

UK ABWR

Document ID	:	GA91-9101-0101-05005
Document Number	:	HPE-GD-H019
Revision Number	:	A

UK ABWR Generic Design Assessment

Generic PCSR Sub-chapter 5.5 : Qualification of SSCs



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5.5.1 Introduction

This section defines the environmental conditions with respect to limiting Operating conditions for the mechanical and electrical equipment delivering the safety function, and documents the qualification methods and procedures employed to demonstrate the capability of this equipment to perform safety functions when exposed to the environmental conditions in their respective locations.

5.5.2 Definition of EQ

UK ABWR designs to provide several reliable levels and methods of protection to minimize the occurrence of NPP accidents, to mitigate their radiological consequences and to prevent the release of radioactive materials. Fundamental to providing such reliable protection is the need to ensure that safety systems and equipment are capable of performing their safety functions when required during Nuclear Power Plant (NPP) operational conditions defined in sub-section 5.5.3.2.

Definition of Equipment Qualification (EQ) is such that the qualification of mechanical and electrical equipment important to safety in UK ABWR ensures its capability to perform designated safety functions on demand under postulated environmental conditions including accident environment (e.g. Loss of Coolant Accident (LOCA), High Energy Line Break (HELB) and seismic or other vibration conditions). EQ demonstrates that equipment designs are capable of functioning under such environment conditions.

EQ is an important design tool whenever safety equipment has to tolerate environmental conditions that could cause equipment failures.

EQ process consists of as follows basically;

- Identifying safety functions and equipment requiring qualification
- The set of operating conditions existing when the performance of equipment has to be accomplished
- Selecting appropriate qualification methods and establish qualification

5.5.3 Scope of application for EQ

5.5.3.1 Identifying safety functions and equipment requiring qualification

Safety equipment need only be qualified for the operating conditions when specific equipment safety functions are required.

Safety functions are identified to prevent or reduce the radiological risk for all identified faults and they are then categorized according to their importance for safety, and equipment that deliver each safety function are identified and assigned a classification based on the importance of the safety

functions they perform. The safety functions of UK ABWR, the safety categorization of those safety functions and the safety classification of equipment delivered those safety functions are defined in Generic PCSR Sub-chapter 5.4.

In principle, the mechanical and electrical equipment of UK ABWR which delivers safety function as a safety class 1 and 2 equipment are qualified according to EQ process.

5.5.3.2 Specifying Operating Conditions

Safety equipment must perform its proper safety function during normal, abnormal, test, design basis accident and post-accident environments as applicable.

The Operating Conditions (Operating Condition I, Operating Condition II, Operating Condition III, Operating Condition IV) for which qualification is to be established need to be selected so as to provide confidence in equipment performance during expected Operating conditions.

The expected Operating conditions are defined in Generic PCSR Sub-chapter 5.2.

Environmental conditions are typically considered during EQ concern ambient temperature, pressure, humidity/steam, radiation, and seismic vibration, and generally involve process related conditions such as vibration, load cycling, electrical loading parameters, Electromagnetic Interference (EMI), mechanical loads and process fluid conditions (e.g. pressure, temperature, chemistry, cavitation, flow rate).

5.5.3.3 Selecting appropriate qualification methods and establish qualification

EQ process includes qualification prior to initial equipment installation and subsequent requalification or replacement during the life of the plant as appropriate to demonstrate continuous fulfillment of performance requirements.

The methods of qualification are:

- (1) Performance of a type test on equipment representative of that to be supplied;
Performance of an actual test on the supplied equipment;
- (2) Application of pertinent past experience in similar applications;
- (3) Analysis based on reasonable engineering extrapolation of test data or operating experience under pertinent conditions.
- (4) An appropriate combination of these three methods.

5.5.4 Qualification method of facilities and functions (Provisional)

5.5.4.1 General

Equipment Qualification (EQ) verifies that equipment with safety function is operated as expected in design under those environment conditions considered according to internal hazard, external hazard and fault study. Hitachi-GE Nuclear Energy, Ltd. (Hitachi-GE) evaluates the validity and the effectiveness of equipment with safety function by means of verification test, analysis or comparative evaluation of Japanese past verification data. Test conditions such as the environment simulating severe accidents, postulated accidents, and transient conditions that are specified by internal hazard, external hazard and fault study, as well as dynamic load, static load and functional requirement of equipment are described in each design specification.

Qualification test, analysis evaluation or evaluation of past verification data will be compiled on a report after clarifying its verification method (qualification test/analysis).

5.5.4.2 Synergistic Effect

Equipment Qualification test condition is assessed individually as far as possible only if any significant synergistic effect would not occur, in order to evaluate the impact on equipment properly. If synergistic effects caused by interrelated events are assumed, it is considered in test specification of Equipment Qualification.

5.5.4.3 Mild Environmental Condition

Implementation of qualification test or analysis according to each environment is permissible under the environment conditions such as Main Control Room and electric panel rooms. Temperature, moisture, and radiation condition under severe accident is not applied to Main Control Room, control panel of electric panel rooms, and racks.

5.5.4.4 ASME B&PV Code Sec. III

Equipment that is not related to dynamic function qualification, such as pressure component and core support structure manufactured in accordance with ASME B&PV Code Sec. III is substituted for qualification test by the analysis evaluation in the design report since combination load condition is taken into account in the design report.

5.5.4.5 IEC60780

Equipment Qualification is performed on electrical and instrumentation products in accordance with IEC 60780. Test items and condition for each equipment are specified in design specification of each equipment. All or a part of test items might be evaluated by analysis or past verification results.

Furthermore, it is evaluated by other code and standard such as IEEE Std 334 after consideration of gap analysis with IEC 60780.

5.5.4.6 Equipment Qualification

Equipment Qualification on applicable items is planned and carried out after considering the 60 years design life or the equipment life specific to product. The design life is evaluated and verified by qualification test, analysis or past verification data. If the design life of the expiration date is set, requirements for maintenance, surveillance, and periodic test are also specified in order to maintain the structural integrity of equipment.

The following test specification is considered when performing Equipment Qualification.

- (1) Because semiconductor device may cause impairment of the computer based control devices due to the influence of magnetic field, thermal and radiation environment and Electromagnetic Compatibility (EMC) testing is performed. EMC test condition specifies thermal environment and radiation environment, taking into account the environment at Operating Condition I, Operating Condition II, Operating Condition III, Operating Condition IV, based on internal hazard, external hazard and fault study. In thermal environment, the influence of pressure, temperature, and moisture are considered. EMC is performed to consider the influence of transient, conducted noise, emissions at working site, and resistance to electromagnetic waves.
- (2) Product function and function time
When the operation of equipment with safety function is verified, the time until its safety function is operated and the time that safety function is maintained, are taken into consideration.
- (3) Plant events and combination of events based on internal hazard, external hazard and fault study
Qualification requirement for the significant equipment among those with safety function needs to consider plant events. It is specified plant events that should be considered on equipment specifications and Equipment Qualification procedures of each equipment. Moreover, if events occur at simultaneously or sequentially within the scope of reasonable assumption, verification condition is considered.

5.5.4.7 Qualification of Seismic Load and Dynamic Load

Seismic and dynamic qualification for system and component is performed in terms of structural integrity and functionality. The qualification is basically in accordance with ASCE 43. The detailed qualification methods are based on ASME Sec. III and IEC 60780 for structural integrity, and are based on ASME QME-1, IEC 60980, IEEE Std 344, etc. for functionality.

The principle of seismic and dynamic qualification is to confirm that the capacity of equipment exceeds demand of that. The demand of equipment is derived from required response spectrum based on dynamic analysis. The capacity of the equipment is evaluated by test, analysis, experienced data in actual plants or combination of test and analysis.

5.5.4.8 Recommended Qualification Code and Standard

Recommended code and standard for Equipment Qualification are as follows. If necessary, designer may establish the test items.

Qualification for structural integrity

Equipment Name	Qualification Code and Standard
Vessel, incl. Heat Exchanger Piping Pump Reciprocating Pump Valve Dynamic Support Structure	ASME Sec. III Subsection NB, NC, ND
Metal Containments	ASME Sec. III Subsection NE
Support (Dynamic support Structure)	ASME Sec. III Subsection NF
Core Support Structure	ASME Sec. III Subsection NG

Qualification for functionality

Equipment Name	Qualification Code and Standard
SSCs with dynamic and electrical function <ul style="list-style-type: none"> • RCIC Turbine • Electric Motor • Fan • Damper • Emergency DG • Pump • Valve • Dynamic Support Structure 	ASCE 43 ASME QME-1 IEC 60780 IEC 60980 (IEEE Std 344)

Qualification for Electric and I&C

Equipment Name	Qualification Code and Standard
Electric parts	IEC 61000-SER IEC 60780 IEC 60980

5.5.5 Qualification Documentation

Hitachi-GE verifies the environment, earthquake-proof, and dynamic function maintenance by dynamic load that are specified in design specifications, and prepares qualification documentation. Safety function and critical characteristics required for product and equipment are clarified, and relationship between verification test, analysis or design evaluation and qualification record is comprised in qualification documentation. Qualification documentation ensures the traceability of product or installation product which is delivered to nuclear power plant.

5.5.5.1 Qualification Plan

Qualification test is carried out on equipment with safety function in accordance with Qualification Plan. Qualification Plan states the testing procedures, environment and also equipment. Test items are generally determined based on the provision of recommended code and standard, but for equipment proven in reference plant, the design department may specify a verification test, analysis item or technical assessment separately at the Design Review.

5.5.5.2 Instructions and Implementation of Qualification Test

Qualification test is carried out and instructed in accordance with qualification plan. For verification of equipment with significant safety function, verification by the third party inspection agency might be included depending on the importance of verification items.

5.5.5.3 Qualification Test Report

Qualification test report basically describes all test results and verification results. Typical report items are listed below.

- (1) Overview of Test Results
- (2) Consideration of Test Results
- (3) Technical Specification in regards to Product Qualification Test
- (4) Specific Condition and Resolution
- (5) Qualification test results is reviewed and approved. The person responsible is required to be approved for Qualification test.

5.5.6 References

[Ref-1] IAEA SAFETY REPORTS SERIES No.3- Equipment Qualification in Operational Nuclear Power Plants: Upgrading, Preserving and Reviewing [1998 Edition]