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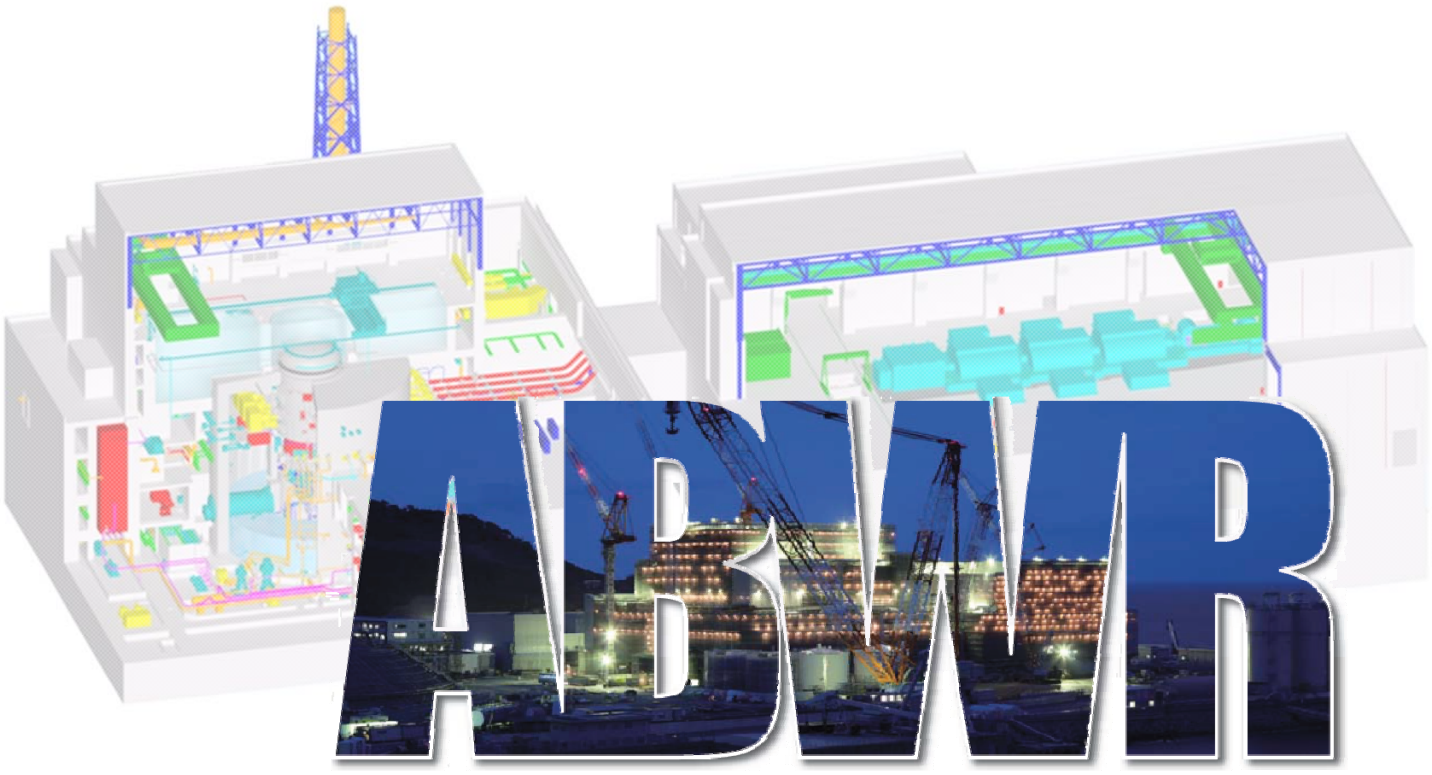
UK ABWR

Document ID	:	GA91-9101-0101-30000
Document Number	:	QGI-GD-0012
Revision Number	:	B

UK ABWR Generic Design Assessment

Generic PCSR Chapter 30 : Operation



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30.1 Introduction

The scope of the chapter is to consider all pertinent issues related to operational aspects and to discuss the overall safety case elements for operations of the UK ABWR.

This chapter contains a description of the conduct of operations to be established by the Site Licence Company. Because this PCSR is based on the generic design and is prepared by the RP, the descriptions contained in this chapter are the operational assumptions that underpin the plant design basis for safety. These operational assumptions have been developed jointly with the participation of a future site licensee, as described in the UK ABWR GDA: Human Factors Concept of Operations Report (COR) [Ref-1], to ensure alignment with current UK modern nuclear industry good practice for operations.

It should be noted that although the information in this chapter is weighted towards reactor operations and control room personnel as these are related to the highest risks and most significant claims related to safety, “operations” should be taken to mean all aspects of plant operations (i.e. including maintenance, testing, in-service inspection, radioactive waste processing, fuel route, outages, etc.) where appropriate given the context.

The conduct of operations and the plant design features that support it can only be described at a relatively high level at this stage. Aspects of design and safety analysis that are currently in development will be described further in the future iteration of this GDA PCSR chapter.

30.2 Operational Strategy

This section describes the overall strategy and underlying philosophy of the concept of operations assumed during the design of the generic UK ABWR. The assumptions are captured in greater detail within the COR [Ref-1]. The assumptions and the COR will be subject to change as the design progresses throughout the remaining GDA activities. However, the assumptions have been and will continue to be used to support human factors (HF) analyses and other activities that form part of the UK ABWR GDA HF Integration (HFI) programme, as detailed in the HFI Plan (HFIP) [Ref-2]. This work then feeds into the design features and plant functional requirements put in place to support safe operation and personnel contribution to plant safety goals. In addition, the operational strategy underpins all of the specific human actions that are claimed within this safety case; these are the Human-Based Safety Claims (HBSCs) that are stated in Generic PCSR Chapter 27 (GA91-9101-0101-27000) and supporting report on HBSCs [Ref-3].

30.2.1 Level of Automation

For the current generation of ABWR plants, which form the reference design for UK ABWR, a high level of automation has been the general overall concept of operations for the design, particularly for reactor operations. Normal plant operation can be conducted automatically from cold start-up to rated power, during full power operation and from rated power operation to plant shutdown. Operator burden has been reduced for all safety-critical related normal tasks, through carefully selected “breakpoints” requiring operator attention (“acknowledgment”) between automation sequences during normal operations. No safety-related RPS/ECCS protection or control rod movement block protection is lost in automation, and any operator decision or control rod block that requires operator intervention can convert the plant back to manual operation. Operator burden is also reduced in abnormal events through automation of plant responses, particularly immediately following a reactor scram. This general strategy has been carried through to UK ABWR design.

To balance the level of plant automation during operation and ensure the operator retains an adequate level of situational awareness, key “supervisory” actions are required and confirmation of successful implementation of automated sequences is maintained as part of the operator’s role. As described in this PCSR in Chapter 21 Human Machine Interfaces (GA91-9101-0101-21000) Section 21.3, the human-machine interfaces (HMIs) within the Main Control Room (MCR), in particular the large, overview wide display panel (WDP), have been designed to ensure that any failures within the automated operations and any incursions into abnormal plant states are immediately revealed and obvious to all operators within the MCR. The design of the WDP includes the following key features for maintaining plant status awareness in all instances:

- A first-hit and important alarms display on the left-hand panel.
- All key plant parameters presented in a logical intuitive mimic display in the centre fixed panel.
- Context-sensitive trend and other plant item displays that automatically appear on the large variable display to the right side.
- System-level alarm tiles across the top of the entire WDP.

This design of the WDP has been assessed through simulator sessions as part of the baseline HF assessment, as summarised in the Baseline Assessment Report (BAR) [Ref-4], as being successful in supporting key communications and operator situational awareness particularly in fault conditions. Further details on the operating system and how it supports required operations is given in Section 30.3.

The above strategy is based on the general automation level for the current functions defined within the reference plant design (J-ABWR). The allocation of these functions for the UK ABWR is being confirmed and justified, or if necessary their allocation modified, through HF and other design activities within GDA; any new functions are also being appropriately allocated accordingly. Thus, the level of automation may change at the detail level. However, for the purposes of this PCSR, the level of automation is assumed to be generally the same as for J-ABWR with the exception of known improvements to further automate remaining safety system initiation. Therefore, the operational strategy above is expected to remain generally applicable.

30.2.2 Contribution to Plant Safety Goals

In addition to optimising operational burden whilst maintaining situational awareness, the operational strategy for the ABWR plant includes an assumed level of contribution from the operations personnel (including maintenance) to maintaining the plant within its limiting conditions of operations, thereby supporting the achievement of the plant safety goals. Suitable facilities, controls and plant design features (i.e. bypass systems, test modes, calibration equipment connection points, etc.) are provided for the regular testing, inspection and calibration of safety-related structures, systems and components (SSCs).

The specific actions and related plant design features required to meet this contribution will be determined through the results of the evolving safety analyses (fault studies, PSA, reliability-centred maintenance review, etc.) for UK ABWR and be confirmed in the final revision of this PCSR. The required actions related to achieving the safety goals of the plant will be reported in the HBSC report [Ref-3]. However, the actions are generally expected to constitute:

- Regular frequent non-invasive testing of identified SSCs from the MCR or local-to-plant with the plant “in service” (i.e. running at power).
- Regular visual inspection of healthy status, availability and operability of identified SSCs through frequent (shiftly or daily) plant walk-arounds or “patrols”.
- Regular monitoring and recording of key parameters within the MCR or from key SSCs (visually or through remote monitoring equipment) to allow monitoring of conditions and early identification of potential deterioration of expected plant condition.
- Regular but less frequent removal from service of diverse SSCs divisions with the plant online in order to perform more “invasive” testing, calibration or maintenance (“online” maintenance).
- Ensuring the required plant configuration and equipment in service, as specified through Limiting Conditions of Operation (LCOs), are met at all times (see also Plant Status Control, Section 30.4).

- Shutting down the reactor periodically ("outage") to remove spent fuel, replace it with new fuel and conduct more complex and invasive maintenance that cannot be completed with the plant at power, including equipment removal, overhaul and upgrades.

30.2.3 Command and Control

International good practice in nuclear power operations dictates that the operating organisation has a Command and Control philosophy. A clear definition of responsibilities and lines of authority is important to the safe operation of the plant, particularly in abnormal and fault conditions. The Command and Control philosophy for UK ABWR is assumed to be similar to that used in existing UK nuclear power plants as follows:

- During normal and fault conditions the Control Room Operators (CROs; see Section 30.5.3 regarding roles), or if applicable, depending on the Site License Company (SLC), the nominal lead CRO, are responsible for control of their unit and will refer to procedures and other documents as required to keep or return the plant to within its defined safe operating envelope. The MCR Supervisor (MCRS) provides support and oversight to the CROs as well as overseeing field operators (FOs) who perform supporting operations local to plant.
- If an event progresses beyond design basis, and in particular if it develops into a severe accident, the CROs or if applicable, the nominal lead CRO, are still responsible for implementing specific emergency operating procedures and responding to emerging plant conditions as required. However, the MCR Supervisor and the Shift Manager are assumed to have a greater role in developing the response strategy, supporting or even in some cases advising on operational decisions, and keeping a broader overview based on the status of the entire station in the context of the conditions emerging throughout the event.
- The Shift Manager is assumed to be the acting Emergency Controller (EC) when a site incident is declared, and assumed to remain so until the duty EC is confirmed as in-post and the Emergency Control Centre (ECC) is established.
- There are assumed to be on-call standby emergency crews, who are assumed to be suitably experienced station personnel with designated positions and emergency response duties as described in the SLC's Emergency Preparedness procedures (see also Chapter 22 of this PCSR (GA91-9101-0101-22000)). There are also assumed to be personnel available and responsible to provide out-of-hours technical advice locally to the station's operational crews. During an incident or emergency, the Shift Manager is assumed to be able to recall the standby emergency crews.
- Any centrally-located/off-site and externally-managed emergency response support centre (i.e. Technical Support Centre, etc.) is outside the remit of this GDA. However, arrangements currently within the UK are assumed to be similar for UK ABWR in terms of roles and lines of authority (i.e. the on-site ECC is always in control of the incident and the strategy and actions on site; the external centre provides enhanced technical support and manages public communications, etc.). This type of centre or some equivalent form of off-site technical support during events is assumed to continue to be available for the entire operating life of any sites.

The above philosophy is described in greater detail with respect to Roles and Responsibilities within the COR [Ref-1].

30.2.4 Communications

Key to safe operations within the UK ABWR plant is clear, effective communications. The plant operating and maintenance organisations need to keep in regular communication both within and between teams, as well as with the various support teams available to them. This is particularly true when performing tasks related to safety and when dealing with fault conditions.

The HF analysis and design support activities for GDA have included consideration of the communications requirements in general, through the use of requirements in the HF Engineering Specification (HFE Spec) [Ref-5], as well as in detail for key tasks, particularly the HBSCs. The design of the plant therefore takes these requirements into account. Specifically, the following features have been or will be incorporated into the ABWR design:

- An MCR that is designed to be operated at low ambient noise levels, even in plant upset conditions, to help permit clear communications and instructions.
- Any other local control rooms, plant equipment rooms, local control panels, and external facilities or equipment housings have the means to provide clear communication routes to the MCR or alternative main control point (i.e. Remote Shutdown System (RSS) room, Backup Building (B/B)).
- Where necessary based on safety significance of tasks being conducted, such communication means are suitably robust and diverse from other systems that might be impacted by fault scenarios in which human actions are claimed within the safety analysis.
- Where local ambient noise conditions are high (equipment rooms) and frequent, safety-related tasks need to be carried out, suitable acoustic insulation or noise enclosures are added to the design, without creating any other operability and maintainability issues.

Portable communications equipment and any equipment not part of the generic design (i.e. specified by the Site Licensee) are assumed to meet the same requirements for availability and clarity as that permanently part of the UK ABWR plant.

In addition to these design features, the operations strategy for GDA assumes that effective communciations management policies will be put in place by the Site Licensee. These measures are assumed to include:

- Techniques to minimise human performance errors when verbally communicating important information and operating instructions, such as hand-raising/single-person speaking, use of the phonetic alphabet and three way communications. Other examples of techniques assumed to be used are given in industry good practice guidance document, INPO 06-002 [Ref-6]
- Effective shift handover arrangements: handover from an outgoing shift to an oncoming shift is expected to be formally trained, managed and documented, in accordance with good shift handover practices. It is assumed that shift handover arrangements are such that they do not

negatively impact the successful transfer of key items of information from shift to shift, particularly during abnormal, fault or accident scenarios.

- Use of a "visible safety case" programme to ensure that all claimed human actions from the case, and their consequences if not performed correctly, are clearly communicated to all relevant personnel through training and documentation.
- Use of suitably graded procedures to control all activities where personnel interact with the plant. Grading of procedures is expected to relate to consequences of failing to perform the task correctly. An example of such a grading scheme is detailed in the industry guidance document INPO 09-004 [Ref-7].
- Suitable procedure development and configuration control and management, such that all written operating instructions will be duly authorised, validated and approved prior to their use.

30.3 Operating System

It is assumed that the Site Licence Company will implement a risk-based operational decision-making policy that will underpin daily management of the plant. Operational decisions concerning normal and degraded plant conditions that could affect safe plant operation are assumed to be made based on an in-depth understanding of short- and long-term operational risks as well as the potential effects of alternative operational options. This type of operating policy ensures that decisions are made such that the plant is operated with margin to the design limits. Where there is doubt over safety margins, conservative decisions will be made to optimise the route to a known safe state. This decision-making will be underpinned by the information generated by the safety analyses conducted in GDA as outlined in this PCSR and future operational documentation.

During GDA, HF design activities focus on ensuring that the operating systems are designed to effectively support these risk-based decisions, such that:

- The state of the plant can be clearly determined at any time and in any conditions;
- The various systems and equipment can be controlled effectively to within the required limits; and
- The effectiveness of any actions can be monitored until the condition is resolved and the plant returned to a safe state.

These operating systems are described more fully in the various engineering sections within this PCSR in Chapter 21 Human Machine Interfaces (GA91-9101-0101-21000). A summary is given here in terms of how these systems relate to the operational strategy outlined in Section 30.2.

The MCR is central to the operating system for the ABWR containing both the operations personnel and the main HMIs for monitoring and controlling the plant. The MCR equipment provides the crew on duty with suitable visual and audible information to allow them to monitor the performance of the automated features of the plant, provide “supervisory” control to automated sequences when required, conduct routine surveillance tests, and respond appropriately to plant conditions that deviate from what is expected. The arrangement of displays and controls on the Main Control Console (MCC) allows the CROs to focus on reactor, turbine and balance of plant during all plant operating conditions. The Supervisor station behind the MCC allows the MCRS to have the required oversight of all operations and equipment.

As described in 30.2.1, the ABWR has a large degree of automation, and the contribution of the operations team with respect to the operational safety goals of the plant during normal operations (including start-up and shut down modes) consists largely of monitoring the plant to ensure it stays within its safe operating envelope. The crew in the MCR monitors plant parameters at a frequency based on importance and plant conditions. It is assumed that they communicate to other crew members effectively, as described in Section 30.2.4, when they need to share important information, seek confirmation of diagnosis and action needed, and/or to have verification of an action taken.

During abnormal and accident conditions, the role of the crew with regards to the plant changes slightly and they are required to take a more active role in maintaining or returning the plant to safe conditions. Their monitoring context changes from “normal” plant to needing a heightened awareness required to ensure automated safety systems have correctly initiated and, where necessary, diagnose alarms and implement abnormal and/or emergency operating procedures accordingly.

The operating system functionality includes an alarm system that directs the MCR personnel attention to any changing conditions that may challenge safety. The alarm system will be designed to ensure wherever possible that:

- alarm conditions are clearly indicated, in priority order;
- nuisance alarms are minimised,
- alarms are limited to situations where action is required, and
- alarm “flooding” is minimised by showing only the highest priority alarms first during upsets that trigger multiple alarm conditions.

Because the UK ABWR is a highly-automated plant, often the “actions” required of the operator during alarm states are just to change monitoring “regime”. In other words, the operator needs to make themselves aware of the change in conditions that might threaten plant safety and monitor the automated system(s) response to ensure they operate correctly. In some cases, specific operator actions are required to maintain or restore the plant in a safe state. These are detailed in the list of HBSCs for UK ABWR as described in Chapter 27 Human Factors (GA91-9101-0101-27000) Section 27.5.

As described in Section 30.2, it is assumed that during normal and fault conditions, the CRO(s) are responsible for control of the unit and will refer to approved procedures and other operating documents as required to keep or return the plant to within its defined safe operating envelope. They are supported as required by the FOs who will monitor and control the plant at local control panels or at the plant equipment itself. The MCRS provides support and oversight to the CROs and FOs.

If an event progresses beyond design basis, and in particular if it develops into a severe accident, the operators are assumed responsible for implementing the applicable emergency operating procedures, and severe accident management guidelines, responding to emerging degraded plant conditions as required. The general Command and Control philosophy assumed to be in place for such events is described in 30.2.3.

30.3.1 Operating Procedures

The operating procedures for the UK ABWR consist of: operating rules and operating instructions. The operating rules are derived from the safety case and will define and justify the operating envelope. The operating rules are contained in the Technical Specifications. The operating instructions describe the tasks to be performed by the operators to monitor and control the plant. The operating procedures will encompass all planned evolutions and response to unplanned events.

30.3.2 Technical Specifications

The purpose of the Technical Specifications (Tech Specs) is to impose conditions or limitations upon reactor operation necessary to prevent the possibility of an abnormal situation or event giving rise to an imminent threat to nuclear safety. The Technical Specifications document defines the operational parameters and actions required to ensure that station operations remain inside the limits and requirements of the Safety Case, with a preserved level of margin (i.e. the operating envelope must always sit inside the safety case envelope), and contain the following:

- The operating limits for the parameters and system configurations
- The required actions when a parameter limit or system configuration is outside of the safe operating envelope
- The time limit allowed to return the parameter or system to within the safe operating envelope
- The surveillance that must be performed to verify parameter or system is within the safe operating envelope
- The frequency of the surveillance

The Tech Specs are derived from the assumptions contained in the safety case, defining the parameters and configurations of the SSCs required to ensure the safe operation of the plant. The criteria contained in the Tech Specs will be applied to each operating state and define the operability limits of a SSC, including its necessary auxiliaries, supports and electrical power supplies, to perform its functions and meet the safety objectives.

30.3.3 Maintenance and Inspection

Whereas the operators and MCR are remote from the plant systems and equipment, direct plant interactions are performed by the FOs (to support operations) and maintenance personnel. The goal of the maintenance personnel with respect to plant safety is to support the availability and operability of the SSC to perform its design function through the implementation of a preventative maintenance (PM) programme. The ability to access local control panels and plant equipment controls and indications, and effectively operate or maintain them has been considered throughout the UK ABWR design (plant layout, plant equipment, HMIs, etc.) using the HFE Spec [Ref-5] to implement applicable HF requirements from the list of standards and guidance applicable to relevant aspects of the design.

The Maintenance and Inspection programme will be established prior to the start of commissioning, will be updated to incorporate lessons learned from commissioning and will see continual improvements over the operational life of the plant.

The programme will be developed to maximise the availability and reliability of equipment such that the equipment performance achieves its design function, with the ultimate goal of avoiding in-service equipment failures and ensuring the ability of the plant to operate continuously between refuelling outages. The programme will include activities associated with reliability centred

maintenance, preventive maintenance (periodic, predictive, and planned), surveillance and testing and equipment performance and condition monitoring. The programme will be based on a clear understanding of the equipment, both in terms of the probability and consequence of failures. The equipment details will be provided by the equipment manufacturers and the maintenance schedules will be developed through the incorporation of relevant operating experience.

The distribution and allocation of maintenance, inspections and testing activities between outages and at power operation, requires due consideration of the plant configurations required to perform those activities. The plant configurations will be specified within the operational documentation and will ensure that the activities are ALARP and bounded by the Safety Case and Technical Specifications. Unit availability will be optimised through the performance of preventive maintenance activities both during power operation and during outages, and be aligned with the assumptions of the safety analysis. All maintenance activities will be concluded by post-maintenance tests to confirm that the equipment meets the specific performance criteria required by the plant.

When conducting on-line maintenance and testing, plant safety is achieved through the application of the Technical Specifications (Tech Specs), which detail minimum diverse plant (i.e. system “divisions”) availability/operability and time limits on degraded plant configurations before alternative actions must be taken. The bases for these controls are derived from the GDA safety analyses. The design of the UK ABWR to support these operational controls is described further in Section 30.4 Plant Status Control.

In order to optimise the PM programme, optimising availability whilst ensuring no unnecessary intervention is required on functional plant, the UK ABWR maintenance programme will outline the nature, extent and frequency of inspections, tests, overhauls and replacements of components and equipment based on Reliability-Centred Maintenance analysis methods. Such analysis methods takes inputs from the safety case and reliability data from operating experience. A robust PM programme maintains or replaces equipment before it fails but not more often than needed, and results in a highly reliable plant at reduced risk to personnel (i.e. radiation exposure, injury, etc.). An example of developing an Equipment Reliability-based PM programme is described in the industry guidance document, INPO AP-913 [Ref-8].

Support is assumed to be provided to operations and maintenance through a suitably implemented work management process that covers all areas and functions of the plant, for both online work and during outage periods (this may be covered by a separate work management programme specific to outage, for example Outage Management). These processes will be developed by the Site Licence Company and detailed in the site-specific PCSR. However, it is assumed that the process integrates, coordinates and schedules all plant activities and defines the responsibilities and interfaces between the functional organisations. It is also assumed to be designed to minimise the operational risk through the prioritised sequencing of tasks, detailed task analysis and risk assessments prior to work execution. An example of best practise in Work Management process is described in the industry guidance document, INPO AP-928 [Ref-9].

30.4 Plant Status Control

Operators are responsible for the control and monitoring of the status of the plant and are required to be fully aware of the operational state and availability/operability of SSCs, together with their associated functions, at all times. Operations personnel are assumed to ensure that equipment and systems are in the correct configuration and operating if required, and maintenance personnel are assumed to ensure that equipment is maintained, available and operable as required, in order to meet specified safe operating envelope for each plant state.

These envelopes and required plant configurations are established through the application of the Technical Specifications (Tech Specs). It is assumed that only suitably qualified and experienced personnel (SQEP) will perform operations and maintenance tasks at the station, and that work will only be performed once it has been authorised by operations.

The design of the plant is such that the plant status can be managed and controlled to facilitate the changes required to support periodic maintenance, modifications, and testing activities. Furthermore, various design features ensure that required minimum plant availability/operability is achieved at all times through interlocks and automatic realignment. Specifically, the ABWR includes such features as:

- Interlocks that prevent an operator from removing a system or component from service if it violates the Tech Specs.
- Interlocks that prevent certain restart sequences if identified plant is not yet brought online.
- SSCs requiring frequent test and inspection are made accessible and safe to do routine tasks on either locally or remotely, when online (minimising requirements to take plant out of service, which in turn reduces dose to personnel, risk of latent maintenance errors and risk of incorrect plant configuration).
- Lockout and isolation features throughout the plant to clearly identify SSCs that are not in service.
- Interlocking key systems (e.g. Fortress locking system) linked to operation to prevent leaving plant in an unavailable state.
- Automatic re-alignment on demand of any safety systems that might have inadvertently been left unavailable through being placed in bypass maintenance or test mode.
- Alarms for any SSCs required for safety-related operations that have become functionally compromised or unavailable.

30.5 UK ABWR Operations Personnel Description

This section provides a high-level description of the assumed or minimal requirements for the personnel who will be responsible for operations withn the UK ABWR. It is based on the User Group Description that is detailed in the COR [Ref-1]. It should be noted that the following are the basic details related to safe operations within UK ABWR, to the extent they can be determined within GDA. Many of these aspects of the operating organisation can only be developed fully by the Site Licence Company. As such this section is expected to be more completely populated during the site-specific PCSR stage.

30.5.1 Operations Personnel Overview

The operations crews at UK ABWR power plants are responsible for the safe and compliant operation of the plant; as such there is a minimum complement of operations personnel that are required to be on site and in post 24 hours a day and seven days a week. The formulation of a nuclear safety baseline (i.e. minimum or baseline organisation required to maintain nuclear safety) is a requirement of the UK regulator, but this can only be done by the operating organisation. For the purposes of GDA, the key operations staffing is assumed to be comprised primarily of: Operations Manager, Shift Managers, MCRSs, CROs, FOs, maintenance technicians, and day operations staff.

In addition to operating the reactor unit and balance of plant, these personnel will also:

- Perform on-line maintenance tasks in accordance with nuclear and other maintenance schedule.
- Perform survellance testing activities as required by the Technical Specifications or similar.
- Respond to unexpected events to prevent or mitigate their consequences.
- Isolate plant and equipment from service and release it for maintenance and testing.
- Accepting plant and equipment back into service upon completion of maintenance and testing.
- Process and store new and spent fuel.
- Conduct refuelling outages, which will include performing planned off-load maintenance.

30.5.2 Operation Complement

The UK ABWR will need to have a minimum complement of:

- One Shift Manager (for the entire station)
- One MCRS (for each reactor unit and each shift)†
- One CRO (for each reactor unit and each shift) †
- A suitable number of FOs (e.g. one reactor, one turbine, one BOP, one Radwaste); *exact number is still TBD.*

†Note it is expected the normal complement will be two CROs and a MCRS per shift per unit. However, the MCR needs a minimum of only two fully SQEP MCR operators and two FOs during all plant conditions to meet the requirements of this safety case. The MCR operators are assumed to

be either the MCRS and a CRO or two CROs if necessary (i.e. due to temporary absence of the MCRS). Due to independent checks and oversight tasks expected to be required of the Supervisor particularly during fault and accident scenarios, at least one person acting in the role of Supervisor or DAP (e.g. a delegated "lead" CRO) is required in the MCR at all times.

It is expected that this minimum number of personnel (i.e. two MCR operators plus two FOs) will be able to perform all operator functions in all plant conditions, noting that additional FOs from other units and the Shift Manager are also available to support as appropriate during fault and accident scenarios. This gives the bounding worst-case minimum MCR complement that has been used for all underpinning HF analysis within the UK ABWR safety case.

In addition to the above MCR personnel, if there are two reactor units, they are assumed to share the following support personnel to help achieve the overall operations and maintenance safety goals:

- FOs for common plant; *exact number still TBD*
- Technical Support specialists
- Fire Fighting and Safety specialists
- Administrative support persons
- Security specialists and officers.

30.5.3 Roles and Responsibilities

The following are the assumed main responsibilities for each of the job roles within the Operations shift; these are described in greater detail in the COR [Ref-1]. Note that these will be confirmed and further developed in the site-specific PCSR.

1) Shift Manager

   The Shift Manager is responsible for the safe and compliant operation of the power station. The Shift Manager oversees the activities of the entire plant. During accident scenarios, the Shift Manager is assumed to assist the MCRS in supporting and advising the CROs, particularly maintaining the overall incident and site "big picture" and incident management strategy. However, despite this assumption, note that the Shift Manager role within accident scenarios is not required as part of the minimum MCR operations complement within the safety case (see Section 30.5.2).

   For site incidents or nuclear emergencies, the Shift Manager is assumed to take control of the incident from whichever MCR is closest at the time of the particular event. As such, all the emergency response facilities will be duplicated in each unit's MCR. If a site incident is declared, the Shift Manager is assumed to be the acting Emergency Controller (EC) until the duty EC is confirmed as in-post and the Emergency Control Centre (ECC) is established.

2) MCR Supervisor

Each reactor unit will be under the supervision of a MCRS, who is responsible for safe and compliant operation of their respective unit. The MCRS is assumed to report to the Shift Manager and oversees the CROs and FOs.

The MCRS is assumed to act as the lead Duly Authorised Person (DAP) for their assigned reactor unit and is responsible for the release of nuclear safety related plant or equipment for maintenance. It is assumed that the DAP role with regards to releasing plant may be delegated to a DAP situated within the Maintenance Facility, to help minimise distractions within the MCR.

The MCRS is assumed further responsible for such things as:

- services and fire protection for their respective unit;
- overseeing access and egress to and from the MCR;
- transmitting instructions and information between the National Grid and the CRO.

During an emergency or incident, the MCRS is assumed to maintain oversight of their unit and its MCR crew, including FOs. The MCRS is further assumed to independently verify plant conditions and success paths for recovery from incidents (such as independent verification of fault diagnosis, successful actuation of required safety functions and monitoring of critical safety functions).

3) Control Room Operator

The CROs are responsible for control and monitoring of the main plant items from within the MCR. All MCR operators will be DAPs with the competency and ability to operate all interfaces at any console within the MCR. In the case where the MCRS is temporarily absent, a second CRO is assumed to be assigned to that role whilst the first CRO remains in control of the unit.

In the event of plant faults and design basis events, the CROs are assumed responsible for monitoring the automated responses have implemented correctly for achieving control of the affected systems or plant equipment, and if necessary taking action to provide backup in the case where automated systems have failed.

4) Field Operator

The unit will have a suitable number (*exact complement TBD*) of dedicated FOs. The FOs will take direction from the MCR and perform: plant patrols, routine simple maintenance (procedurally governed), surveillance checks and actions local to plant. Designated FOs will also perform isolations of plant for maintenance.

During an incident or emergency, two FOs are assumed designated to assist the respective unit's MCR with any actions local to plant. The remainder of the FOs are assumed available to support the Emergency Response Team (ERT) and come under the command of the Shift Manager or EC. In particular the FOs are expected to help with the "first responders" for fire and safety response, personnel who deal with the incident local to plant until relieved by local emergency crews in the event of a fire or first aid incident, or the on-call emergency response crews.

5) Shift Maintenance Personnel

The exact composition of the maintenance organisation is still TBD, but will be designed to match the requirements of the proactive PM programme currently being developed.

30.5.4 Physical Capabilities and Attributes

To ensure the environment and equipment are designed to allow the UK ABWR user group to perform their required tasks effectively and safely, the considerable variations in shapes, sizes and strengths of users, as well as the task requirements have been considered throughout the GDA HF design activities. Workspaces will be designed based on the defining or limiting physical characteristics (e.g. arm length, shoulder width, height, etc.); this process will allow the workspaces in the plant to be designed in such a way that they will be usable by the whole range of potential users. For example, providing access for the tallest and broadest of users whilst ensuring the smallest user can reach and use all necessary controls.

For the purposes of design, the UK ABWR user group has been defined as being within the UK 5th percentile female to the 95th percentile male range. Further information on the sources of anthropometric data, how it will be used and how compromises with other design requirements will be managed can be found in the COR [Ref-1].

30.5.5 Training and Competence

Each job role within the UK ABWR Operations organisation is expected to have a set of basic requirements in terms of qualifications, training and experience for the individual to be considered competent. These role specific requirements and any additionally general training that all Operations staff will be expected to have completed are described in more detail in the COR [Ref-1]. However, these aspects of the operating organisation can only be fully developed by the Site Licensee.

The assumption for all HF analysis underpinning the GDA PCSR is that training and competence is adequate to allow any job role to carry out the expected actions related to safety knowledgeably and within a timely manner.

30.5.6 Social and Cultural Characteristics

Previous experiences within different social, cultural and industrial backgrounds lead to the creation of mental models that drive an individual's expectations for what is considered normal in regards to behaviours, team dynamics, terminology, etc. These expectations can influence task performance and as such they have been considered during GDA both within the design (e.g. UK expectation for control direction meaning) and within the HF analysis through the use of performance influencing factors in human error analysis.

Information on the specific social, cultural and industrial characteristics and stereotypes considered during the design phase of the UK ABWR is further detailed within the COR [Ref-1].

30.6 References

[Ref-1] Hitachi-GE Nuclear Energy, Ltd., “Human Factors Concept of Operations Report”, GA91-9201-0001-00034 (HFE-GD-0060), Revision B, May 2015.

[Ref-2] Hitachi-GE Nuclear Energy, Ltd., “UK ABWR GDA: Human Factors Integration Plan”, GA32-1501-0007-00001 (HFE-GD-0058), Revision D, October 2015.

[Ref-3] Hitachi-GE Nuclear Energy, Ltd., "UK ABWR GDA: Human-Based Safety Claims Report", GA91-9201-0001-00043 (HFE-GD-0064), Revision B, October 2015.

[Ref-4] Hitachi-GE Nuclear Energy, Ltd., “UK ABWR GDA: Baseline Human Factors Assessment Report”, GA91-9201-0001-00032 (HFE-GD-0068), Revision B, August 2015.

[Ref-5] Hitachi-GE Nuclear Energy, Ltd., “UK ABWR GDA: Human Factors Engineering Specification”, GA91-9201-0001 -00037 (HFE-GD-0001), Revision B, May 2015.

[Ref-6] Institute of Nuclear Power Operators, “Human Performance Tools for Workers”, INPO 06-002, April 2006.

[Ref-7] Institute of Nuclear Power Operators, “Procedure Use & Adherence”, INPO 09-004, February 2009.

[Ref-8] Institute of Nuclear Power Operators, “Equipment Reliability Process Description”, INPO AP-913, November 2001.

[Ref-9] Institute of Nuclear Power Operators, “Work Management Process Description”, INPO AP-928, Novermber 2007