to allow quick and efficient surveillance and maintenance operations.
- Consideration is also given to locating lighting fixtures in easily accessible locations, thus reducing the exposure time for bulb replacement.
- Emergency lighting enables workers in the plant to leave quickly from the radiation controlled area in emergency situations and to avoid unforeseen radiation exposure.

6.2 Material Selection

To maintain radiation exposure ALARP has been considered in the design, in the material selection of systems and components exposed to reactor coolant. This means that the materials are selected to minimise activated corrosion products which are the primary sources of radiation during maintenance after shutdown.

For example, radiation exposure potential has been reduced appreciably through the removal or reduction of cobalt from components as compared to early BWR fleet.

The material selection is strongly connected with reactor water chemistry, which is discussed in a field of reactor water chemistry.

6.3 Layout Design

This subsection describes features of equipment layout and design which are employed to maintain personnel exposures ALARP.

(1) Penetrations

- Penetrations through shielding walls are avoided whenever possible to reduce the number of streaming paths provided by these penetrations. Whenever penetrations are required through shielding walls, however, they are located to minimise the impact on surrounding areas.
- Penetrations are located so that the radiation source cannot “see” through the penetration. When this is not possible or to provide an added order of reduction, penetrations are located to exit far above floor level in open corridors or in other relatively inaccessible areas.
- Penetrations which are offset through a shielding wall are frequently employed for penetrations to reduce the streaming of radiation through these penetrations.
- Where permitted, the annular regions between pipe and penetration sleeves are filled with shielding material to reduce the streaming area presented by these penetrations.
- Penetrations through outer walls of the building containing radiation sources are sealed to prevent miscellaneous leaks into the environment.

(2) Sample Stations

- Sample stations are located in low radiation areas to reduce the exposure to operating personnel.
- Flushing provisions are included and pipe drains to plant sumps are provided to minimise the possibility of spills.
- Fume hoods are employed for airborne contamination control.

(3) Ventilations

- Major Heating Ventilating and Air Conditioning System (HVAC) equipments, blowers and coolers, and the like, are located in low radiation areas to minimise exposures to personnel maintaining these equipments ALARP.
- The HVAC ducting penetrations through walls of shielded cubicles are located to minimise the impact of the streaming radiation levels in adjoining areas.
- The HVAC is designed to limit the extent of airborne contamination by providing air flow patterns from areas of low contamination to more contaminated areas.
- The HVAC has the feature that the extracted air is filtered before discharge to the atmosphere.

(4) Piping

- Piping containing radioactive fluids is routed through shielded pipe chases, shielded equipment cubicles, or embedded in concrete walls and floors, whenever possible. The accessibility for maintenance and repair is considered if these provisions are adopted.
- Radioactive services are routed separately from piping containing nonradioactive fluids, whenever possible, to minimise the exposure to personnel during maintenance.
- Penetrations for piping through shielding walls are designed to minimise the impact on surrounding areas. Approaches used to accomplish this objective are described in (1).
- Piping configurations are designed to minimise the number of “dead legs” and low points in piping runs to avoid accumulation of radioactive crud and fluids in the line. Drains and flushing provisions are employed whenever feasible to reduce the impact of required “dead legs” and low points.
- Provisions are also made in radioactive systems for flushing with condensate or chemically cleaning the piping to reduce crud buildup.

(5) Equipments

- Equipment layout is designed to reduce the exposure of personnel required to inspect or maintain equipment.
- “Clean” pieces of equipment are located separately from those which are sources of radiation whenever possible to avoid cross-contamination.
- For systems that have components that are major sources of radiation, piping and pumps are located in separate cubicles to reduce exposure from these components during maintenance.

(6) Floor Drains

- For systems containing highly radioactive fluids, drains are hard piped directly to equipment drain sumps, rather than to allow contaminated fluid to flow across the floor to a floor drain.
- Appropriately sloped floor drains are provided in shielded cubicles and other areas where the potential for a spill exists to limit the extent of contamination.
- For the spillage of radioactive materials onto the floor or wall, the application of appropriate coatings on the concrete surfaces to be potentially contaminated is considered in order to decontaminate easily.
- Curbs, which are the physical boundaries on the floor to be potentially contaminated to avoid contamination spread, are also provided to limit contamination and simplify washdown operations.

6.4 Radiation and Contamination Zoning

UK regulations require the operators of nuclear licensed sites to ensure that adequate protection measures are in order to restrict the radiation exposure of all persons on site and members of the public.

In UK, the primary statutory instrument to regulate radiation exposure of persons is the Ionising Radiations Regulations 1999 (IRR99) [2-1], which describes engineering provisions including adequate shielding, interlocks and appropriate warning devices based on radiation zones.

In terms of radiation zones, there is a requirement under Regulation 16 (1) of IRR99 to designate two areas, supervised area and controlled area, as controlled on the basis of projected or potential dose rate in excess of 1mSv per year but less than 6mSv and more than 6mSv per year, respectively.

Radiation zones are established in all areas of the plant as a function of radiation sources in that area. Operating activities, frequency of access to the area and maintenance activities are considered in determining the appropriate zoning for a given area. The classification of radiation zones for the UK ABWR is presented in Table 6.4-1. This may be amended later by the future operator.

Table 6.4-1 Classification of Radiation Zone

Designation	Maximum Design Dose Rate	Access	Typical UK Area Designation Arrangements	
-	≤ 0.5 μSv/h	Unlimited general occupancy	Undesignated Area	
A	≤ 2.6 μSv/h	No restriction on access	Supervised Area	
Restricted Radiation Zones				
B	< 0.01 mSv/h	Restrected access	≤ 48 h /week	Controlled Area
C	< 0.05 mSv/h		≤ 10 h/week	
D	< 0.25 mSv/h		≤ 2 h/week	
E	< 1 mSv/h		For a short time	
F	≥ 1 mSv/h		Inaccessible	

The dose rate applicable for a particular zone is based on operating experience and represents design dose rates in a particular zone, and should not be interpreted as the expected dose rates which would apply in all portions of that zone, or for all types of work within that zone, or at all periods of entry into the zone.

The F area is inaccessible by access control such as door lock during normal operation in order to suppress unforeseen occupational exposure. The measurement of dose rate in the area is conducted before entering the area if it is necessary to enter.

BWR plants have been in operation for a few decades, and operating experience with similar design basis numbers shows that only a small fraction is received in such zones from radiation sources controlled by equipment layout or the structural shielding provided. Therefore, on a practical basis, a radiation zoning approach as described above accomplishes the as low as reasonably practicable objectives for doses.

The UK ABWR also has a zoning classification for designating areas based on airborne contamination. This classification system has been derived in order to assist in the design of ventilation systems, rather than for operational contamination control purposes. The classification of contamination zones for the UK ABWR is provided in Table 6.4-2.

Table 6.4-2 Classification of Contamination Zone

Classification		Designation*	Notes
Clean Area	I	A	An area in which there is no potential of airborne contamination.
Low Contamination Area	II	B ~ E	An area in which there is low potential to be exposed from airborne contamination.
High Contamination Area	III	F	An area in which there is high potential to be exposed from airborne contamination. There is normally no access without appropriate provisions.

*: There is exception considering operating experience.

6.5 System Design

This sub-section provides design considerations in regard to radioactive systems for maintaining personnel radiation exposures ALARP for the following systems.

< Reactor Building >

(1) Reactor Water Clean-Up System (CUW)

- The CUW is designed to remove impurities continuously by using filter demineralisers to reduce radioactive substances in the reactor water.
- Each of two filter demineralisers is located in separate concrete-shielded cubicles respectively to minimise radiation levels in the area.
- The filter demineralisers are designed to be backwashed and precoated to replace spent resins.
- Most of the valves and piping are located in a shielded valve gallery outside the filter demineraliser cubicles.

(2) Residual Heat Removal System (RHR) [Shutdown Cooling Mode]

- The RHR is designed to be used in the Shutdown Cooling Mode during normal operation to recirculate reactor water and remove reactor decay heat.
- The heat exchangers and associated pumps are located in separate concrete-shielded cubicles.
- The cubicles are accessible through labyrinths which reduce radiation levels outside the cubicle to acceptable levels.

(3) Fuel Pool Cooling and Cleanup System (FPC)

- The FPC is designed to operate continuously to cool the Spent Fuel Pool (SFP) and to remove impurities by using a demineraliser.
- The FPC demineraliser units are located in a concrete-shielded cubicle respectively to minimise radiation levels in the area.
- The FPC demineraliser are designed to be backwashed and precoated to replace spent resins.
- The FPC pumps are located in a low radiation area adjacent to the shielded backwash tank.

(4) Main Steam System (MS)

- Leakage from selected valves on to surrounding areas is minimised by providing valve drains piped to equipment drain sumps.
- Penetrations through the steam tunnel walls are minimised to reduce the streaming paths made available by these penetrations.

< Turbine Building >

(1) Off-Gas System (OG)

- The OG is designed to treat off-gas from the condenser via the Steam Jet Air Ejector (SJAE) so as to facilitate recombine hydrogen and radioactivity delay.
- The main equipments and piping in the OG are enclosed by a shielding wall, taking account of high radioactivity in the OG.

In addition, for the turbine building, actual dose rate in many areas in the turbine building are less than 0.001mSv/h during outage and radiation exposure for workers is low level.

Also, radiation dose rate in the area that it is necessary to access the turbine building is low level during operation because of significant shielding provisions around equipments and piping including radioactive substances.

< Liquid and Solid Radioactive Waste Management System >

(1) Liquid and Solid Radioactive Waste Management System

- The main equipments and piping in this system are enclosed by a shielding wall, taking account of high radioactivity in this system.
- The cubicles are accessible through labyrinths which reduce radiation levels outside the cubicle to acceptable levels.
- This system includes engineered flushing points to allow plant to be flushed clean prior to maintenance work.

6.6 Transport and Storage of Radioactive and/or Contaminated Items

For transport and storage of the spent fuel, the remote-automatic refueling machine is used when nuclear fuels are exchanged after reactor shutdown in order to minimise radiation exposures to workers. This refueling machine moves automatically by using a process computer to cover areas of the reactor well and the spent fuel storage pool including the cask pit. Furthermore, the refueling operation can be done from the remote control room.

In addition, the spent fuel is transported to the spent fuel pool from the reactor core within the water while keeping the adequate water depth to minimise exposures to workers.

Spent fuel transport outside the reactor building uses transfer casks which have the functions of radiation shielding and containment.

On the other hand, handling the other radioactive and/or contaminated items is done using remote tools and shielded transfer casks.

7 Internal Exposures

The internal exposure during normal operation and outage for workers in the plant is controlled by the provisions as follows:

(1) Equipment design to minimise the leakage of radioactive substances such as leak-tight provisions of pumps, valves and piping described in sub-section 6.1 Equipment Design.

(2) Layout design of contamination control such as the provisions of ventilations and floor drains described in sub-section 6.3 Layout Design.

(3) Operation considerations such as establishing access control points in low radiation areas to minimise the excessive exposure and contamination containments to minimise the spread of contamination described in sub-section 5 Operational Considerations for ALARP Exposures.

In terms of the operating experiences based on the internal dose measurement by using whole body counter, there are almost no workers exposed internally. Therefore, risk of the internal exposure for workers is minimised by means of those provisions.

8 Justification of ALARP with Annual Dose

8.1 Justification Process

This subsection describes the method to evaluate the annual collective dose for workers to justify the above-mentioned provisions of shielding design. This method consists of:

(1) Selecting the activities of high collective dose during outage and normal operation from the existing ABWR plant in Japan, taking into account deriving the annual collective dose prediction after at least 5 years of plant operation. The reason to select after 5 years of plant operation is that the annual total occupational exposure is converged because the half-life of Co-60, which is the primary source during outage, is about 5 years.

(2) Conducting the Cost and Benefit Analysis (CBA) against the activities selected. For radiation protection, the "benefit" means dose reduction for each activity to the workers in the plant against cost benefit.

(3) Incorporating the improvements selected by cost and benefit analysis into the UK ABWR. If additional improvements related to shielding design are considered, evaluating whether incorporating them or not by that analysis.

The collective dose for workers of the UK ABWR is evaluated based on the above-mentioned procedure, shown in Figure 8.1-1. In accordance with the ALARP approach, the choice of activities has been iterated to be optimized and on the UK ABWR features that have an impact on radiation protection.

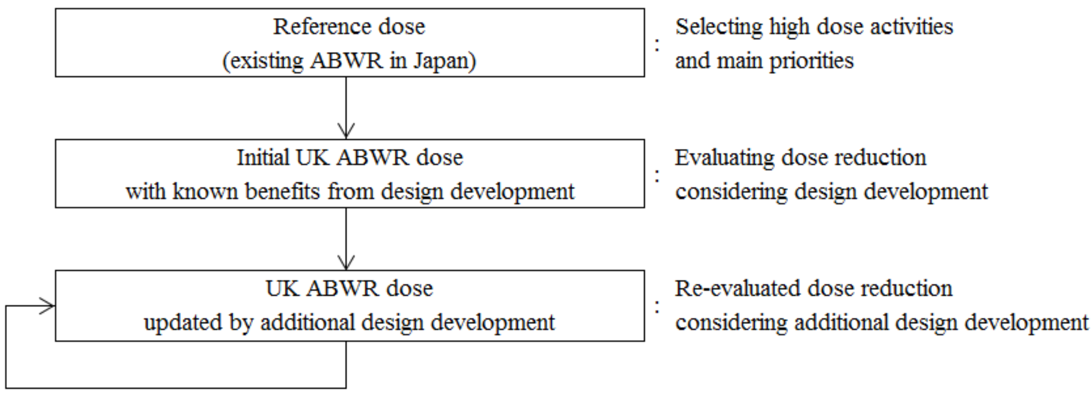

Figure 8.1-1 Dose assessment process

8.2 Maintenance Work

This subsection describes the maintenance works during outage and normal operation from the aspect of occupational radiation exposure, which is based on operating experience of ABWR plants. These maintenance works are listed in Table 8.2-1.

Table 8.2-1 Primary Maintenance Work

Scope	Example
Reactor Building	
Reactor Core	Maintenance for RPV and Core Internals (RIP and FMCRD)
Fuel	Maintenance for Fuel and Fuel Handling
Primary Valve	Maintenance for MSIV and SRV
Instrument	Maintenance for LPRM and TIP
RHR/CUW	Maintenance for Piping, Heat Exchangers, Pumps and Valves
Turbine Building	
Turbine	Turbine Overhaul
Primary Valve	Maintenance for MSV
Condensate System	Maintenance for Condenser, Piping, Pumps and Valves
Radwaste Building	
Pumps and Valves	Maintenance for Pumps and Valves
Radwaste Handling	Maintenance for Radwaste Handling
Work during normal operation	
Each Building	Surveillance

9 References

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[2-4] 1990 Recommendations of the International Commission on Radiological Protection, ICRP Publication 60, ICRP

[2-5] Occupational Radiological Protection Principles and Criteria for Designing New Nuclear Power Plants, No.6975, NEA