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MQP Working Instruction

Working Instruction for the Qualification of ITER safety codes

This document defines the process to be used when developing software documentation for ITER safety analyses, setting a framework for Qualification of codes/models in all activities related to safety, environment as well as worker and public health.

Approval Process			
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Change Log			
Working Instruction for the Qualification of ITER safety codes (258LKL)			
Version	***Latest Status***	***Issue Date***	***Description of Change***
v1.0	In Work	12 Feb 2007	
v1.1	Signed	13 Feb 2007	
v1.2	Signed	14 Feb 2007	
v1.3	Signed	15 Feb 2007	
v1.4	Approved	20 Feb 2007	
v2.0	Signed	07 Mar 2012	Scope more precisely defined in order to target computer codes used for modelling and simulation in safety analyses (to avoid that the procedures described in the document would be wrongly applied to other codes). Updating in respect of the IO organization structure.
v2.1	Signed	12 Jun 2012	Version 2.1 makes use of last MQP template; Comments to version 2.0 have been implemented.
v2.2	Approved	12 Jul 2012	Concepts of acceptance/ approval have been added in par.3 (Definitions) Exhibit 1 has been reorganised and amended. To be noted that Exhibit 1 is an example of cover sheet underlining the roles of the different involved actors (acceptance, review and approval roles). These roles are defined in Exhibit 2 as explained in sect. 5 of the cover sheet. Exhibit 1 is an example to be followed in particular by external contractors or DAs (a note for clarification has been added).
v3.0	Revision Required	06 Aug 2018	update to consider French 2012 INB order and the ASN guide on qualification of scientific calculation tool used in the nuclear safety demonstration
v3.1	Approved	12 Sep 2018	minor change to consider reviewers comments.

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1 Purpose

1.1 Context

By application of the French 2012 INB order [1], the safety demonstration covers the control of the risks and inconvenience of the facility for all the phases of ITER: design phase, construction and assembly, staged approach, progressive commissioning, operations (including surveillance and maintenance), modifications of the facility during operations, decommissioning and dismantling. The safety demonstration is based on graded approach versus all these risks and inconvenience comprising all technical topics as well as human and organizational factors.

The safety demonstration corresponds then to all the information and requirements mentioned in the safety reports used for ITER life cycle (e.g. RPrS, its updates or its supporting documents) presenting, substantiating and demonstrating that all the risks (including for incidents and accidents) and inconvenience (e.g. routine impact), radiological or not, coming from ITER nuclear facility are reduced to levels as low as possible at a reasonable cost and using the best available techniques.

When the use of software, code or data library is required to demonstrate the safety of workers, the environment and the members of public against these risks and inconvenience, and when this use is reported in the safety demonstration, then this software, code or data library is a part of the safety software, code or data library, also called safety codes, in consistency with the ASN guide [12] on qualification of scientific calculation tool used in the nuclear safety demonstration.

1.2 Purpose

This document provides guidance for the steps to follow in order to qualify a Safety code in accordance with the French 2012 INB order, and in particular the article 3.8 of this INB Order.

It defines and justifies requirements needed for validating the methods, for qualifying the calculation and modelling tools in the safety demonstration.

2 Scope

This document applies to software, codes or data libraries intended to be used in the safety demonstration or for ITER safety calculations that have not been qualified yet for their intended areas of use. This document is particularly concerned with the safety codes/software in need of validation and verification described in chapter 8.

This document is also applicable to the new codes or new versions to be issued when these new versions are used in the safety demonstration.

It does not apply to preliminary or scoping calculations that are to be superseded by later analysis.

This document does not apply to code, software or data library which are not used in the safety demonstration, even if they are used for a Protection Important Activity (PIA). Therefore, if a code is used for a PIA (e.g. for design activity), but not used in the safety demonstration (e.g. not referred in the determination of safety parameters, not used to demonstrate the limit to which a specific safety function can be designed), then this code would not have to follow the steps mentioned in this document.

This document does not provide definition and justification of the criteria for validating the methods, for qualifying the calculation and modelling tools requested in the article 3.8 of the 2012 INB Order. The definition and justification of the criteria must be detailed in the planning phase defined in § 8.2.2.1.3 **for each specific code.**

This Level 3 document is part of the Nuclear Safety process and is attached to the Level 2 Procedure for safety demonstration (U33S8T) [11].

3 Definitions and acronyms

This section uses definitions already given in reference [6] and also adopted in this procedure.

Acronyms:

ASN	Autorité de Surete Nucleaire
INB	Installations Nucléaires de Base
PIA	Protection Important Activity
RPrS	Rapport Préliminaire de Sûreté
PBS	Plant Breakdown Structure
IO	ITER Organization
DA	Domestic Agency
EPNSD	ITER Safety Department, Environmental Protection and Nuclear Safety Division
IO TRO	ITER Organization Technical Responsible Officer
IO SRO	ITER Organization Safety Responsible Officer
EI	External intervener
V&V	Verification and Validation
IDM	ITER Document Management (system)

Definitions:

Acceptance	The process of accepting the process of verification/ validation and the results of analysis/ calculation as an accurate representation of the real world from the perspective of the intended uses of the model. Acceptance roles are played by the Requester, the EPNSD responsible person and the Independent Peer Reviewer if applicable (see § 8.2.2.1.2). The process of acceptance refers to intermediate steps of the flow chart (§ 7), and is different from the final approval of the deliverable.
Analyses/calculations	Quantitative computations to determine the value of a quantity or a physical parameter (such as flow rate, temperature, stress, or neutron flux). Calculations may be performed and documented in various forms (such as hand calculations, spread-sheets, Math-Cad files, or finite element models and associated computer output).
Approval	The process of approving a deliverable (e.g. documentation which describes the degree of validation of the safety code). The deliverable is approved by the EPNSD responsible person (e.g. Safety Code Validation and Verification Cover Sheet in template STMCPF).
Approver	The EPNSD responsible person in charge of approving the deliverables of this MQP procedure.
Deliverables	Reports, models and software/codes documentation.

External intervener	Any natural or legal person other than the operator and his employees who carry out operations or who supply goods or services: – who participate in a protection-important activity or a protection-important component; – or who participate in an action in application of the Order of 7 February 2012 [1] and related to such an activity, service providers and subcontractors, experimenters and users are in particular concerned;
IO Technical Responsible Officer	Including PBS TRO and responsible officer/coordinator for transversal functions.
Performer	An analyst who performs, and documents the analysis or calculation.
Protection important activities	As defined in the article 1.3 of the INB Order [1]: *"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;"* The "qualification of a safety code" is a Protection important activities.
Qualification (of a safety code/software)	The process of determining if a safety code/ software may be used, under a specified set of assumption and for a specified range of applications, for the safety demonstration of ITER. To be qualified by IO, a safety code/software shall: – Be verified and validated. – Have adequate software documentation (specific reports or journal publications with peer reviewers).
Requester	The IO Responsible Officer (from Technical departments, from central teams, from EPNSD) or DA Task Officer (e.g. if the analysis is performed under an ITER Task Agreement) who requests the safety code/software qualification.
Reviewer	An individual or group of individuals selected to verify all or specific aspects of the methodologies, analyses and calculations. Reviewers are required to be sufficiently qualified by education and/or experience on the specific aspect they have to verify.
Safety demonstration	The safety demonstration corresponds to all the information and requirements mentioned in the safety reports used for ITER life cycle (e.g. RPrS, its updates or its supporting documents) presenting, substantiating and demonstrating that all the risks (including for incidents and accidents) and inconvenience (e.g. routine impact), radiological or not, coming from ITER nuclear facility are reduced to levels as low as possible at a reasonable cost and using the best available techniques.
Safety calculations	Calculations performed in order to provide data that will be used for the safety demonstration.

Safety code/software	A safety code or a safety software is a particular computer program/application which is used for ITER safety analysis (see the more general definition "calculation software" from reference [6]). N.B.: this meaning of "code" it is not to be confused with references "codes" such as RCC-MR or ASME-8.
Technical checker	The technical checker is a reviewer who belongs to an organization independent from the organization of the performer. He may be from the same organization as the performer if he is not involved in the performance or decision-making regarding the original work. The technical checker is sometimes referred to as a "peer reviewer," "independent reviewer," or "verifier" by certain organizations.
Technical checking	A critical review of the analysis or calculation by a qualified individual (see technical checker and reviewer definition) to verify that the methodologies, analysis or calculation is correct and satisfies the stated objectives.
Independent peer reviewer	A qualified individual who performs the independent peer review and is not involved in the original analysis, calculation, or validation, and is a distinctly different person than the **technical checker**.
Validation	The process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model.
Verification	The process of determining that a computational model accurately represents the underlying mathematical model, and its solution. Verification can also be done by using software/codes already validated and by showing that the code/software in need of validation shows results within accepted margins (benchmarking).

Refer also to the definitions and acronyms of Nuclear safety common definitions (RLZXMV).

4 Reference Documents

[1] Order of 7 February 2012 *setting the general rules relative to basic nuclear installations*, called "INB Order" (English translation for guidance) (7M2YKF)

[2] Preliminary Safety Report (RPrS) (3ZR2NC)

[3] General Safety Principles (33AMDD) – *appendix to [2]*

[4] Accident Analysis Report (AAR) Volume II - Reference Event Analysis (2DJFX3) – *appendix to [2]*

[5] Accident Analysis Report (AAR) Volume III - Hypothetical Event Analysis (2E2XAM) – appendix to [2]

[6] Analysis and calculations (MQP) (22MAL7)

[7] List of ITER-INB Protections Important Activities (PSTTZL)

[8] Provisions for Implementation of the Generic Safety Requirements by the External Interveners (SBSTBM)

[9] Overall Surveillance Plan of External Interveners Chain for Protection Important Components, Structures and Systems and Protection Important Activities (4EUQFL)

[10] Deviation request and nonconformity procedures:

[10.1] Procedure for the management of Deviation Request (2LZJHB)

[10.2] Procedure for management of Nonconformities (22F53X)

[10.3] Procedure for Processing Deviation Requests and Nonconformance Reports submitted by a DA, a Supplier or a Sub-contractor (3E65VE)

[11] Procedure for safety demonstration (U33S8T)

[12] Guide de l'ASN n°28 - Qualification des outils de calcul scientifique utilisés dans la démonstration de sûreté nucléaire – 1re barrière - FR (VSYDFX)

5 Responsibilities

5.1 Requester

Any request for safety code/software qualification is initiated by the **Requester**. The requester can be an IO Responsible Officer (from Technical departments, from central teams, from EPNSD) or DA Task Officer (e.g. if the analysis is performed under an ITER Task Agreement).

If the requester is an external intervener, the requester shall submit the request to the IO TRO managing his contract. The IO TRO may himself reject the request based on her/his professional experience (e.g. if the code is clearly not a safety code and/or the validation domain is clearly out of scope of the one used for ITER in the safety demonstration). If the IO TRO accepts the request, he shall submit the initial request to EPNSD responsible person.

5.2 IO Technical Responsible Officer

The ITER IO technical responsible officer, including PBS TRO and responsible officer/coordinator for transversal functions, can directly submit a request to EPNSD responsible person for the safety code qualification. If the initial code qualification request is from EI, the ITER IO TRO could reject the request or submit the initial request to EPNSD responsible person based on their technical experience. If the request is from EI, the IO TRO is responsible to do the technical control of the submitted request together with technical checker.

5.3 EPNSD Responsible Person

The whole process concerning the qualification of safety software is under the surveillance of a **Responsible Person** within the EPNSD.

This person may be the EPNSD SRO in charge of the topic concerned by the safety code (if the code is used by someone outside the EPNSD) or another person inside EPNSD (in case the requester or performer is already a person inside EPNSD).

This person shall notably specify whether the code is used in the safety demonstration and needs to follow the same whole qualification process.

5.4 Performer

The **Performer** carries out the analysis in order to verify and validate a safety code.

This person can be either:

– internal to the EPNSD;

– or IO staff in technical department or an external collaborator or contractor (including requester from DA task officer), being in this case an external intervener.

In all cases, the compliance with the instructions specified in this procedure is required. If he is an external intervener, then he shall follow also the procedure regarding the surveillance of external interveners [9].

The **performer** shall have a proven qualification to perform the requested analysis or calculation, and shall understand its meaning, objective and impact in the context of the ITER design.

The **Performer**'s manager or supervisor is involved in the process via technical reviews and/or via the validation of the proven qualification of the performer.

5.5 Technical checker

A **technical checker** is an individual or group of individuals selected to verify all aspects of completed analyses. They are performing the technical controls required by the article 2.5.3 of the INB Order [1]; it implies therefore that they shall sufficiently qualified (by education and/or experience, for instance).

In addition, **technical checkers** are required to be independent (cf. § 3). These individuals can be internal to the ITER technical departments, or central teams or external interveners.

5.6 Independent peer reviewer

A qualified individual who performs the independent peer review and is not involved in the original analysis, calculation, or validation, and is a distinctly different person than the **technical checker**. To avoid being influenced by cost and schedule considerations, an independent peer reviewer from the same company or organization of the **performer** and/or **technical checkers** may not be involved in a project/program funded by the same budget line used by the **performer** and/or **technical checkers**.

The independent peer review is not systematically mandatory and may be required on a case by case basis by the EPNSD, especially for safety codes "in need of validation and verification" (cf. definitions in § 3).

6 Basic principles

6.1 Regulatory requirements

As stated in article 3.8 of the INB Order:

I. The nuclear safety demonstration is based on:

- *updated and referenced data; the demonstration specifically takes into account the information available mentioned under Article 2.7.2;*
- ***appropriate, explicit and proven methods**, which integrate assumptions and rules adapted to the uncertainties and to **the sphere of knowledge of the phenomena involved**;*
- ***qualified calculation and modelling tools adapted to the specific areas of use**.*

II. The operator specifies and justifies his criteria for validating the methods, for qualifying the calculation and modelling tools and for appraising the results of studies carried out to demonstrate nuclear safety.

In application of this article, **a safety code/software shall be qualified before** it is used for ITER safety calculations.

6.2 Protection important activities involved

The activity of "qualification of a safety code" is a Protection important activity.

In application of the INB Order, this implies *notably* that:

- A technical control shall be performed by a person distinct from the individual(s) who have accomplished the activities.
- The person(s) performing this PIA and the person(s) performing the technical control shall have appropriate competences and qualifications.
- The PIA and the related technical controls shall be:
  - documented to demonstrate a priori that they comply with the defined requirements,
  - traced to check a posteriori that they comply with the defined requirements,

For IO staff, the respect of the present procedure ensures compliance with the 2012 INB order for this PIA.

If external interveners are involved in this PIA, the persons managing these external interveners within IO shall ensure their specific surveillance. The external interveners shall in addition comply with the requirements of the reference [8], and are subject to a surveillance performed by IO, in application of the reference [9].

6.3 Qualification of a safety code/software

As defined in § 3, to be considered as "qualified" by IO, a safety code shall:

- be verified and validated (see § 8.2);
- have an adequate software documentation (e.g. specific demonstrative qualification reports, credited publications in journals with peer reviewers…); for commercial codes that are widely used in the specific technical field, the documentation shall demonstrate the adequate validation domain for the use requested by the requester (see § 8.3 and 9.1).

7 Workflow

The Figure 1 shows the flowchart of the procedure leading to the qualification of safety software/ codes:

- The input is a request for the qualification of a safety code;
- The output is an approved "Software documentation Check list". The check list should be filled by requester of the code qualification and approved by EPNSD responsible person.

The Figure 2 shows the sub-process for the validation and verification of ITER safety codes/software.

- The input is a request for validation and verification of a safety code;
- The output is an approved "Safety code validation and verification report", including the cover sheet.

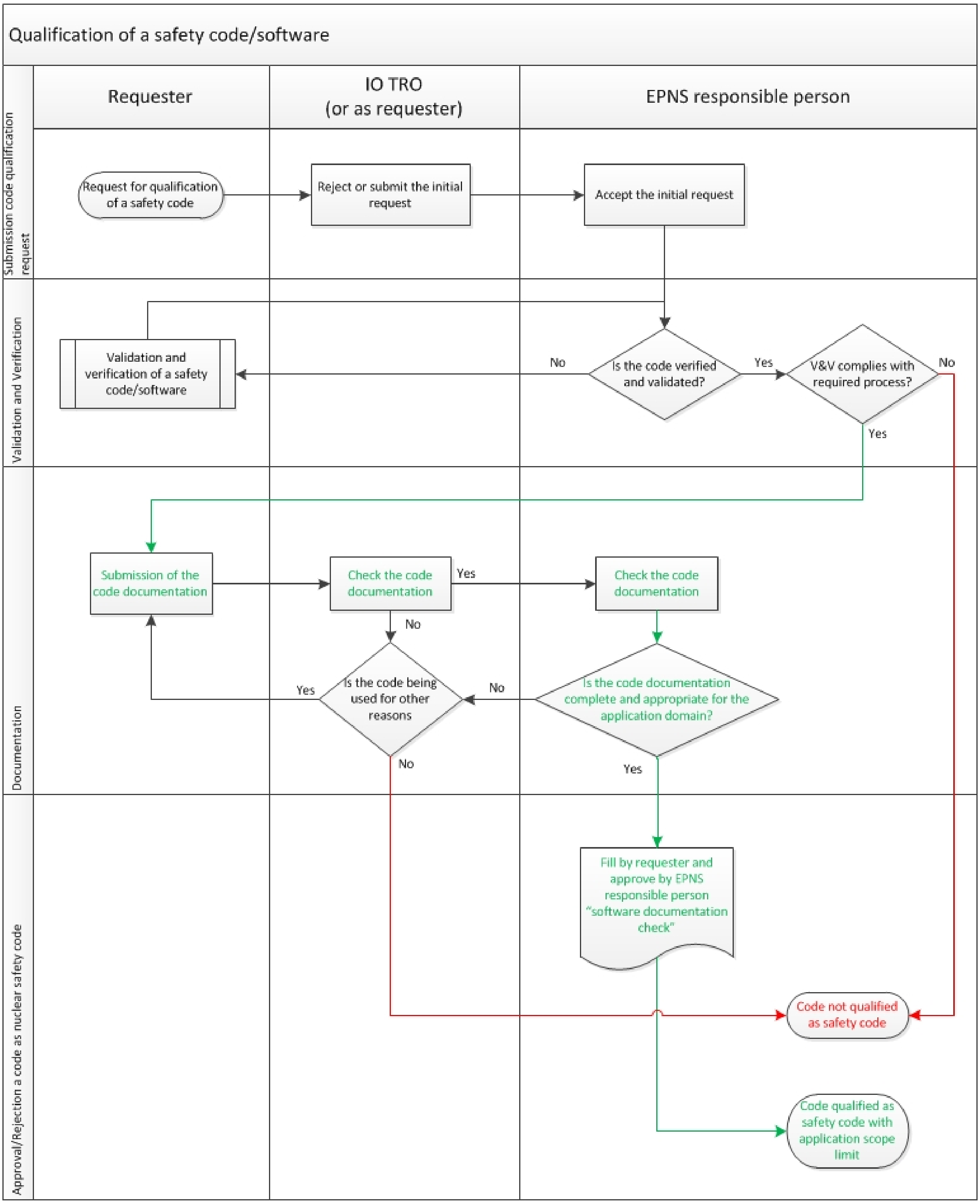

Figure 1: Flowchart for the procedure for the qualification of ITER safety codes/software

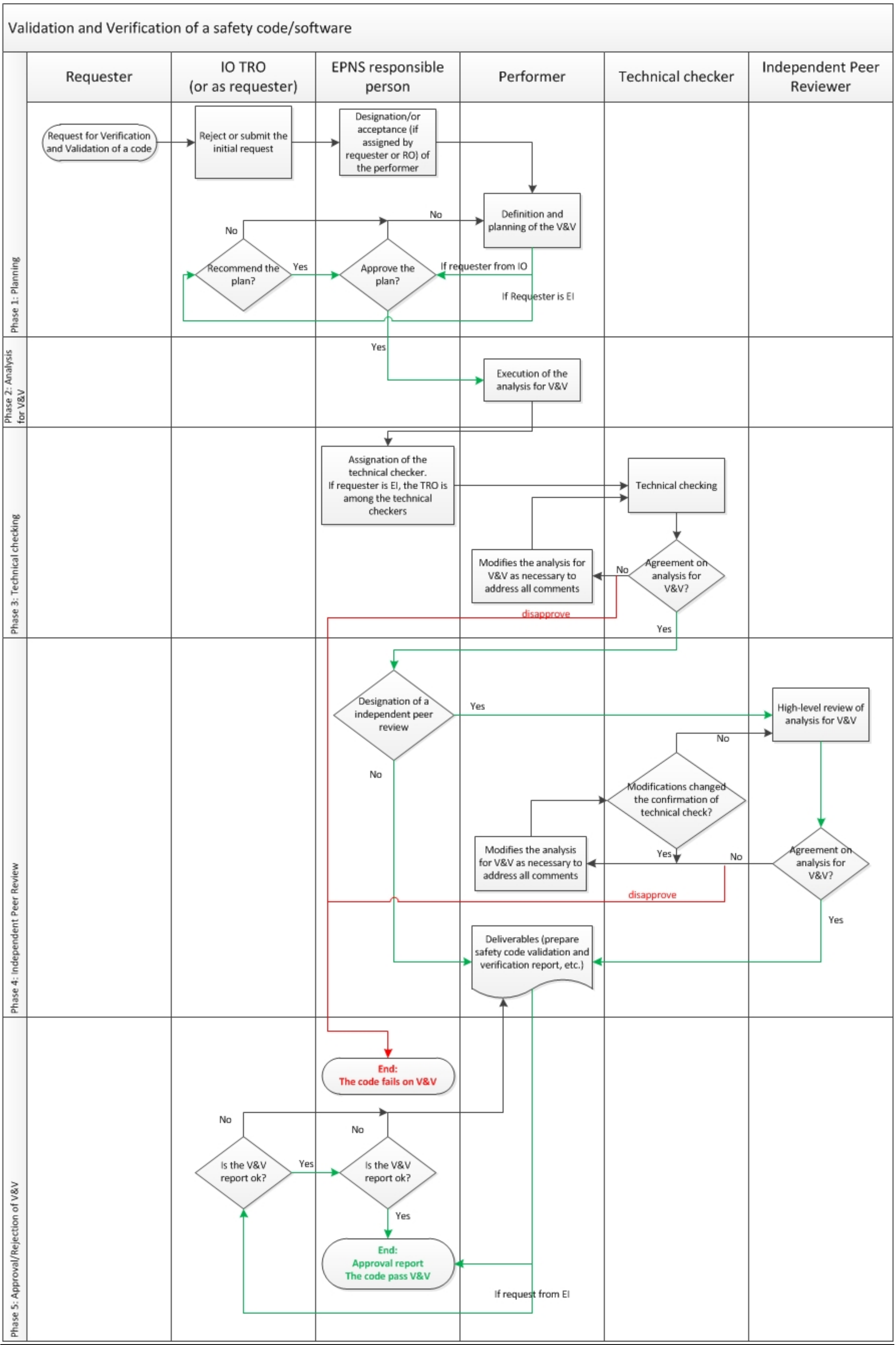

Figure 2: Flow chart for the sub-process for the validation and verification of ITER safety codes/software

8 Process for the qualification of a safety code/software

8.1 Submission of code qualification request

Any request for safety code/software qualification is initiated by the **Requester**. In order to ensure surveillance of the safety code qualification process, which is a PIA, the requester makes a request to the competent **EPNSD Responsible Person**. The request shall be submitted as a request form that allows understanding the request. The request form shall be stored in the ITER IDM system and provide useful description like the name of the requester, requester organization, date, code name, version, domain of applicability, etc. If the requester is EI, the request will be first submitted to IO corresponding TRO. The TRO can reject the request if being judged that the code is obviously not applicable to the analysis domain as safety code. If the request is accepted by TRO, the TRO shall submit the initial request to EPNSD responsible person, who will accept the request for further process.

8.2 Validation and verification of a safety code

There are mainly two cases that are described in the following sections:

- The code/software is already verified and validated (cf. § 8.2.1);
- The code/software needs validation and verification (cf. § 8.2.2).

8.2.1 Verified and validated computer software

An extensive work of validation and verification of safety computer codes has been performed during ITER R&D activities.

Information examples on computer codes and models used in ITER accident analyses are in references [2], [3], [4] and [5]. These documents give summary information on computer code/software mostly for thermohydraulic analyses including applicability, limitations, availability, and physical modelling approaches and simplifications. They also include a description of the validation and verification status of the codes, including previous studies and summary of results of ITER validation studies.

For safety codes/software that have already been verified and validated, the available software documentation must comply with the requirements of the §8.3 and §9.1 to be qualified.

8.2.2 Software in need of validation and verification

This section provides explanation of the steps included in the flow chart in figure 2.

In some cases, the analysis/calculation performer and/or the EPNSD may identify safety code/software applications different from the reference code. This will happen in limited cases and for very specific purposes. These software applications, including versions, shall be uniquely identified and shall be provided with documentation requested in §8.3 and §9.1 to enable the EPNSD Responsible person to determine if the candidate software application will meet the needs of the safety demonstration for ITER Project.

The objective of the verification is to determine if the code/software application:

- is working as intended;
- uses reliable techniques and correct algorithms;
- performs the selected functions in the correct manner;
- is used in an adequate validation domain for ITER.

This verification is generally performed through the analysis of the provided documentation.

The objectives of the software validation procedure are to:

- Determine the range of applicability;
- Determine if the software complies with the requirements;

- Establish the sensitivities to relevant parameters for different studies needed in the safety demonstration;
- Estimate the uncertainties of relevant parameters on the overall results for different studies needed in the safety demonstration.

The validation of a safety code/software is generally based on a set of calculations and on the benchmarking of the results with others code/software or with experimental results:

- by comparison with results of available experiments, including fusion benchmark experiments performed during ITER R&D activities. The same inputs as applied to the experiments are used and the outputs are compared to the results of the experiments;
- by comparison with the results of simulations performed using other validated software applications. The same inputs must be defined as applied to the validated applications;
- by analysis of simplified test cases and comparison, if possible, to hand calculations.

Since it cannot be proven that a code is error free, the accumulation of test cases provides evidence that the code is sufficiently error-free and accurate. These test problems must be documented, accessible, repeatable, and capable of being referenced. Documentation must also record the computer hardware used, the operating system, compiler versions, etc.

8.2.2.1 Phase 1: Planning

8.2.2.1.1 Validation and verification request

The requester:

- Starts of the validation and verification process by contacting the ITER Responsible Person within the EPNSD and submitting the request form. If the requester is external intervener, she/he should submit the request form to the corresponding IO TRO. The IO TRO shall assess the request and submit the request to EPNSD responsible person, or reject it.

8.2.2.1.2 Designation or acceptance of the performer

The EPNSD responsible person:

- Accepts and starts the surveillance of the validation and verification process;
- Assigns/ or accepts (when assigned by requester or IO TRO) a person(s) to perform the validation and verification work and ensures that he meets the minimum qualification requirements for this task

8.2.2.1.3 Definition, planning and recording of the work

The requester and the performer prepare the Planning of the validation and verification and submit the plan to EPNSD responsible person and IO TRO (if applicable) for review. This plan shall:

1) Specify the objective, its work scope, domain of applicability, requirements, input data, methodology and assumptions.
2) Select the validation and verification tests to be performed.
3) Specify the expected output results and deliverables (define acceptance criteria).
4) Establish a level of “validity” (deviation and reproducibility) that is to be applied during the technical checking process.
5) Establish the required approvals including acceptance by the requester and the EPNSD division head.
6) Establish an independent peer review level of effort that is commensurate with the importance of the analysis or calculation.
7) Records the whole plan in a document which can be called “Planning of the validation and verification of the code *NNN*” duly reviewed/recommended by IO TRO and approved by

EPNSD responsible person to be later attached to the "Safety Code Validation and Verification Report" (cf. § 8.2.2.2) and which includes the step 1 to 7 above.

8.2.2.1.4 Revisions communication and documentation

The requester and the performer:

- Communicate any revisions in the task planning to the affected parties and document as necessary to reflect the revisions.

8.2.2.2 Phase 2: Performance of the analysis for V&V

The performer:

- Fills the Safety Code Validation and Verification Cover Sheet (see template in ITER_D_ STMCPF);
- Uses only assumptions and applicable input data as specified in the "Planning Document" produced in § 8.2.2.1.3;
- Performs the analyses or calculations planned for the validation and verification process in accordance with the requirements contained in the "Planning Document";
- Documents the analysis by drafting a "Safety Code Validation and Verification Report" (see template in ITER_D_ STGKQP). S/he notably includes the "Planning Document" as an annex;
- Includes sufficient detail so a person who is technically qualified in the subject can understand the work, review it, and check the adequacy of the results;
- Documents all material legibly and in a form suitable for reproduction, filing, and retrieval (electronic documents adequate). Attach the software input and output files;
- Submits the analysis or calculation documentation to the EPNSD;
- If during the analysis, a suspected error is confirmed in the calculation of an existing safety demonstration, report it using the ITER nonconformities system (cf. [10]). A "Nonconformity Report" (NCR) will be used to document the suspected error and a remedial action will be proposed.

8.2.2.3 Phase 3: Technical Checking

8.2.2.3.1 Assignment of the technical checker(s)

The EPNSD responsible person will assign the technical checker. If the code qualification request is from an external intervener, or the performer is from an external intervener, the IO-TRO is also one among the technical checkers who will provide expertise on the related product to assess. The assigned technical checker(s) shall:

- have not been involved in the validation and verification process;
- demonstrate technical expertise relevant to the process being reviewed. This individual may also have sufficient technical experience on similar work to assess the validation and verification process and compliance with design inputs.

8.2.2.3.2 Technical checking

A technical checker:

- Checks the analysis or calculation package for technical adequacy and conformance with requirements specified in the Planning Document. S/he checks:
    - o The required information specified in the "Safety Code Validation and Verification Report" (see template in ITER_D_ STGKQP);
    - o The basic approach, assumptions, and subject-specific data;
    - o That input data are consistent with requirements or validated by referenced sources;
    - o That calculations are mathematically correct;

  - o That the validation domain is stated and consistent with the use;
  - o That requirements and acceptance criteria (defined in § 8.2.2.1.3) are appropriate and used correctly.
- – Checks that conclusions reached are reasonable and consistent with the analysis or calculation approach, assumptions, input, and acceptance criteria;
- – Checks the analysis/calculation fits within the limitations of the software, including any software errors that have been reported limiting the use of the software;
- – Checks that all references cited are retrievable and applied correctly (references such as e-mail messages and phone call records are attached to the analysis as appendices);
- – Provides any comments resulting from review of the analysis or calculation to the performer for resolution.

8.2.2.3.3 Consideration of the comments

The performer:

- – Modifies the analysis or calculation and documentation as necessary to address review comments, and provide the modified analysis or calculation to the technical checker for concurrence.

The technical checker then:

- – Checks the modified analysis or calculation by confirming that the review comments have been addressed;
- – Could disapprove the analysis work if it is deemed substantially not enough after iterative work. This disapproval will fail the code V&V as safety code.

8.2.2.4 Phase 4: Independent Peer Review (if designated by EPNSD)

As defined in § 8.2.2.1.3, depending on the required degree of validation of a specific safety software/code or the complexity of its models and/or complexity of the analysis performed by the Performer, the EPNSD Responsible Person may decide to put in place an independent Peer Review.

8.2.2.4.1 Assignment of the independent peer reviewer

The EPNSD Responsible Person:

- – Assigns an independent peer reviewer who is knowledgeable with the subject matter under review.

The performer:

- – Submits the analysis or calculation documentation to the independent peer reviewer for review.

8.2.2.4.2 Independent Peer Review

The Independent Peer Reviewer

- – Provides a high-level review of the completed analysis or calculation that includes the following, as a minimum:
  - o Analysis or calculation approach/ philosophy is reasonable and appropriate
  - o All pertinent factors are considered
  - o Inputs are reasonable and correct
  - o Assumptions are reasonably substantiated and justified
  - o Computer models are appropriate and contain sufficient detail
  - o The validation domain is clear and the code is used in its validation domain
  - o Outputs are reasonable for the given inputs and assumptions

  - Defined acceptance criteria (in 7.2.1.3) are appropriate
  - Conclusions are reasonable and representative of outputs
- Provides any comments resulting from review of the analysis or calculation to the performer for resolution.

NOTE: The independent peer reviewer does not perform a detailed check of the calculations because that would duplicate the technical checkers function.

8.2.2.4.3 Consideration of the comments

The performer:

- Modifies the analysis or calculation as necessary to address all independent peer review comments.

The technical checker:

- Confirms that the analysis or calculation modifications made in response to independent peer review comments did not change the confirmation reached during the technical check.

The independent peer reviewer

- Confirms that comments have been resolved;
- Could disapprove the analysis work if it is deemed substantially not enough after iterative work. This disapproval will fail the code V&V as safety code.

8.2.2.4.4 Transmission Procedure

After having been formatted, checked and validated, the performer shall transfer all duly signed deliverables/documents to the EPNSD for review, approval and recording. The performer shall provide EPNSD with the cover page of these files indicating the list of file references. If the requester is EI, the V&V report should first be reviewed by ITER TRO before being delivered to EPNSD responsible person.

8.2.2.5 Phase 5: Approval / rejection of the verification and validation

The code V&V will be approved or rejected by EPNSD responsible person according to the results of the V&V process. The “Safety code validation and verification report” needs to be approved by EPNSD responsible person.

8.3 Process to check the code documentation appropriateness

This section provides explanation of the steps included in the flowchart displayed in Figure 1.

8.3.1 Submission of the needed documentation

Once the safety code/software is verified and validated, the requester provides to the EPNSD responsible person all documentation described in § 9.1.

8.3.2 Verification of the needed documentation

The EPNSD responsible person checks that, for a given version of a given code, the minimum documentation/reference is provided and satisfies the requirement of § 9.1.

8.4 Approval/rejection of the code/software as safety code

The “Software Documentation Check” must be filled and approved by the EPNSD responsible person. Once the code has been verified and validated, the documentation requested in § 9.1 has been provided and checked, and the Software Documentation Check is approved, the code is considered as qualified.

NOTE: some of these documents can be regrouped in a single one –after prior approval of the EPNSD Responsible Person.

9 Outputs

9.1 Minimum documentation for qualification of ITER safety codes

The minimum documentation to properly qualify a safety code can be classified in three sets of documents:

- Part D: code description;
- Part A: code assessment;
- Part U: "code use" documents (manuals).

Description of files to be included in each category is given in the following sub-sections. Depending on the code contractual issues, the access to some of the documentation may be restricted.

9.1.1 Part D: Code description

This set of documents will include an overview section that recalls the physical laws applied, including the main assumptions and approximations made, and when necessary gives appropriate references for the detailed physical basis. It also describes the calculation code in computing terms, while specifying the digital processing algorithms and programming details (according to the code complexity, the following first three sections may or not be independent documents).

- Overview section, which includes:
  - o Introduction (context of development, intended code applications, background);
  - o Code architecture (language, operating system, top level organization, pre-processing overview, transient overview, post-processing overview);
  - o Overview of models (field equations, correlations, specific models);
  - o Other techniques (time step control, mass and energy error checks, etc.).
- Numerical techniques section: describes numerical modelling and discusses on stability, accuracy and convergences of the numerical techniques used in the code.
  - o Modelling of phenomenology;
  - o Numerical methods used;
  - o Domain of applicability of the numerical techniques;
  - o Comparison with analytical solution and separate effects experiments.
- Models and correlations section: presents a detailed discussion of code physical models and correlations, including:
  - o Field equations;
  - o Detailed description of correlations and models and their domain of applicability (i.e. thermal-hydraulics models, aerosol behaviour, dose rate attenuation models…);
  - o Specific models (e.g. abrupt contraction/expansion within the thermal-hydraulics model).
- Programmer's manual: contains detailed information of the code structure, the program flow, internal databases, programming techniques, property tables, interpolation subroutines (if any), input and output processing subroutines, and file structures.
- Program description note: for reasons of practicability and readability (especially in large codes) it is not suitable to include detailed descriptions of the program units within the programmer's manual. Therefore, for each program units, this note describes the parameters, calling trees, flow diagrams, etc.

9.1.2 Part A: Code assessment

This set of documents will provide a range of code applications (phenomenological, separate effects, integral) for the purpose of demonstrating the applicability of the code and to ascertain code capabilities and limitations. The developmental assessment deals with separate effect tests, whereas the verification process concerns integral tests and usually includes calculations performed externally to the code team.

- Developmental synthesis (separate effects tests);
- Verification synthesis (integral tests);
- Comparison with analytical solutions, if applicable;
- Comparison with other codes, if applicable;
- Uncertainties of the constitutive relationships (field equations, correlations, empirical models, etc.);
- Uncertainties analysis reports (give uncertainties associated with physical key parameters);
- Developmental/Verification reports: analyses, for each new delivered version, how the code copes with the developmental/verification tests. These reports must reflect to what extent the code is representative of the simulated physical phenomena.

9.1.3 Part U: Code use

This documentation regroups all information required for the correct use of the safety code. This document is usually drafted by the developer of the code with the aim of helping code users. The code developer will make sure that all installation procedures have been defined correctly so that licensees with the source file can install the safety code on their own operating system. The operating instructions must not refer to the developer's own files.

This file or set of documents includes:

- User's guidelines (give advice about the most appropriate choices for modelling and limitations on the valid use of the code);
- Reference manual (gives the most comprehensive information about objects, operators, keywords, data …);
- Updates note (help the user in the migration of the code);
- Non-regression test report (this document presents the non-regression calculations performed to validate a version of the code);
- Delivery test report (presents the tests and results necessary for approval of a particular code version. Note: a non-regression test can also be considered a delivery test);
- Installation manual, including test cases to verify installation (this manual details the requirements for code installation, specifying system requirements and directory structure, installation scripts, customization scripts and delivery test package);
- Pre and post processing guide (depending on the complexity of the code, pre- and/or post-processing may be required for data integration).

Note: In practice, some of these documents can be regrouped in a single document (for simple calculation codes and/or simple phenomenology/models).

9.2 Synthesis

The execution of this document requires at least the following outputs:

Name of the output	Is there a need for template? If yes, UID	Where this output stored?	If IDM, which document type?	How do you name this file? (naming convention)	Accountable team for the availability of the output	Retention period
Software documentation Check list	ITER_D_SUDNWD	ITER_D_VK4M6G	Memorandum /note	Check list	requester	over the project lifecycle
Safety code validation and verification report with cover sheet	ITER_D_STGKQP (report) ITER_D_STMCPF (cover sheet)	ITER_D_VK4M6G	Memorandum /note	V&V report	requester	over the project lifecycle

9.3 MQP records

The deliverables of this procedure (Working Instruction for the Qualification of ITER safety codes) and relevant documentary evidence, including submissions (plan for V&V, performer analysis report, V&V report, software documentation check list, and any other documentations) during the different review and approval process defined in the flowcharts of figures 1 and 2, shall be properly stored, reviewed and approved in ITER IDM system. In the case that the technical checker or the independent peer reviewer has no access to ITER IDM system, the comments or recommendation evidence need to be recorded in ITER IDM system.