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Plan

Equipment Qualification Program

The objective of the Equipment Qualification is to plan, implement, provide the evidence and preserve the capability of Protection Important Component to fulfil intended service conditions. The demonstration of this capability has to be ensured through a program that includes design control, procurement, qualification, quality control, delivery, installation, commissioning, operation maintenance, periodic testing and surveillance.The objective of this Equipment Qualification Program is to define the strategy and the organization for the PIC equipment qualification, in alignment with the... (Please see complete abstract on document metadata.)

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Change Log			
Equipment Qualification Program (XB5ABP)			
Version	***Latest Status***	***Issue Date***	***Description of Change***
v1.0	Revision Required	05 Oct 2018	
v1.1	Revision Required	06 Dec 2018	Comments from reviewers implemented: - 7.2: SROs added in the workflow diagram; - 8.6: RACI matrix updated to change accountability for qualification plan and for the list of the equipment; - 9.16: Sign-off authority updated to change approver of the qualification dossier; - 2: clarify the how to proceed for qualification of passive mechanical components.
v1.2	Approved	07 Feb 2019	Reference 19, 38 and 39 modified. Item #5 in Sect. 1 refers to Sect. 0. => correction implemented Definition of Active Equipment (Sect. 3.2): considered an active equipment -> considered active equipment => correction implemented

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1 Purpose

This document provides the Equipment Qualification Program applicable to ITER.

The objective of the Equipment Qualification is to plan, perform, provide evidence (document) and maintain (preserve) the capability of Protection Important Component (PIC) to perform the required safety function(s) without experiencing common-cause failure during normal, incidental and accidental conditions.

The demonstration of this capability has to be ensured through a program that includes design control, procurement, qualification, quality control, delivery, installation, commissioning, operation maintenance, periodic testing and surveillance.

The Equipment Qualification refers to a qualified life with specific qualification conditions.

Preserving the Equipment Qualification during installed life has to be guaranteed through the execution of specific instructions defined in the Operation and Maintenance Plan based on the outcomes of the Equipment Qualification (see Qualification Preservation Sheet in § 9.11).

The objective of this Equipment Qualification Program is to define the strategy for the PIC equipment qualification, in alignment with the Systems Engineering Management Plan [R01]. It represents a Plan Level 3 of the SEMP in the frame of the verification process [R11].

The overall workflow diagram for execution purpose is presented in § 7.2.

This document provides the organization and methods for equipment qualification and it specifies:

1. The scope of equipment to be qualified according to their safety function(s) (§ 2);
2. The purpose of qualification process and its role in the safety demonstration (§ 7.1);
3. The qualification condition(s) to be considered, such as normal conditions, seismic conditions and other accidental conditions, electromagnetic field, etc. (§ 10 and 10.12);
4. The methods to be used for qualification demonstration (§ 11);
5. The documents necessary to provide the evidence of equipment qualification (§ 9);
6. The instruction to be implemented for preserving the qualification during the whole equipment life (design, procurement, manufacturing, transportation, installation, commissioning, operation and maintenance) (§ 9.11);
7. The management of qualification modification, which could include equipment change, plant life extension, qualification conditions modification, etc. (§ 8.4).

2 Scope

The Equipment Qualification Program applies to all ITER Protection Important Components[1] including:

- Electrical equipment;
- Instrumentation and Control equipment;

1 For the purpose of this document it is considered that the term component is equivalent to term equipment.

- Electro-mechanical and mechanical equipment.

The equipment qualification includes the qualification the entire mechanical and control chain of the equipment in the scope and it requires the identification of sub-equipment to be qualified, such as actuators, limit switches, electrical connections, and all equipment, components and materials which failure can compromise the intended function, such as lubricants, bellows, etc.

The equipment shall be qualified to defined environmental conditions (normal, incidental and accidental) from manufacturing until decommissioning.

Note 1: The equipment qualification also includes the functional qualification.

Note 2: The extension of the Equipment Qualification Program to non-PIC equipment can be considered for Investment Protection purposes.

Note 3: The Safety Relevant (SR) components, as defined by ITER, do not require environmental qualification (see the SR definition in § 3.2 and [R24], Annex C).

Note 4: Qualification methods and/or instructions are provided in dedicated documents, as indicated in § 9.1, and the complete set of references will be added to the EQP in a future version.

Note 5: The evidence of the capability of passive equipment, such as heat exchangers, vessels, piping, etc., to perform the intended functions is mainly related to the compliance with specific Standards and Technical Codes for design, quality assurance, manufacturing, tests, analyses, etc. as proven by suitable documentation. However, specific needs for including passive equipment into the scope of this Equipment Qualification Program based on a case-by-case analysis and using the equipment list as input. This document does not include the qualification required by the pressure equipment directive and relevant French regulation for nuclear facilities. . In particular, when a static component shall be qualified by test and not only by calculation, it will be included in the qualification plan.

Note 6: This document does not include the qualification required by the pressure equipment directive and relevant French regulation for nuclear facilities.

3 Definitions and acronyms

3.1 Acronyms

For a complete list of ITER abbreviations refer to: ITER_D_2MU6W5.

ASN	French Nuclear Safety Authority (from French Autorité de Sûreté Nucléaire)
CDR	Conceptual Design Review
CIO	Central Integration Office
CMM	Configuration Management Model
DA	Domestic Agency
DIR	Design Integration Review
EQP	Equipment Qualification Program
ESPN	Nuclear Pressure Equipment (Equipement Sous Pression Nucléaire)
FDR	Final Design Review
FRS	Floor Response Spectra
INB	Basic Nuclear Installation (Installation Nucléaire de Base)
MRR	Manufacturing Readiness Review

NA	Not Applicable
NB	Notified Body
NSQ	Note de Synthèse de Qualification
PBS	Plant Breakdown Structure
PDR	Preliminary Design Review
PIA	Protection Important Activity
PIC	Protection Important Component
RO	Responsible Officer
SD	Safety Department
SR	Safety Relevant
SSC	Structure(s), System(s) and Component(s)
TBD	To Be Defined
TF	Transverse Function
TRO	Technical Responsible Officer

3.2 Definitions

Accidental conditions

Includes accidental and post-accidental conditions.
These are conditions caused by postulated event sequences that are not likely to occur during the life of the plant.
These events require activation of emergency safeguards systems to protect the plant.
Post-accidental conditions are the plant conditions after the occurrence of an accidental situation. Some safety relevant equipment shall stay operational after an accident.
See definition in [R30].

Active Equipment

Active equipment is defined as equipment that is controlled or operated manually or automatically by a driving mean.
Automatic equipment (that operates without needing of external power and control) is considered active equipment since its position changes when it performs the required function (e.g. a safety valve or check valve).
See definition in [R30].

Configuration Control

Configuration control ensures that all changes, deviations and waivers to agreed configuration baselines, including their released and approved documentation are processed and controlled in a traceable manner.
Additional information is available in ITER_D_TZY7YV - Procedure for Configuration Control, Review and Audit.

Environmental Conditions

The expected temperature, pressure, humidity (including submergence or impingement), chemical, radiation, seismic, electromagnetic interference, ageing, etc. that a SSC may experience during normal, incidental and accidental conditions at the location within the facility at which the SSC is installed.

Equipment	In this context equipment is a generic term used to call any element of a system including components that provides at least one function. For the purpose of this document it is considered that the term component is equivalent to term equipment.
Equipment Qualification	Generation and *maintenance* of evidence to ensure that equipment performs the intended functions under given environmental conditions that may arise during their service. See definition in [R30].
Family of Equipment	Equipment with same technology, design, manufacturer and similar size. Rule for definition of family of equipment shall be established and/or proposal provided in the qualification plan. The family of equipment is qualified for a given function to be performed under defined environmental conditions, and for given qualified life. Any equipment belonging to a given family could be considered "qualified by similarity".
Incidental conditions	Deviations from normal operation, event sequences or plant conditions that are not planned but that are likely to occur due to failure of one or more times during the life of the plant. The categorisation of an event as either an incident or an accident is done mainly according to its likelihood. List of incident and accident referenced in Table 2.2.1 in ITER_D_2DPVGT - Accident Analysis Report (AAR) Volume I - Event Identification and Selection
Installed Life	The installed life is the period from equipment installation to its removal, during which it is subject to established conditions, normal and/or accidental conditions.
Normal operational conditions	Includes operation, testing, and maintenance. Events and plant conditions that are planned and required for ITER normal operation, including some faults, events or conditions that can occur as a result of ITER's experimental nature (for example, disruption type I, very small leaks that we expect to be accommodated within the operational procedures).
Notified Body – NB	Technical organisation, either for approval and monitoring of the manufacturer's quality assurance system or for direct product inspection for the manufacture of Pressure Equipment.
Operational conditions	Includes all operational conditions, storage, normal, incidental, accidental and post accidental conditions
Passive Equipment	Passive equipment is mechanical equipment with no moving part nor change of physical status to accomplish the intended safety function.

Protection Important Activity	As per article 1.3 of the INB Order 7th February 2012 [R05]: *"Activity important for protecting the interests mentioned under Article L. 593-1 of the Environmental Code (public safety, health and sanitation, the protection of nature and of the environment), i.e. activity that falls under the technical or organizational provisions mentioned under the second paragraph of Article L. 593-1 of the Environmental Code or that is liable to affect them;"* These activities include design, purchase, fabrication, manufacture, construction, assembly, installation, testing, commissioning, operating, maintenance, modifications and the most of sub-activities under these ones (non-exhaustive list).
Protection Important Component - PIC	Specific category of Systems, Structures or Components as defined per articles 1.3 and 2.5.1 of the INB Order 7th February 2012 [R05]: *"A component which is important for protecting the interests mentioned under Article L.593-1 of the Environmental Code (nuclear security – i.e. nuclear safety, radiation protection, the prevention and fight against malicious acts, and also civil security actions in the event of an accident –, public health and sanitation or protection of nature and the environment), i.e. structure, equipment, system (programmed or not), material, component or software that is present in the basic nuclear installation or that is under the responsibility of the operator and that implements a function required for the demonstration mentioned under the second paragraph of Article L. 593-1 of the Environmental Code (safety demonstration) or that ensures that this function is implemented;"* As stated in article 2.5.1 of INB Order, the list of ITER Protection Important Components (PIC) shall be set up and kept updated by IO.
Qualified Life	The qualified life is the period of time for which the equipment is demonstrated to meet the design requirements for the specific service conditions.
RACI matrix	Matrix which describes the participation by various roles in completing tasks. - **R**esponsible: Those who do the work to complete the task. - **A**ccountable: Those who makes ultimate decision and take actions on the task. - **C**onsulted: Those whose opinions are sought, typically subject matter experts. They are consulted for review, prior to a final decision or action. - **I**nformed: Those who are kept up-to-date on progress, often on completion of the task. They may be required to take action as a result of the outcome.
Requirement	Need or expectation that is stated, generally implied or obligatory.

Safety Functions	See definition provided in [R30]. Principal safety functions at the ITER facility are: - Confinement of radioactive and toxic substances to prevent their release - Limitation of external exposure to ionizing radiation.
Safety Relevant - SR	Among systems not classified as PIC, a Safety Relevant category was introduced in order to identify systems that may have some relevance to safety. They are not credited in the safety analysis and their failure would not impact any safety function. Concerning the design phase, no safety requirements are defined for these SR components. In operation, some requirements, such as periodical maintenance, could be defined [R24].
Safety requirements	The defined requirements as per the INB Order 7th February 2012 [R05]: "*requirement assigned to an element important for protection, so that it fulfils - with the required characteristics - the function provided for in the demonstration mentioned in the second paragraph of article L. 593-7 of the environment code, or to an activity important for protection so that it meets its objectives with respect to that demonstration"*

4 Reference documents

[R01] ITER Systems Engineering Management Plan (SEMP), ITER_D_2F68EX

[R02] Project Requirements (PR), ITER_D_27ZRW8 v5.3

[R03] Preliminary Safety Report (RPrS), ITER_D_3ZR2NC v3.0

[R04] Project Issue Management Procedure, ITER_D_SSU96T v1.3

[R05] Order dated 7 February 2012 relating to the general technical regulations applicable to INB – EN, ITER_D_7M2YKF v1.7

[R06] Nuclear safety common definitions, ITER_D_RLZXMV v2.0

[R07] 00 - Nuclear Regulatory Framework for INB ITER, ITER_D_2WBB8P v3.8

[R08] Analysis of regulation applicable to ITER INB, ITER_D_TQPJJG v1.3

[R09] Qualification guidelines ITER_D_WGFF3G v1.0

[R10] Design Change Control Procedure, ITER_D_U2QPDS v2.0

[R11] Design Verification and Validation Procedure, ITER_D_R3KD8C v2.1

[R12] EEE Nuclear Radiation compatibility Handbook, ITER_D_U65BH5 v2.1

[R13] Procedure for Analyses and Calculations, ITER_D_22MAL7 v5.1

[R14] Instructions for Structural Analyses, ITER_D_ 35BVV3 v2.1

[R15] Instructions for Seismic Analyses, ITER_D_VT29D6 v1.3

[R16] Instructions for Electromagnetic Analyses, ITER_D_TSZ9KQ v2.9

[R17] Instructions for Nuclear Analyses, ITER_D_R7XRXB v4.3

[R18] Technical Specification for the Experimental Seismic Qualification of Active Electrical and Mechanical Components, ITER_D_AGL2QP v2.1

[R19] Instructions for the use of MFM (ITER_D_XETY2P)

[R20] Design Seismic Floor Response Spectra in the Tokamak Complex, ITER_D_SVBRJZ v1.1

[R21] Global Tokamak Seismic Analysis Report, ITER_D_33W3P4 v2.1

[R22] ITER Buildings Floor Response Spectra, ITER_D_PVC9VH v2.3

[R23] PIC classification by PBS, 96D8CQ

[R24] Safety Important Functions and Components Classification Criteria and Methodology, ITER_D_347SF3 v1.8

[R25] IO Template of Qualification Synthesis Report, ITER_D_X3AUHZ v1.1

[R26] Safety Requirements Roombook, ITER_D_KF63PB

[R27] Electrical Design Handbook (EDH), 2DSPT6

[R28] ITER System Design Process (SDP) Working Instruction, ITER_D_4CK4MT

[R29] PRE-REVIEW_DR_L2_MQP doc Request WYKZ3A - Sign-Off Authority for Project Documents, ITER_D_X5EN8E

[R30] IAEA Safety Glossary – Terminology used in Nuclear Safety and Radiation Protection 2007 Edition

[R31] Design Planning Procedure [[ITER_D_U34ACR v1.2]

[R32] Design Input Control Procedure [ITER_D_U34CSG v1.2]

[R33] Procedure for the Selection and Modification of the Codes and Standards [ITER_D_46A9KC v2.2]

[R34] Design Development Procedure [ITER_D_U34DDZ v1.1]

[R35] ITER System Design Process (SDP) Working Instruction [ITER_D_4CK4MT v1.0]

[R36] Project Change Procedure [ITER_D_22F4E5 v7.1]

[R37] Procedure for Configuration Management Planning [ITER_D_TZY8BS v1.4

[R38] EDH Part 4: Electromagnetic Compatibility (EMC) [ITER_D_4B523E v3.0]

[R39] Test method for ITER equipment for static (d.c.) magnetic fields [ITER_D_98JL4W v3.3]

The reference to the equipment qualification methods/instructions will be added in a future version of this program. These methods are under development.

5 Regulations, codes and standards

[R40] UNI 8704 – Nuclear power plants — Qualification methods for safety-related equipment

[R41] CEI 45-60 – Nuclear power plants – Electrical equipment of the safety system – Qualification (corresponding to IEC 60780)

[R42] CEI 45-62 – Recommended practices for seismic qualification of electrical equipment of the safety system for nuclear generation stations (corresponding to IEC 60980)

[R43] IEC 60780 – Nuclear power plants – Electrical equipment of the safety system – Qualification

[R44] IEC 60980 – Recommended practices for seismic qualification of electrical equipment of the safety system for nuclear generation stations

[R45] IEC 61226 – Nuclear power plants – I&C important to safety – Classification of I&C functions

[R46] IEC 61513 – Nuclear power plants – I&C important to safety – General requirements for systems

[R47] IEC 62138 – Nuclear power plants – I&C important to safety – Software Aspects for Computer-Based Systems Performing Category B or C Functions

[R48] IEC/IEEE 61508 – Functional safety of electrical/electronic/programmable electronic safety-related systems".

[R49] IEEE 323 – 2003 – IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations

[R50] RCC-E Décembre 2012 Edition – Design and Construction Rules for Electrical Equipment on Nuclear Islands

[R51] RCC-M – 2017 – section VI – Probationary phase rules – Volume Q – Qualification of active mechanical equipment (pumps and valves) requiring qualification to accident conditions

[R52] IEC 60695-11-10 - Fire hazard testing – Part 11-2: test flames – 1 kW nominal pre-mixed flame – Apparatus, confirmatory test arrangement and guidance

[R53] IEC 60544-2 - Guide for determining the effects of ionizing radiation on insulating materials. Part 2: procedures for irradiation and test.

All applicable regulations, codes, standards and guidance documents are listed in the Nuclear Regulatory Framework for INB ITER [R07].

6 Applicable procedures

Table 1: Procedures allocation matrix

	Design Development Plan, including the EQP portion	Equipment Qualification Program				
		1. Definition of equipment qualification methodology	2. Collection of input data	3. Development of qualification plan	4. Implementation of the qualification	5. Qualification summary
Design Planning Procedure [R31]	X					
Design Input Control Procedure [R32]		X	X			
Procedure for the Selection and Modification of the Codes and Standards [R33]	X	X		X	X	
Design Development Procedure [R34]	X					
ITER System Design Process (SDP) Working Instruction [R35]					X	X
Design Verification and Validation Procedure [R11]		X	X	X		X
Design Change Control Procedure [R10]					X	
Project Change Procedure [R36]					X	
Procedure for Configuration Management Planning [R37]	X					
Qualification Guidelines [R09]		X	X			

7 Equipment qualification program

7.1 Qualification process

The conditions to be satisfied for operating PIC equipment are related to both equipment qualification and manufacturer assessment, as listed hereafter:

- The PIC equipment has to be able to perform the intended function(s) for a defined duration, within intended environmental conditions (equipment qualification);
- The manufacturer has to be able to produce equipment conforming to the equipment requirements.

The equipment qualification process is based on the following:

1. The definition of the qualification methods and standards, see phase 1 in the qualification workflow in § 7.2;
2. The definition of qualification input, such as qualification requirements, related to operational conditions and intended function:
    a. Detailed list of equipment to be qualified;
    b. Relevant Safety Functions expected to the fulfilled and for which evidence of equipment qualification shall be provided;
    c. Environmental Conditions, depending on the equipment location and operating scenarios;
    d. Acceptance criteria for equipment qualification.

    see phase 2 in the qualification workflow in § 7.2;
3. The definition of the qualification plans defining qualification approach, according to qualification inputs and qualification methods, see phase 3 in the qualification workflow in § 7.2;
4. The evidence that equipment fulfils the intended safety function(s): this demonstration is generally afforded by testing, analysis, operating experience, etc. and it is proven by the preparation of the Qualification Dossier (§ 9.5) which includes the Qualification Synthesis Report (§ 9.9); in this phase it is required to provide the engineering documents and relevant instructions for preserving equipment qualification during the full lifecycle, of design, manufacturing, delivery, packaging transportation, installation, operation and maintenance, all relevant for the qualified equipment; see phase 4 in the qualification workflow in § 7.2.

In addition, the following is to be guaranteed as well:

5. The quality control of equipment manufacturing, packaging, transportation and delivery; this is to be controlled under the quality control process, and evidence to be recorded for demonstration of the compliance with the ITER Qualification Summary Report (see § 9.12);
6. The qualification preservation during storage, installation, operation and maintenance, performed implementing the instructions defined above and providing the evidence of that; this is to be controlled under the handling, storage and transportation process, the assembly and installation process, the operation and maintenance process; evidence

shall be recorded for demonstration of the compliance with the ITER Qualification Summary Report (see § 9.12);

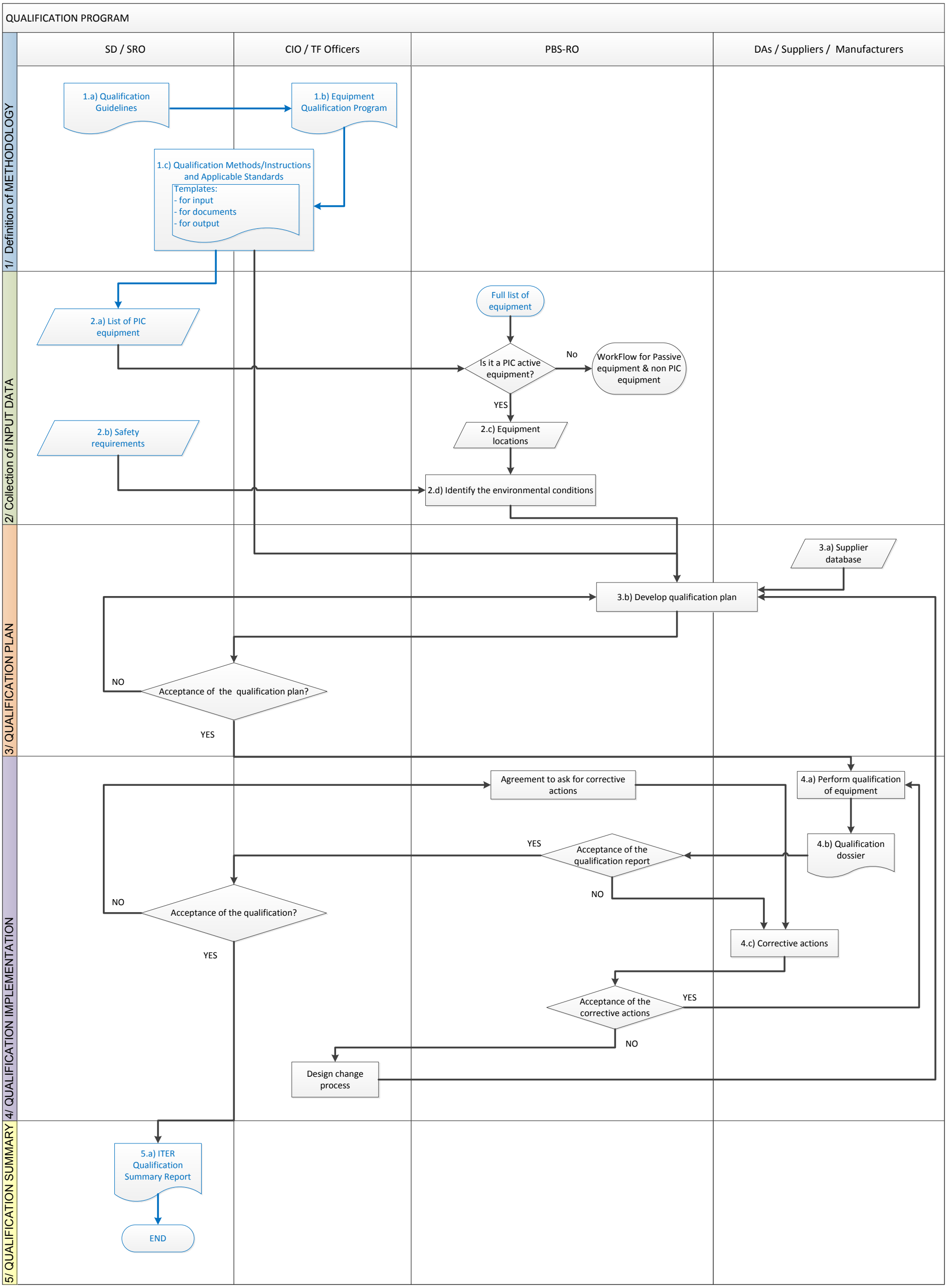
7. The traceability of any equipment modifications, through the update of the Reference File (see § 9.10.) under the manufacturer responsibility.

All the ITER processes are provided in the ITER Management and Quality Program.

7.2 Workflow diagram

Note:

- In blue: project level workflow, general process or data applicable to all equipment;
- In black: single equipment workflow, applicable to each single equipment or family of equipment.


QUALIFICATION PROGRAM
SD / SRO
CIO / TF Officers
PBS-RO
DAs / Suppliers / Manufacturers
1/ Definition of METHODOLOGY
2/ Collection of INPUT DATA
3/ QUALIFICATION PLAN
4/ QUALIFICATION IMPLEMENTATION
5/ QUALIFICATION SUMMARY
1.a) Qualification Guidelines
1.b) Equipment Qualification Program
1.c) Qualification Methods/Instructions and Applicable Standards
Templates:
- for input
- for documents
- for output
2.a) List of PIC equipment
2.b) Safety requirements
Full list of equipment
Is it a PIC active equipment?
No
WorkFlow for Passive equipment & non PIC equipment
YES
2.c) Equipment locations
2.d) Identify the environmental conditions
3.a) Supplier database
3.b) Develop qualification plan
NO
Acceptance of the qualification plan?
YES
Agreement to ask for corrective actions
4.a) Perform qualification of equipment
4.b) Qualification dossier
YES
Acceptance of the qualification report
NO
NO
Acceptance of the qualification?
YES
4.c) Corrective actions
Acceptance of the corrective actions
YES
NO
Design change process
5.a) ITER Qualification Summary Report
END

8 Description, roles and responsibilities

The following paragraphs detail each phase and related tasks shown in the workflow diagram (see § 7.2).

Role and responsibility for each task is summarized in § 8.6 and for each document is given in § 9.16.

8.1 Phase 1 - Definition of methodology

Description: To provide all methodology, guidelines, and templates necessary for implementation of equipment qualification. It includes:

- The definition of qualification guidelines (SD, task 1.a) [R09];
- The issuing of the equipment qualification program for PIC equipment (CIO, task 1.b);
- The definition of methodologies and instructions for qualifying the equipment to various environmental conditions (SD/CIO, task 1.c);
- The selection of the applicable codes and standards (SD/CIO, tasks 1.a and 1.c);
- The preparation of templates for input collection, documents and output (SD/CIO, task 1.c).

Roles and responsibilities

- Safety Department provides the qualification guidelines and validates the EQP;
- CIO provides this EQP;
- SD and CIO elaborate the qualification methods and templates, as per the § 9.1, and they also define the applicable codes and standards, based on Table 6 in § 10.

Deliverables:

- Qualification guidelines [R09];
- Equipment Qualification Program [this report];
- Qualification Methods and Instructions , list of applicable codes and standards and template (see [Table 6] and § 9.1).

8.2 Phase 2 - Collection of input data

Description: To define and maintain input data for proper implementation of equipment qualification program. These input data includes:

- The list of equipment to be qualified, based on the list of Protection Important Components (SD, task 2.a) and related safety requirements (SD, task 2.b);
- The detailed list of equipment with safety functions intended to be fulfilled within specified service conditions [R30]; location of equipment is essential for definition of environmental conditions for qualifying the equipment to normal, incidental and accidental conditions (TRO, task 2.c and 2.d).

Roles and responsibilities

- SD supplies the list of PIC and related safety requirements. The TRO is responsible for identifying the detailed equipment list which will perform the safety function;

- The TRO is in charge for completing the input data with detailed list of equipment and relevant safety functions and environmental conditions.

Input

The documents used to extract the input data may include:

- PIC classification reports (IDM folder 96D8CQ);
- Safety Requirement Roombook (ITER_D_KF63PB v2.11);
- Preliminary Safety Report (ITER_D_3ZR2NC v3.0);
- PBS Load Specifications;
- Nuclear Radiation map;
- Electromagnetic map;
- Floor Response Spectra;
- Etc.

Deliverables

- List of equipment to be qualified (see § 9.2), with relevant safety functions and environmental conditions.

8.3 Phase 3 - Qualification plan

Description: To define the Equipment Qualification Plan per equipment or family of equipment (TRO and DAs/Manufacturer depending on Procurement Arrangement / Procurement Strategy, task 3.b).

Roles and responsibilities

- TRO is responsible for elaboration of the qualification plan, jointly with DA and/or manufacturer;
- CIO and SD shall validate the qualification plan before starting the qualification.

Input

- Equipment Qualification Program [this report];
- Qualification Methods, Instructions and Template ([Table 6] and § 9.1);
- List of equipment to be qualified, deliverable of phase 2;
- Manufacturer database with equipment qualification data and history for any potential use of equipment already qualified in other context (Manufacturers, task 3.a).

Deliverables

- Equipment Qualification Plans for equipment or specific family of equipment (see § 9.4).

8.4 Phase 4 - Qualification implementation

Description: To generate the evidence that equipment will operate on demand, under specified service conditions, to meet system performance requirements. It includes:

- Performing the qualification (DAs/suppliers/manufacturers, task 4.a), based on the qualification plan;

- The issuing of Qualification Synthesis Report (DAs/suppliers/manufacturers, task 4.b) and all reports providing the evidence of qualification (Test Reports, Analysis Reports…);
- The acceptance of the qualification by verifying the qualification plan implementation, the compliance and exhaustiveness of the results (PBS-RO, CIO and SD).

In case of non-qualification or non-acceptance of the supplier qualification by IO, corrective actions shall be implemented (DAs/suppliers/manufacturers, task 4.c). These actions may imply a design change process following the ITER Design Change Control Procedure which shall be applied [R10].

Roles and responsibilities

- DA/manufacturer is responsible for the qualification of equipment in the scope of work: it includes performing of the qualification and the issuance of the Qualification Dossier; DAs shall approve the Qualification Dossier prior IO review;
- In case of non-qualification or non-acceptance of the qualification by IO, DA/manufacturer is responsible for proposing corrective actions, which have to be validated by the TRO;
- Prior to the final acceptance of the Qualification Dossier by CIO and SD, TRO shall recommend it; if not, proposal of corrective action applies as per point above;
- CIO and SD are responsible for the final acceptance of the Qualification Dossier (responsibility is on the Officer of Transverse Functions);
- In case CIO or SD does not accept the Qualification Dossier, they shall agree with the TRO prior to demanding to the supplier to implement corrective actions;
- If the corrective actions require a design change, the Design Change Control Procedure applies [R10].

Input

- Qualification plan relevant for a specific family of equipment, deliverable of phase 3;
- Qualification Methods and Instructions.

Deliverables

The deliverable is the Qualification Dossier relevant for a specific family of equipment. It includes the following detailed list of deliverables:

- Test Specifications (see § 9.6);
- Test Reports (see § 9.7);
- Analysis Reports (see § 9.8);
- Qualification Synthesis Reports (French “Note de Synthèse de Qualification”) issued per family of equipment (see § 9.9);
- Reference Files (see § 9.10);
- Qualification Preservation Sheets (see § 9.11).

8.5 Qualification summary

Description: Final summary providing the evidence of the qualification of the ITER for PIC equipment (CIO, task 5.a).

Input

- Qualification Dossiers.

Deliverables

- ITER Qualification Summary Report submitted to the ASN with all results and qualification (see § 9.12).

8.6 Responsibility assignment matrix

Table 2: Equipment Qualification Program RACI matrix for PIC equipment

	Responsible	Accountable	Consulted	Informed
Qualification Guidelines	SD	SD	CIO	TRO
Equipment Qualification Program	CIO	CIO	SD TF-Officers	TRO
Qualification Methods and Applicable Standards [Table 6]	TF-Officers	CIO	SD	TRO
List of PIC equipment	TRO	SD	CIO	
Safety requirements	SD	SD	TRO / CIO	
List of Equipment to be qualified	TRO	CIO	CIO	TF-Officers
Qualification plan per family of equipment	TRO	Technical Department	DAs / Suppliers CIO	
Perform qualification of the equipment and issue the Qualification Dossier	DAs / Suppliers	DAs / Suppliers	TRO	TF-Officers
Acceptance of the Qualification Dossier	PBS-RO	SD	CIO TF-Officers	
Identify corrective actions at equipment level	DAs / Suppliers	PBS-RO	SD / CIO	
ITER Qualification Summary Report	SD	SD	PBS-RO TF-Officers	DAs

9 Documents required for equipment qualification

The documents required for equipment qualification can be gathered in 4 groups:

- Group 1 - Methods for equipment qualification (output of the activity presented in § 8.1) referring to specific Codes and Standards;
- Group 2 - Project data which concerns the qualification inputs (output of the activity presented in § 8.2):
    - Equipment list with relevant safety functions and environmental conditions (pressure, temperature, radiation, humidity, etc.), as per the service conditions;
    - Dynamic loads;
    - Other accidental loadings and the related safety functions, such as LOCA, HELB;
    - Equipment service conditions, such as range of voltage, frequency, load, electromagnetic interference, etc.;
    - Installation requirements including location (for example, in or out of containment), mounting method and configuration, main electrical and mechanical connections.
- Group 3 - Detailed Equipment Qualification Plans which concerns a specific equipment or family of equipment, and defines the detailed procedure adopted for qualification, taking into account the Group 1 and 2 documents (output of the activity presented in § 8.3);
- Group 4 - Output data and documents providing the demonstration of equipment qualification and the instructions for preservation; the output documents include the Qualification Synthesis Reports, the ITER Qualification Summary Report, etc. (output of activity presented in § 8.4 and 8.5).

This paragraph describes the purpose and the content of each group of document.

Group 1: Qualification Methods and Instructions

Group 2: List of equipment to be qualified

Group 3: Equipment Qualification Plan

Group 4: Test Specification
Test Report
Analysis Report
Equipment Identification File
Reference File
Qualification Synthesis Report
Qualification Preservation Sheet
ITER Qualification Summary Report

A diagram illustrating the connections between the different documents is provided hereafter.

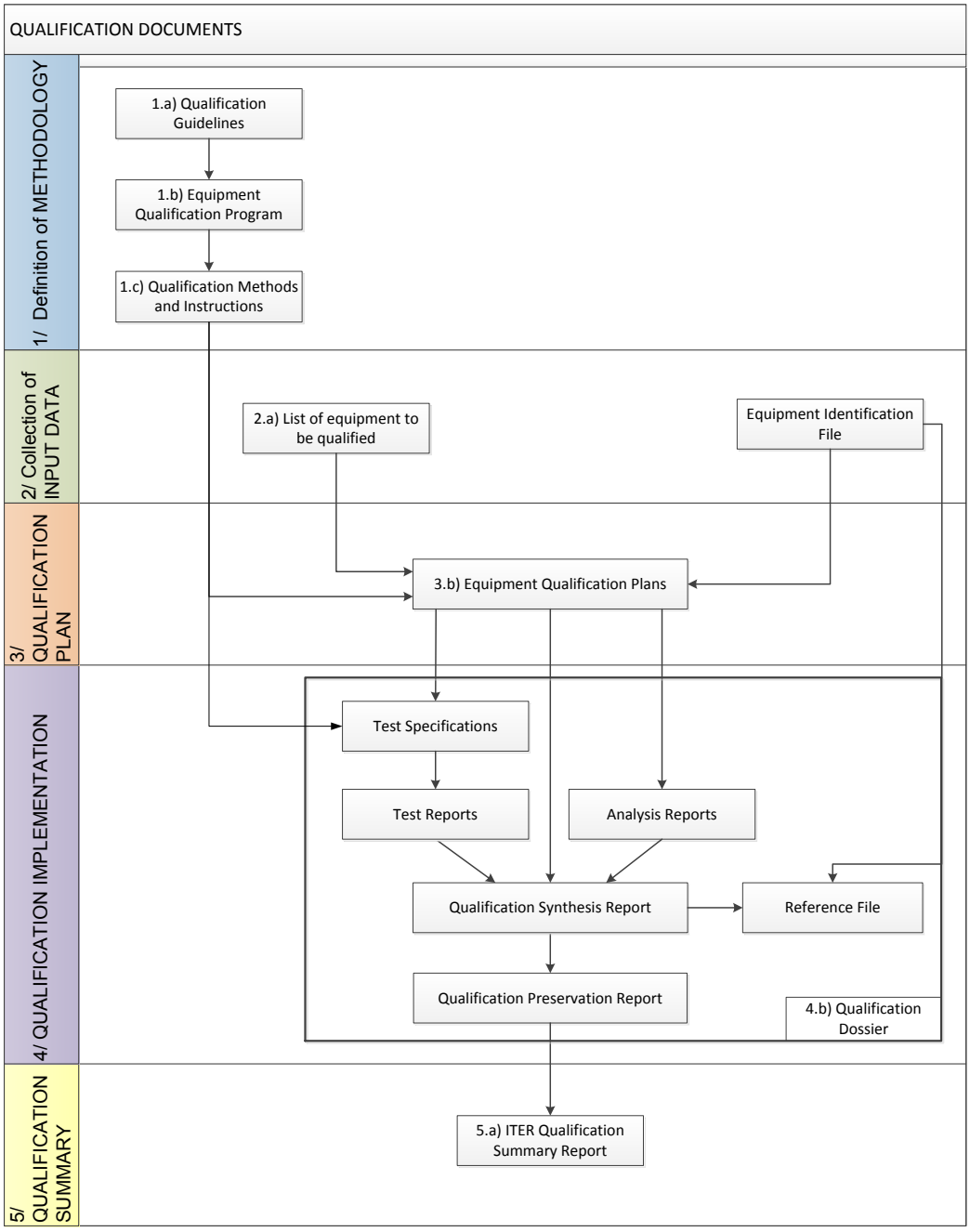

QUALIFICATION DOCUMENTS
1/ Definition of METHODOLOGY
1.a) Qualification Guidelines
1.b) Equipment Qualification Program
1.c) Qualification Methods and Instructions
2/ Collection of INPUT DATA
2.a) List of equipment to be qualified
Equipment Identification File
3/ QUALIFICATION PLAN
3.b) Equipment Qualification Plans
4/ QUALIFICATION IMPLEMENTATION
Test Specifications
Test Reports
Analysis Reports
Qualification Synthesis Report
Reference File
Qualification Preservation Report
4.b) Qualification Dossier
5/ QUALIFICATION SUMMARY
5.a) ITER Qualification Summary Report

Table 3: List of input and output documents for each steps of the equipment qualification process

ID	Phase	Input	Output
1/	**Qualification Methods and Standards**	• Qualification Guidelines • Equipment Qualification Program • Codes and Standards	• Qualification Methods and Instructions • Templates (e.g. Equipment Qualification Plan, Equipment Synthesis Report)
2/	**Collection of input Data**	• Equipment list of all ITER • Project Requirements Document • Preliminary Safety Report • RoomBook • Drawings, CMM, etc. • Load Specifications • Nuclear Radiation and electromagnetic maps • Definition of the seismic FRS for buildings • Thermo-hydraulic and flow dynamics calculations • Etc.	• List of equipment to be qualified
3/	**Develop qualification plan**	• Qualification Methods and Instructions • List of equipment to be qualified • Equipment Identification Files • Templates • Supplier database	• Equipment Qualification Plans
4/	**Implementation of the qualification**	• Equipment Qualification Plans • Qualification Methods and Instructions	Qualification dossiers with: • Test Specifications • Test Reports • Analysis Reports • Equipment Identification Files • Qualification Synthesis Reports • Reference files • Qualification Preservation Sheets
5/	**Qualification summary**	• Qualification dossiers	• ITER Qualification Summary Report

9.1 Qualification Methods and Instructions

The purpose of the "Qualification Methods and Instructions" is to provide the approach to be implemented for the equipment qualification and the standards to be used. It includes the instruction to follow qualification by test (including sequence of test), analysis and/or operating experience according to families of equipment and qualification conditions:

- Test methods and sequence according to qualification conditions, referring to applicable standards;
- Procedure for qualification by analysis, describing the methodology for qualification by analysis, depending on the qualification conditions;
- General procedures describing qualification methods according to qualification conditions.

Link to specific methods and instructions for each qualification conditions will be available in Table 6. These documents are under development.

9.2 List of equipment to be qualified

The purpose of the "List of equipment to be qualified" is to provide the input data related to the conditions relevant to the qualification of the equipment.

The "List of equipment to be qualified" has to provide:

- The equipment with relevant functional reference;
- The expected function with reference to the event or succession of events;
- The location;
- The environmental conditions with reference to the event or succession of events.

Note: A *"List of equipment to be qualified"* template shall be developed.

9.3 Equipment Identification File

The purpose of the "Equipment Identification File" is to provide all input related to the dimensional and functional characteristics, including the detailed nomenclature of the equipment parts. There is one "Equipment Identification File" per family of equipment.

The "Equipment Identification File" has to provide the identification card of the equipment in the scope of a specific equipment qualification plan, for example:

- Drawing of the equipment;
- Identification of sub-parts with relevant nomenclature;
- Dimensions and functions.

For each Equipment Qualification Plan, at least one Equipment Identification File is expected.

Note: An "Equipment Identification File" template shall be developed.

9.4 Equipment Qualification Plan

The purpose of the "Equipment Qualification Plan" is to describe the strategy and the plan for the demonstration of the qualification and specifically the activities to be performed to qualify a specific family of equipment.

The "Equipment Qualification Plan" has to provide:

- The equipment or set of equipment concerned;
- The reference to the Equipment Identification File;
- The assumption made for the strategy of qualification and the justification;
- The methods chosen among the Qualification Methods and Instructions;
- The methodology sequences (i.e. methodology applied and order, with test results that may be used as input for analysis, etc.);
- The margins and acceptance criteria;
- The reference to all applicable codes and standards;
- The schedule for the equipment qualification (in agreement with ITER plan).

Note: An “Equipment Qualification Plan” template shall be developed.

9.5 Qualification Dossier

The purpose of the “Qualification Dossier” is to provide all proof of the equipment qualification. There is one “Qualification Dossier” per family of equipment.

The “Qualification Dossier” has to include:

- The Test Specification (§ 9.6);
- The Qualification Synthesis Report (§ 9.9);
- The Test reports (§ 9.7);
- The Analysis and/or calculation reports (§ 9.8);
- The Reference File (§ 9.10);
- The Qualification Preservation Sheet (§ 9.11).

Note: A “Qualification Dossier” template shall be developed.

9.6 Test Specification

The purpose of the “Test Specification” is to define the procedures, equipment, acceptance criteria and resulting recording methods to be used for the testing.

There may be more than one Test Specification per equipment or family of equipment.

The “Test Specification” has to provide:

- The equipment or set of equipment concerned (the equipment identification, including installation and connection);
- The reference to the Equipment Qualification Plan;
- The qualification requirements and intended functions(s) concerned;
- The acceptance criteria;
- The sequence of tests or test procedure phases;
- The equipment preparation and mounting (orientation, tightening, interfaces, etc.);
- The characteristics to be inspected;
- The specific measurement conditions (environment, number and frequency of measurements, measurement points, accuracy of the measuring devices, recording methods, etc.);
- The number of test samples.

The test specification is to be based on the Qualification Methods and Instructions (§ 9.1).

An example of test sequence may be:

- Reference test;
- Ageing test as part of the assessments of behaviour over time;
- Accidental conditions phase ;
- Seismic testing.

Note that the RCC-E – Design and Construction Rules for Electrical Equipment on Nuclear Islands [R50] section B4000, B5000 and B6000 provides three different test qualification procedures.

Note: A “Test Specification” template shall be developed.

9.7 Test Report

The purpose of the “Test Report” is to provide a written record of the tests and their results. It explicitly indicates whether or not the equipment complies with the criteria specified in the Test Specification.

There may be more than one “Test Report” per equipment or family of equipment.

The *“Test Report”* shall be prepared following the [R50], [R52] and [R53].

The “Test Report” has to provide:

- The equipment or set of equipment qualified by testing (the equipment identification);
- The reference to the Test Specification;
- The qualification requirements and intended functions(s) concerned;
- The description and identification of the test sample;
- The equipment preparation and mounting (orientation, tightening, interfaces, etc.);
- All assumptions;
- The loading conditions and equivalent testing conditions;
- The sequence of tests;
- The specific measurement conditions (environment, number and frequency of measurements, measurement points, accuracy of the measuring devices, recording methods, etc.);
- The results obtained with a comparison between the expected performance and those obtained;
- Details of any incident occurring during the test;
- An explicit indication of qualification and of the qualification limitations.

Note: A “Test Report” template shall be developed.

9.8 Analysis Report

The purpose of the “Analysis Report” is to justify the equipment qualification by analytical means. It is based on analysis or formulae. It explicitly indicates whether or not the equipment complies with the criteria specified in the Equipment Qualification Plan.

The “Analysis Report” shall be prepared following the MQP document [R13], [R14], [R15], [R16] and [R17].

There may be more than one “Analysis report” per equipment or family of equipment.

The “Analysis Report” has to provide:

- The equipment or set of equipment qualified by analysis (the equipment identification);
- The reference to the Equipment Qualification Plan;
- The qualification requirements and intended functions(s) concerned;
- The numerical analysis software used;
- The calculation assumptions;
- The reference to the code and standards used;
- The acceptance criteria;
- For finite element analysis:
    - The model geometry, meshing, material properties, boundary conditions, loads;
    - The solving options;
    - The post treatment assumptions;
- The results obtained with a comparison between the expected performance and those obtained;
- An explicit indication of qualification and of the qualification limitations.

9.9 Qualification Synthesis Report

The purpose of the “Qualification Synthesis Report” is to:

- Identify the equipment and the qualification requirements;
- Summarize the qualification process followed and detail the results obtained;
- Declare the equipment qualification, providing documented evidence.

It has to include also the demonstration of the industrial feasibility of the manufacturing and installation, as defined during the qualification process.

There is one “Qualification Synthesis Report” per equipment or family of equipment.

The “Qualification Synthesis Report” has to provide:

- The equipment identification (drawings, ID, etc.), including installation and connection;
- The qualification requirements, intended functions(s) and the environmental conditions;
- The acceptance criteria;
- The definition of the qualification methods (test, analysis, operating experience, etc.) and qualification procedures applied;
- The reference to qualification documents (such as Qualification Plan, Test Specifications, Test Reports, Analysis reports, etc.) and syntheses of qualification outcomes;
- The results obtained with a comparison between the expected performance and those obtained after qualification;
- An explicit indication of qualification and its limitations;
- The equipment qualified life.

Note: The “Qualification Synthesis Report” template shall be used [R25].

9.10 Reference File

The purpose of the "Reference File" is to gather the data required to ensure that the qualification remains valid between the qualified model and the production equipment. It allows any changes to the equipment or its manufacture to be monitored throughout its service life.

The "Reference File" includes two lists:

- The list of reference documents, including:
    - The description of the equipment model, any modifications made to the model, and correspondence with the documents;
    - The main characteristics of the equipment, including as a minimum the variables taken into account for qualification;
    - The assembly and manufacturing drawings;
    - The procurement specifications for the main constituent parts, together with the names of the suppliers;
    - The manufacturing specifications;
    - The identification numbers of the machines whose process management requires qualification;
    - The test and inspection specifications;
- The list of modifications made with respect to the above, if any.

Note: A "Reference File" template shall be developed.

9.11 Qualification Preservation Sheet

The purpose of the "Qualification Preservation Sheet" is to provide instructions and recommendations resulting directly from the qualification process, to ensure that the qualifications are guaranteed through the entire service life of the equipment.

The "Qualification Preservation Sheet" provides:

- The equipment or set of equipment concerned;
- The requirements for preserving qualification;
- The instructions resulting from the qualification process, including particular sensitivity during installation, operation and maintenance;
- The recommendations resulting from the qualification process;
- Information on the source documents (including the assembly instructions).

There is one "Qualification Preservation Sheet" per equipment or family of equipment.

The "Qualification Preservation Sheet" may be included in the Qualification Synthesis Report.

Note: A "Qualification Preservation Sheet" template shall be developed.

9.12 ITER Qualification Summary Report

The purpose of the "ITER Qualification Summary Report" is to summarise and conclude on the qualification of all concerned equipment that contributes to the ITER safety demonstration.

The "ITER Qualification Summary Report" will be submitted to the ASN.

The "ITER Qualification Summary Report" has to provide:

- The list of all the PIC equipment included in the scope of the EQP;
- The reference to the Qualification Synthesis Reports of all qualified equipment;
- The qualification requirements (qualification conditions, intended functions, etc.);
- An explicit conclusion on the equipment qualification.

9.13 Management of the qualification documents and records

The documents required for the equipment qualification shall be prepared at dedicated project gates (§ 9.14) and controlled (§ 9.15).

9.14 Qualification documents work plan

Table 4: Equipment qualification documents maturity at the end of the design phases

	Design Phase Gates			
	Conceptual Design Review	**Preliminary Design Review**	**Final Design Review**	**Manufacturing Readiness Review**
Description (DEF)				
List of equipment to be qualified	Preliminary	Consolidated	Complete	
Equipment Identification File			Preliminary	Complete
Equipment Qualification Plan		Preliminary	Preliminary	Complete
Test Specification		Preliminary	Preliminary	Complete
Qualification Preservation Sheet		Preliminary	Preliminary	Complete
Justification (DJF)				
Test Report				Complete
Analysis Report				Complete
Qualification Synthesis Report				Complete
Reference File				Complete

9.15 Configuration management of the qualification documents

All documents issued in the frame of the equipment qualification (i.e. listed in Table 5) shall go under configuration control.

9.16 Qualification document sign-off authority

Table 5: Sign-off authority for equipment qualification documents[1]

	Author	**Reviewer**	**Approver**
Qualification Guidelines	SD	CIO SD	SD
Equipment Qualification Program	CIO	CIO SD	COO
Qualification Methods and Instructions	CIO	CIO	CIO
List of equipment to be qualified	TRO	PBS CIO	Technical Department

[1] Additional details on roles and responsibilities are available in [R29].

		Author	Reviewer	Approver
Equipment Identification Files		TRO	PBS CIO	Technical Department
Equipment Qualification Plans		TRO	PBS CIO	Technical Department
Qualification Dossier	**Test Specifications**	TRO	CIO	Technical Department
	Test Reports	TRO	CIO	Technical Department
	Analysis Reports	TRO	CIO	Technical Department
	Qualification Synthesis Report	TRO	CIO	Technical Department
	Reference File	TRO	CIO	Technical Department
	Qualification Preservation Sheet	TRO	CIO	Technical Department
ITER Qualification Summary Report		SD	CIO	SD

10 Equipment qualification requirements

For qualifying the equipment, the appropriate applicable environmental conditions shall be identified and used in the evaluation process. The environmental conditions are directly linked to the equipment location as it determines the temperature, pressure, flooding, radiation, etc. The main environmental conditions are listed below and presented in the following paragraphs:

- qualified life;
- operating time;
- temperature;
- pressure;
- humidity;
- submergence;
- chemical spray;
- total ionizing dose;
- electromagnetic compatibility (EMC);
- static magnetic field;
- seismic.

10.1 Qualified life

The qualified life corresponds to the period of time for which satisfactory performance shall be demonstrated. During this period of time, the equipment will very likely be submitted to ageing and vibration.

Ageing:

It is mandatory that the equipment relevant for safety is operational through its entire service life, whatever the environmental conditions. The ageing requirements and equipment limiting

operable time shall be defined as part of the SSC requirements. They are equipment dependent as the ageing is based on the equipment specific set of service conditions.

The main factors impacting ageing includes design, function, humidity, radiation levels, materials, storage, wear and tear, oxidation, loss of material strength, cycling, temperature, vibration and other items. Ageing may have an impact on the capacity of the equipment to resist other environmental conditions. This impact has to be accounted in the equipment qualification plan.

Vibration:

Vibration is a highly damaging effect as it induces fatigue, accelerated ageing, etc. Equipment required performing safety functions shall be assessed against vibrations. They typically occur during normal operation conditions and may be increased during incidental or accidental event.

Special care shall be taken with the design of the equipment to minimise the normal operation vibrations.

Note: The storage conditions shall be taken into account as the storage time and environment may affect the equipment operability.

Note: The qualified life of the equipment may be inferior to the system service life. A replacement program shall be defined accordingly. Additionally, the inspection and maintenance plan shall be defined including the ageing characteristics and vibrations of the equipment. The results of inspection and maintenance shall be recorded to assure that the equipment which is exhibiting ageing related degradation will be identified and replaced as necessary.

Operating time

The operating time is evaluated for a time dependent safety function. The operating time shall be respected in case of an incident or accident allowing to switch the system in a safe state. Additionally, some equipment shall remain operational following an incidental or accidental event such as post-accident monitoring equipment or containment related equipment.

10.2 Temperature

Normal operating temperature:

This is the temperature to which the equipment requiring environmental qualification is submitted during normal operation conditions. It includes the effects of transient operation that are expected over the plant lifetime. This temperature is directly related to the equipment location, system function, and effects of any engineered ventilation.

Incidental and accident temperatures:

The incidental or accidental temperature is the temperature to which the equipment is submitted during an incident or accident, respectively. The equipment is designed to function at the higher temperature for a period of time. The maximum temperature shall be identified in case of incidental or accidental event based on the equipment location.

10.3 Pressure

Normal operating pressure:

The equipment will operate at a defined pressure corresponding to the normal operation conditions. The impact of the variation of pressure under normal conditions shall be assessed for qualifying the equipment. The pressure and pressure variations depend on the equipment location and system function.

Incidental and accidental pressures:

It is very likely that during an incidental or accidental events the pressure increases. The equipment required to perform safety functions shall sustain the peak of pressure for a period of time.

10.4 Humidity

Humidity refers to the moisture content in the atmosphere. The amount of humidity will be controlled by the plant Heating, Ventilation and Air Conditioning (HVAC) systems. Loss of HVAC may result in elevated humidity levels and the maximum possible humidity level is used to qualify equipment.

The heating and conditioning of ITER equipment is further developed as part of the transverse function 'TF 41 - Global services: Heating and Conditioning' [R01].

10.5 Submergence

Submergence includes spillage and/or flooding of equipment. This topic is dealt with 'TF 32 – Flooding' [R01]. The objective of the Flooding TF analysis is to avoid any submergence of PIC equipment. Thus, submergence is not applicable for the equipment qualification.

10.6 Chemical spray

Chemical spray relates to the release of chemicals into the equipment environment during incidental or accidental conditions.

This is not applicable to ITER.

10.7 Total ionizing dose

The safety relevant components shall stay operational even when submitted to radiation dose. They may be submitted to radiation during normal operation. Additionally, equipment may undergo peaks of radiations. The equipment total ionizing dose during incidental and accidental events shall be assessed.

The data to be used as design input for the nuclear radiation qualification of all components installed in Tokamak complex are available in TBD.

Notes:

- As per EEE-RC rule 1 from [R12] §.17.1, PIC electronics or PIC items with embedded electronics shall not be exposed to nuclear radiations conditions above the alert thresholds specified in table 1-a of [R12].
- As per [R12] §.7.5, optical fibers, optical windows and optical lenses exposed to radiation conditions above the alert thresholds specified in table 1-b and 1-c of [R12] shall be radiation-qualified.
- As per [R12] §.7.5, electrical and electromechanical items exposed to radiation conditions above the alert thresholds specified in table 1-d of [R12] shall be radiation-qualified.

10.8 Electromagnetic compatibility (EMC)

Electrical equipment is sensitive to electromagnetic interference or radio frequency interference. The equipment qualification shall address the exposure of PIC equipment to electromagnetic field and to any disturbances due to an incident or accident.

Qualification should also ensure that the electromagnetic emissions from equipment stay within acceptable limits through the qualified life and during incidental or accidental events, otherwise they may affect other equipment.

The EMC qualification is not applicable to mechanical equipment unless it contains embedded control electronics.

10.9 Static magnetic field

Due to the magnetic configuration of the ITER Tokamak, static stray magnetic field of relevant magnitude will be present, during normal and off-normal operations, in the whole area of the tokamak complex. Depending on the distance from the tokamak axis the absolute value of the stray static filed will range from few hundreds of millitesla (at the external wall of the bioshield) to about 5-10 mT at the farthest wall of the tokamak complex. The operation of any sensitive equipment located in the tokamak complex may be, then, affected by this magnetic field. All sensitive equipment located in the tokamak complex shall be qualified to insure they will operate accordingly to their specification. The procedure and the static field values requested for the qualification are detailed in [R19] and [R39].

The electromagnetic interference of ITER equipment is further developed as part of the transverse function ‘TF 05 - EM compatibility, Magnetic perturbation’ [R01].

The EM field maps in Tokamak complex are available in the ‘STATIC AND TRANSIENT MAGNETIC FIELD MAPS IN THE TOKAMAK COMPLEX’ folder (QCTTFX [R19]).

10.10 Seismic qualification

In case of an earthquake, the safety relevant components shall be operational during and after the worst seismic event. In order to be conservative, the seismic loads shall be combined to the effect of ageing at the equipment end of life.

The equipment seismic qualification methods include qualification by:

- Analysis
    - Response spectra analysis
    - Time history analysis
    - Equivalent static analysis
- Testing using shake table
- Combined testing and analysis (example: for large equipment)
- Experience data

The Floor Response Spectra (FRS) of SL-2 to be used as design input for the seismic qualification of all equipment installed in Tokamak complex, except the Tokamak machine are available in the report ‘Design Seismic Floor Response Spectra in the Tokamak Complex’ (ITER_D_SVBRJZ).

The Tokamak machine Floor Response Spectra are provided in the ‘Global Tokamak Seismic Analysis Report’ (ITER_D_33W3P4).

For the other buildings the FRS to be used are defined in ITER Buildings Floor Response Spectra (ITER_D_PVC9VH).

10.11 Qualification criteria

Qualification criteria:

Prior to qualifying the equipment, it is essential to determine the qualification or acceptance criteria for each environmental condition. They are used to assess that the equipment achieves its safety requirements under normal, incidental and accidental conditions. They may be limits, ranges or any other suitable indicators.

Margins:

Additionally, margins are normally applied to the various environmental conditions being evaluated. The use of margins increases the confidence in the qualification of the equipment and in the fact that the equipment shall meet or exceed the safety requirements under all anticipated conditions.

The margins are to compensate:

- the fabrication variations and tolerances of the components;
- the inaccuracies in the qualification methods (e.g. test instrumentation accuracy, etc.);
- the potential deviation between the defined operational environmental conditions and the real service conditions.

The qualification criteria and margins shall be compliant with the relevant codes and standards.

10.12 Operational conditions

In order to qualify equipment, it is necessary to specify the environmental conditions the equipment is exposed to. It goes from storage to installation, normal operational conditions, incidental and accidental conditions with a requirement to stay functional.

Storage conditions apply prior to assembly and to operational conditions. Even though the storage environment is optimised to minimise its impact on the equipment, they may be submitted to ageing effects or others environmental conditions.

The normal operational conditions include the operation, testing and the maintenance of the equipment.

Some equipment with safety functions shall not lose its capability to perform after an accidental event. These post-accidental conditions are included in the accidental conditions.

Note: A more complete definition is available in § 3.2 for the various operational conditions (i.e. normal, incidental and accidental).

The following table lists the environmental conditions required for the various operational conditions (Table 6).

Note: Methods/instructions are under development. The reference will be added in a future version of the EQP.

The objective of the methods is to provide a methodology on how to qualify the equipment to certain environmental conditions. It does not intend to provide the environmental condition range or applicable values.

Table 6: Qualification data per operational conditions and related reference documents

	Storage conditions	Normal conditions	Incidental conditions	Accidental conditions	Input for environmental conditions	Method/ Instruction reference	TFs relevant for Equipment Qualification
Qualified life	number of years	number of years	number of years	number of years	NA[1]	NA[1]	NA[1]
Operating time	NA	duration Δt	duration Δt	duration Δt	NA[1]	NA[1]	NA[1]
Temperature	maximum excursion range in the room ΔT	maximum excursion range in the room ΔT	peak and duration	peak and duration	Safety Requirement Roombook [R26]	TBD	TF 13 - Overall Structural behaviour (including Thermal Behaviour) TF 14 - Material Integration
Pressure	room pressure	room pressure	peak and duration	peak and duration	Safety Requirement Roombook [R26]	TBD	TBD
Humidity	maximum room humidity	maximum room humidity	peak and duration	peak and duration	TBD	TBD	TBD
Submergence	No	No	No	No	-	NA[2]	NA[2]
Chemical spray	No	No	No	No	-	NA[2]	NA[2]

	Storage conditions	Normal conditions	Incidental conditions	Accidental conditions	Input for environmental conditions	Method/ Instruction reference	TFs relevant for Equipment Qualification
Total Ionizing dose	No	dose rate (Gy/h) end of life dose (Gy)	maximum dose rate (Gy/h) integrated dose (Gy)	maximum dose rate (Gy/h) integrated dose (Gy)	TBD	[R12] for Electronics and Electro-mechanical TBD for Materials	
Electromagnetic fields	No	Yes	Yes	Yes	[R19]	Low frequency (and static) [R39] High frequency [R38]	TF 05 - EM compatibility, Magnetic perturbation
Seismic / Dynamic Load (Vibration)	No	No/Yes	Yes	Yes	[R20], [R21] and [R22]	[R18]	TF 13 - Overall Structural behaviour (including Thermal Behaviour)

1. No method/instruction is foreseen for the qualified life and operating time as they are input applicable transversally to all other environmental conditions.
2. Submergence and chemical spray are not applicable to ITER PIC.

11 Equipment qualification methods

This section discusses the different methodologies applicable for the equipment qualification. Any of the following method, or combination of them, may be used as long as it is justified and relevant for the equipment undergoing qualification. The applied methods shall be detailed in the equipment qualification plan and justified in the equipment qualification final report.

Equipment qualification methods are:

- Type testing
- Analysis
- Similarity
- Operating experience, experience based approach
- Substitution

The qualification test shall be performed following the selected methodology and standard. A list of applicable standards to be followed is provided in § 5 and [R07]. The request of selecting a standard which is not listed in § 5 shall need to be submitted following the RACI matrix defined in Table 2.

11.1 Type test

The type test demonstrates that the equipment performance characteristics meet or exceed its specified safety-related performance requirements. The type test will consist of a planned sequence of tests based on the service conditions of the equipment. It takes into consideration the margins for normal, incidental and accidental conditions.

Special mock-up may be produced to undergo testing. However, it shall be the same as the equipment to qualify.

The mounting of the equipment on the test facilities shall simulate the real plant installation. The interfaces shall be as similar as possible to the final installation, the orientation, the tightening; all parameters shall closely fit the service conditions of the equipment

The most severe sequence of event shall be applied to the test equipment. The same test sample shall be used for the entire test sequence.

The performances of the test sample shall be monitored through the entire testing, either continuously for short term test or at a predefined frequency allowing the evaluation of the equipment. The equipment shall be inspected before, during and at the end of the test sequence. The test sample should be retained in storage in case of need for later analysis and not installed for operational use.

Equivalent testing parameters may be used especially for long term effects. For example, a factor may be applied to the service conditions to simulate the effect of ageing and allow the assessment of the equipment. This equivalence should be justified and in accordance with the applicable codes and standards.

The equipment qualification program should include an as-built inspection in the field to verify that equipment is the same as the one used for testing, in terms of material, fabrication process, installation, etc.

11.2 Analysis

Qualification of the equipment may be done by using an analytical approach. It allows assessing equipment to various environmental conditions such as pressure, temperature, radiation, fluid flow, etc. It is applicable to complex structures. It usually implies modelling assumptions that must be justified and verified. Test data may be used to validate the analysis or vice versa.

Analyses and calculations shall be performed following the MQP document [R13], [R14], [R15],[R16] and [R17].

Various software programs are used by ITER to perform analysis. The selected software shall be validated prior to be used. IO policy for software validation is provided by the MQP level 2 document "Software Qualification Policy" (ITER_D_KTU8HH). For software used for ITER safety analyses or for the determination of safety parameters, the procedure defined in Quality Assurance for ITER Safety Codes Procedure (ITER_D_258LKL) shall be used.

11.3 Similarity

The qualification by similarity is the fact of using results from already qualified equipment to assess similar equipment. When applicable, qualification by similarity may facilitate the qualification process. However, the condition for using this method is that the differences between the already-qualified equipment and the equipment to be qualified should be minor. This includes the design, the service conditions (ageing, radiation, etc.), the loads, the margins applied, the safety requirements, the manufacturing and assembly process, the material properties, etc. Each parameter shall be compared and all variations shall be evaluated by testing or analysis. The suppliers shall confirm that the qualification conditions of the already qualified equipment are enveloping of the ones of the equipment to qualify.

An example of applicability of this method is for qualifying equipment from the same manufacturer (i.e. same fabrication, quality process, materials,…) and located in the same area (i.e. with the same service conditions). A combination between the most severe operational conditions and the equipment with conservative dimensional and functional characteristics may be used to qualify the equipment by testing and/or analysis. This result implies that the other equipment is as well qualified.

11.4 Operating Experience

Operating experience is comparable to qualification by similarity. The qualification of the equipment is based on the results from similar equipment that has successfully operated under similar service conditions, performance requirements, etc. The equipment to qualify should have equal or less severe operational conditions.

Note: For incidental and accidental conditions, the operating experience methods shall be combined to testing and/or analysis.

11.5 Substitution

In case the original as-designed components are no longer available, this component may be replaced by a substitute component. This component shall be evaluated to verify it will at least meet the previous component safety requirements. Some of the parameters to be assessed are the equipment material, manufacturing process and manufacturer's quality programs, the equipment design and functions.

Note: Substitution is most generally combined to other qualification methods to assess the variation in the parameters.

11.6 Combination of methods

In case one of the qualification methods is not sufficient to qualify equipment, a combination of the aforementioned methods shall be used. As for any single method, a justification shall be provided to guarantee that the choice of methods is applicable, relevant and conservative.

11.7 On-going qualification

The qualification methods described in the previous paragraphs can be used for the initial qualification of the equipment. The on-going qualification can be adopted for extension of the qualified life, for re-assessing the initial qualification considering the feedback from the operating experience (e.g. different rates of ageing factors, etc.).

Annexes

Annex: Forms and templates

The various templates are under development. They will be added in a future version of this document.

- Input templates
- Document templates
- Output templates