# ITER on the Way to Become the First Fusion Nuclear Installation

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**Abstract**

On the 31st of January 2008, the General Director of ITER Organization sent the request for Authorization of Creation of the ITER Basic Nuclear Installation (INB), "Demande d'Autorisation de Création, DAC". This paper presents the licensing process for ITER in application of "loi n° 2006-686 relative aux installations nucléaires de base et au contrôle, en matière de sûreté nucléaire, du transport de substances radioactives", the so-called "Transparency Law, TSN law" and the technical content of the DAC files with special emphasis on the issues that new laws and new orders published in France since the ITER site selection have introduced in the ITER design and in the safety analysis. This paper pays special attention to regulation application and licensing process which is new for the fusion community. Examples of practical implications for ITER as a nuclear facility such as operational domain and safety important components are given for the plasma current, the plasma facing materials and the test blanket modules.

## 1. Introduction

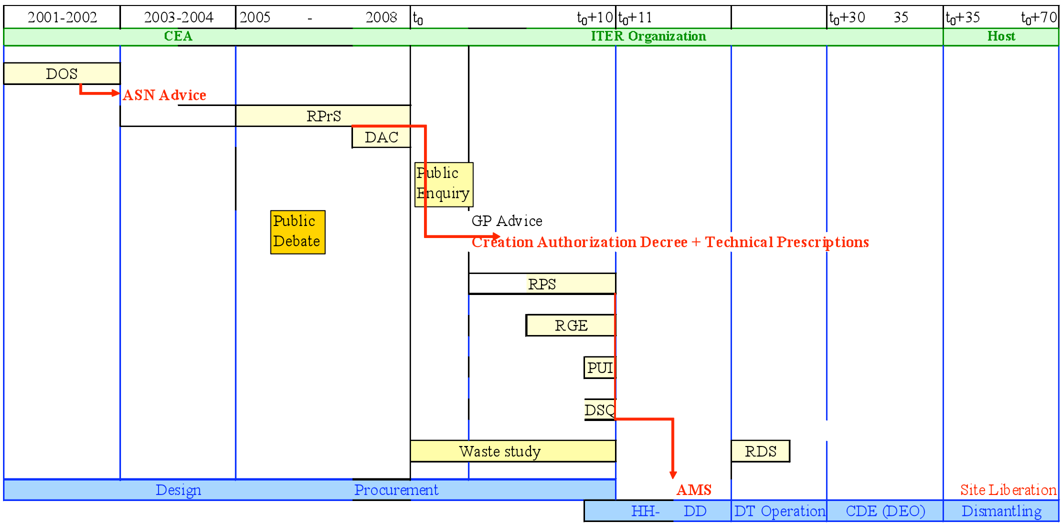
The licensing procedure of a Basic Nuclear Installation (Installation Nucléaire de Base, INB) follows the French regulations which define a mostly non prescriptive approach based on a continuous dialogue between the nuclear installation owner and the Nuclear Safety Authority, "Autorité de Sûreté Nucléaire, ASN". This dialogue is based in particular on the writing and the analysis of more and more detailed safety documents, reflecting the progress in the definition and the construction of the project. This approach is regulated by Law no 2006-686 of 13th June 2006 on transparency and nuclear safety (TSN Law), which has been further developed in the Decree N° 2007-1557 of the 2nd of November 2007. The TSN law has slightly modified the licensing process presented previously [1], but the main content of the documents to be provided has not been substantially changed, although some new documents have to be provided in the Request for Authorization of Creation for a new INB (Demande d'Autorisation de Création, DAC).

On the 31st of January 2008, the Director General of ITER Organization (IO) sent the request for Authorization of Creation (DAC files) of the ITER INB and, following French law, formally became a Nuclear Operator. This paper presents the licensing process for ITER following the application of the TSN Law. A large number of experts have participated in providing technical elements for these files, in particular the European Domestic Agency which has contributed on subjects such as codes and standards, waste management, operational feedback gathering and zoning definition [2]. In addition, in the framework of 2007 ITER Design Review, the Working Group on Safety (see author affiliation 3) has contributed by addressing important subjects before the submission to the files to the Safety Authorities and by recommending some others for future studies. The outline of this safety documentation is presented in Section 2. The integration of the safety approach of ITER in the physics programme of the machine is described in Section 3 with practical examples of the ramifications for ITER of being classified as a French nuclear facility in areas such as operational domain, safety important components, plasma current, plasma facing materials and the test blanket modules.

## 2. Licensing Process for ITER

### 2.1. DAC files

ITER is the first INB to start the licensing process since the introduction of the TSN law in France and the preparation of the safety files has therefore also been governed by Decree of the 2nd of November 2007. The host state anticipated the need for a Dossier d'Options de Sûreté (DOS) [3] and this was therefore the first step of the licensing process for ITER. The requirement was subsequently confirmed by the TSN law (see FIG 1). Subsequent recommendations and commitments following the examination of DOS by ASN have been the main guidance for completing DAC files.




| *Acronym* | *French meaning* | *English translation or meaning* |
|---|---|---|
| | *Entities and Authorities* | |
| ITER Org. | Entité Juridique ITER | ITER Legal Entity |
| CEA | Commissariat à l'Energie Atomique | French Atomic Energy Research Institute |
| ASN | Autorité de Sûreté Nucléaire | French Safety Nuclear Authority |
| GP | Groupe Permanent | Permanent Group (in charge of Request Examination |
| | *Licensing Procedure and main documentation to be prepared* | |
| DOS | Dossier d'Options de Sûreté | Description of Safety Objectives |
| DAC | Demande d'Autorisation de Création | Request of Authorisation of Creation |
| RPrS | Rapport Préliminaire de Sûreté | Preliminary Safety Report |
| RGE | Règles Générales d'Exploitation | General Rules for Operation |
| PUI | Plan d'Urgence Interne | Emergency Internal Plan |
| DSQ | Dossier de Synthèse de la Qualité | Summary of Quality Assurance |
| RPS | Rapport Provisoire de Sûreté | Provisional Safety Report |
| RDS | Rapport Définitif de Sûreté | Final Safety Report |
| AMS | Autorisation de Mise en Service | Authorisation for operating with radioactive material |
| CDE | Cessation Définitive d'Exploitation | Definitive End of Operation |

*FIG. 1: Scheme of the Licensing Process for ITER*

The DAC dossier presently includes 14 files, notably reports such as the impact study which was previously in the DARPE (Demande d'Autorisation de Rejet d'Effluents et de Prélèvement d'Eau, i.e. request of authorisation for water intake and effluent release). In addition, there is a report on risk control, a dismantling plan and the full report of the Public Debate is also included.
One very important document is the Preliminary Safety Report, (Rapport Préliminaire de Sûreté, RPrS), in which a chapter which was not previously a part of an RPrS covering the basic layout and contents of the on-site emergency plan (PUI) has been added to comply with the decree.
DAC dossier is presented to a Public Enquiry that must be launched by the local authorities on ASN request. Some conclusions of the Enquiry may be integrated in the technical files. A thorough technical review of the RPrS by the IRSN (see FIG 1) will finish by the examination of the IRSN report with questions to the IO experts by Groupe Permanent. GP final advice will lead to the Decree of Authorisation of the INB that has to be issued by the ministries involved in this process: Ministry of Ecology and Sustainable Planning & Development, Ministry of Economy, Finance and Employment, Ministry of Health, the Youth and Sport.
The following steps to come in the licensing procedure are represented in detail in FIG 1 and are related to the authorization for operating with radioactive fuel, “Autorisation de Mise en Service, AMS”. As after DOS examination, recommendations of the GP for DAC files will become requirements for AMS files.

## 2.1. RPrS

The writing of the RPrS started in 2006 when the table of contents was presented to the ASN. The purpose of this document is to demonstrate that appropriate provisions have been made in the design to accommodate the risks which have been identified. The RPrS describes safety implications and technical choices for the whole project from the core of the tokamak out to the limits of the ITER installation. The RPrS is a document organised in two volumes:

Volume 1 is a detailed description of the whole installation. It covers the neighbouring facilities as well as the ITER site and its environment. One chapter is devoted to a description of the ‘ITER Platform’ which is a flat area on which most of the ITER buildings will be erected. There is a chapter devoted to a building-by-building description of the facility which includes the nuclear buildings (tokamak complex and the hotcell) and the other buildings which play a role in the safety analysis and the functional interfaces between them. There are further chapters describing utilities, instrumentation and control systems, human factors, operation, inclusion of lessons learnt from other facilities in the design, waste and decommissioning/dismantling.

The identification of all risks in the facility is presented in the chapter giving input conditions for the safety analysis. One consequence of this analysis and a good example of its integration in the design is the zoning schemes (for ventilation, radiation, beryllium, fire, waste, etc.) which are defined in a specific chapter.

The chapter on operation sets out the general principles for operation, the experimental programme and the various phases for normal operation. This chapter also describes the organisation of ITER and how the requirements of the Quality Order of the 10th August 1984 are met for all the Quality Related Activities.

Volume 2 is the detailed safety analysis which demonstrates that the technical choices described in Volume 1 are sufficient. The volume starts with a description of the general safety principles and a study of normal operation. The hazards are then analysed and preliminary safety studies of accidents are developed. In this accident analysis a series of worst-case scenarios chosen from the accidents which could happen under normal design parameters and conditions (‘design basis’) are presented. A series of hypothetical accidents based on beyond design basis scenarios are also presented. The latter are either constructed from the earlier worst case scenarios by adding additional independent aggravating failures or they are the result of extremely low probability events.

The analysis of the design basis accidents is intended to present the envelope that has been considered in the design and serves to identify components which are important for safety. The study of beyond design basis accidents is intended to demonstrate that there is a sufficient safety margin in the design and that there are no cliff-edge effects.

The presentation of the accident analyses follows a strict format: definition of initiating boundary conditions, description of the analysis tools (computer codes) and finally presentation of the results in terms of the requirements for the corresponding safety provisions in the design.

A separate chapter is devoted to the radiological consequences of the accidents. The impact is presented in terms of the consequences for the personnel, the public and the environment.

### 2.2. Application of Quality Management Regulations to ITER

The “Quality Order” of the $10^{th}$ of August 1984 clearly specifies that the “quality” (aptitude to provide a function), shall be commensurate with the importance of the SSC (Systems, Structures and Components) with regards of the Safety demonstration and refers then to what ITER has classified as Safety Important Components (SIC), e.g. SSC which are important for personnel and public safety and which are required to perform a safety function. Components not classified as SIC but taking part in the prevention, detection and/or mitigation of the consequences of an event are also governed by the “Quality Order”.

In application of Article 2, ITER has to define the “Activités Concernées par la Qualité, Quality Related Activities (QRA)”; these are activities that could be affected by the quality related to the SIC, i.e. activities carried out by ITER or its service providers which have an impact on the quality of SIC. As a consequence ITER identify all QRAs to ASN. The application of specific quality management procedures to QRAs ensures that the safety requirements of SIC are maintained in order to keep the installation inside the authorized domain. The quality order imposes the following activities as being affected by the quality:

- Correction of off-normal situations and incidents
- Design studies.
- Operations of control judged to be particularly important for the safety (in particular control activities mentioned the quality order such as procurements, survey of suppliers, accreditation of staff, organization, etc.

ITER has defined QRAs in the RPrS according to the three main phases of the project: Design, Construction or manufacturing and Operation:

- during design phase, the QRAs are as follows: definition studies for SSC, safety studies, manufacturing specifications for systems and components including SIC, drafting technical manufacturing specifications for contracts including SIC, management and tracking of changes in any data. Note that some design QRAs were implemented before submission of the DAC files.

- during construction/manufacturing phase, (and its follow-up) activities, the QRAs are listed according to the type of contract: detailed design and manufacturing studies, control of suppliers, inspection of detailed design and manufacturing studies performed by service providers of SIC, verification of the level of requirement met in terms of construction, manufacturing, reception of components and non-conformities management, assembly and on-site testing of SIC.
- during operation/commissioning, activities (restricted to inactive tests) identified as QRAs include the preparation of the following documents for operation phase: draft of General Operating Rules, operating instructions, maintenance procedures, management of input data. For operation and maintenance QRAs include operation safety important systems as defined in Article 1 of the "Quality Order", safety-important component (SIC) maintenance, as well as full follow-up of the on-site inactive tests which are to demonstrate the performance of the systems. This must include drafting of detailed test procedures, carrying out procedures and writing up the related reports. The aim of this ACQ is to ensure that safety functions are properly performed once the systems are installed at the facility.

The quality regulations stipulate that ITER must put in place an adequate organization to define specific requirements of QRAs, to manage and to follow-up them, define the requirements for the accreditation of staff involved, manage and reduce anomalies, check that the organization works correctly, survey subcontractors, provide the regulators with documented evidence of the results and finally maintain appropriate archives for all documentation.

The process of defining and validating changes in the facility is an activity that could be affected by the technical definition and quality management of a Safety Important System (see FIG. 2) and has also to be done in accordance with the "Quality Order" in the framework of a defined envelope. This is explained in the next section on examples of plasma physics and safety related issues. In particular requests made by ASN need to be integrated in the analyses of change.

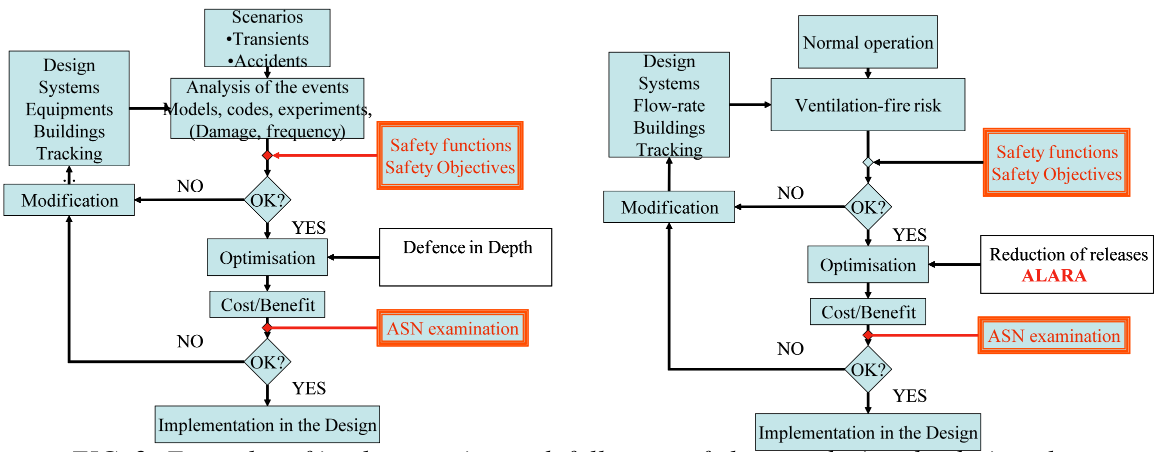



*FIG. 2: Examples of implementation and follow-up of changes during the design phase*

SIC or SSC will evolve with the different risks associated with the different phases of the project, so the QRA will follow resulting in a rearrangement of the QRA for each phase. Modifications have to be managed in such a way that a clear tracking of the evolution is kept. For each SIC the values of their operational limits (range), their threshold levels (alarms for malfunction), their safety limits and limits in the design calculation are recorded in their operating domain.

## 3. Integration of safety approach of ITER in the physics programme of the machine

### 3.1. Operational Domain

One practical example of how Plasma Physics is related with safety issues is the requirement to define an envelope operational domain for plasma physics parameters which will allow with the evolution of design evolution from now to the end of ITER's life. The parameters which define the authorised operating domain have to be defined precisely in the Technical Specification and General Operating Rules in accordance with the official Technical Prescriptions. The latter are prescribed by the Nuclear Safety Authority (ASN) as for application of the Decree of Authorization, and which will remain within the limits imposed by the Decree for ITER.

The authorised operating domain must cover the operation of the entire facility under normal operating conditions, including maintenance, special operating situations and unexpected situations, generally due to component failures, where there is no safety risk for the facility if compensatory actions are provided. The authorised operating domain is defined by a finite list of parameters or charts. For each of these parameters, the list will also include one or more high or low operational thresholds which, in some cases, can be defined or adjusted according to the current operating phase or state.

For example, concerning plasma operation and its implication in safety aspects ITER has proposed to demonstrate that the operation at 17 MA is feasible and to keep this value as a limit for the operational domain. The progressive start-up approach will facilitate the necessary validation of the design assumptions. It is expected that the facility will demonstrate that there is a safety margin resulting from the conservative assumptions made in the design for the load combinations on the vacuum vessel and the in-vessel components. The progressive start-up will ensure safe operation at each step before enlarging the range of the machine parameters in the next step. In such a way the operational limits associated with machine parameters must be defined to envelop all programmed experimental situations. The transition from one experimental programme to another must be made without changing the facility safety baseline; it will therefore be necessary first to show that the new operating conditions will be within the scope of the authorised operating domain. This procedure is illustrated in FIG. 3.

In a large envelope, values that are not yet fully demonstrated can be included. Nevertheless RPrS must provide full demonstration for smaller values of the same parameter. These smaller values can then be included in the Technical Prescriptions that ASN will write for apllication of the Authorisation of Creation Procedure after the RPrS examination process. So the plasma current parameter 17 MA may be the only plasma parameter characterising the physics of ITER to be inserted in the decree of authorizing the of creation of the basic nuclear installation. This limit of the operational parameter "Plasma Current" will be reached inside the operational domain once the experiments at 15 MA have demonstrated that the next step will keep the electromagnetic stresses within the values for which the vacuum vessel has been designed. The safety analysis of the design basis events in these new conditions will show that the previously presented consequences are not exceeded.

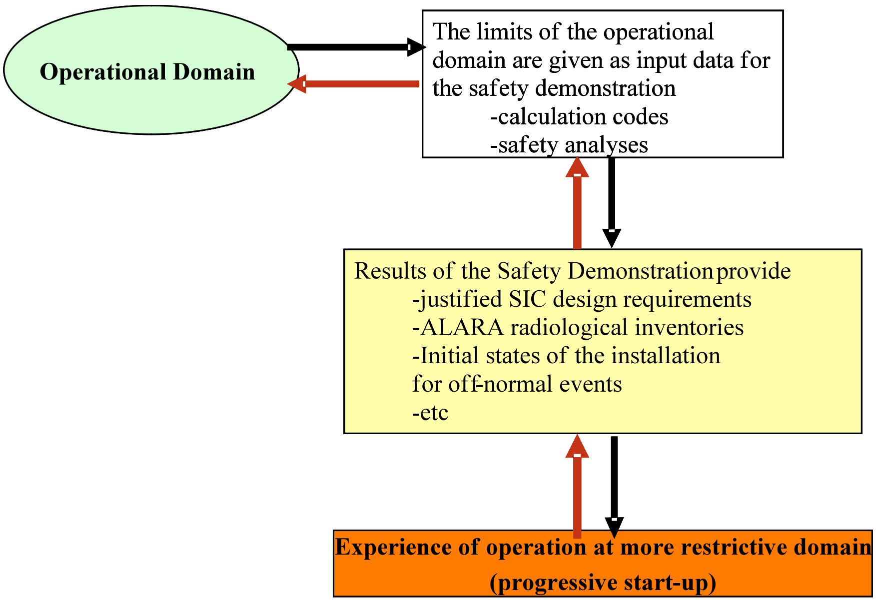



*FIG. 3: Role of the Operational domain in the Safety demonstration*

In parallel, because ITER is the first fusion nuclear installation some aspects must be demonstrated such as the fact that the thermo-hydraulic behaviour of the cooling system is not essential since it is not required that heat evacuation is a safety function. On the other hand, the plasma current produces electromagnetic loads on the vacuum vessel which have to be limited; this gives the dimensioning parameter for the first confinement barrier, the main safety function of ITER.

### 3.2. Plasma Facing Material Choice for In-vessel Components

Another important aspect of the safety demonstration concerns the choice of material for the vacuum vessel and the in-vessel components. Feedback from experience in previous tokamaks it was decided that the baseline 2001 should be Carbon/Tungsten divertor plates and Beryllium tiles on the blankets. Nevertheless the 2007 baseline has the option to optimize plasma performance and safety by changing the plasma facing materials. The decision is waiting for the results of experiments at JET and ASDEX with full beryllium and full tungsten first walls. The present safety demonstration assumes a conservative value for Tritium retention and dust generation that will be verified by the progressive start-up and leaves margins for the acceptance of first wall changes which would imply better T-control and reduction of dust production. For that the development of a dust and tritium management strategy has been foreseen which is based on source term confinement, measurement of T and dust that plasma facing components will generate, estimation of the uncertainties, cleaning systems, optimisation of measurement and cleaning systems and a research and development programme running in parallel [4].

### 3.3. Test blanket modules

One of the aims of ITER is to demonstrate fusion technologies in a system that can integrate the nuclear components ultimately required for the exploitation of fusion energy. One aspect of fulfilling these detailed technical objectives, is to assess blanket design concepts suitable for a future power producing facility. The commissioning requirements, the acceptance criteria and the test programme must be defined to minimize the risks. The initial characteristic parameters used to define the authorised operating domain have to be selected according to the radiological impact estimated using the accident analysis. These scenarios cover: initial operating conditions, source terms for radioactive materials liable to be mobilised, intrinsic characteristics of confinement barriers, the use of detection systems, where applicable, the use of protective/mitigation systems. Consequently the TBM design and safety assessment must follow the ITER safety principles and demonstrate that operation and accidents are within the envelope assessed for ITER. Additional safety requirements for test blanket modules (TBMs) are defined by limiting criteria on their specific materials and parameters (liquid metal and high operating temperatures), additional accident sequences and issues concerning waste, normal releases and occupational exposures as well as structural aspects (codes, testing). If one or more TBMs are substituted by a "dummy" module (for example due to late delivery or failure during operation), it must also be shown that the dummy module meets all relevant requirements, including safety.

## 4. Conclusions

ITER is a nuclear installation and is therefore following the licensing procedure for such installations in France. The initial steps in this procedure have been achieved with the submission of a complete set of safety documents known collectively as the DAC.

In order to integrate the safety approach which has been presented to ASN in the physics programme of the machine, the progressive start-up of ITER is an essential tool to facilitate compliance with the "Quality Order", to provide the highest safety conditions and to protect the investment.

In addition the application of the Quality Order is a guarantee for the successful integration of the nuclear safety requirements in the design, giving the basis for ITER construction, operation and decommissioning of ITER.

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