ITER at Cadarache : An Example of Licensing a Fusion Facility

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The existing regulatory framework in France provides a full and coherent licensing basis to permit ITER to be build and operated at Cadarache. The specific sitting studies including the submission of the first step of licensing documentation for ITER offers an early assessment of fusion power plants.

The regulatory procedure begins with the release of a Safety Objectives Report, which has already been sent to the Safety Authorities in the beginning of 2002. This report is presenting a description of the plant, the radioactive inventory and the identification of the main risks and associated safety functions.

This document includes a preliminary evaluation of the environmental impact associated with normal operation and representative accidental events. The results of this analysis are given. For example the consequences in term of additional doses are estimated to be about 1 μSv per year for the closest inhabitants around the Cadarache site during normal operation.

The licensing of ITER will be the first experience of licensing a major magnetic fusion device on a scale similar to that of a power plant. Thus there are lessons to be learnt and precedents that will be set.

1. Introduction

The objective of the ITER Project is to demonstrate the scientific feasibility of fusion, with extended burns and marginally controlled ignition, for a duration sufficient to achieve stationary conditions on all time scale characteristics of plasma processes. The installation is defined to produce 500 MW of fusion power during pulses of at least 400 s. The facility will present all the key fusion technologies, which will be required for a future power plant. Most of the radiological and nuclear aspects of the future power plants will be also present in ITER : for this reason one objective of ITER is also to contribute to the demonstration of the safety and environmental potential of fusion power.

The aim of this paper is to offer an illustration of this potential on the basis of a real licensing process underway in France.

The French Authorities have proposed the place of Cadarache as a possible European site of ITER construction.

Several technical studies were launched to ensure that Cadarache will full fill all the ITER requirements and examine in detail the level implementation.

Only very few minor adjustments have to be done withregards to ITER generic design.

In parallel the CEA launched the licensing process and begins the dialog with the Safety Authorities.

This process will be described in the next paragraphs and we will try to identify the extrapolations which may be valuable for future fusion installations.

2. The application of the French regulatory framework to ITER

ITER is classified in France, as a nuclear installation ("Installation nucléaire de base") due to at least the expected tritium inventory and the level of activation materials.

The process for licensing a nuclear installations follows a well-established standard in France. It is finalized at the government level by two decisions one is related to the construction authorisation (DAC : Décret Autorisation de Construction). The second one is related to the possibility to reject gaseous and liquid effluents in the environment (DARPE : Décret d'Autorisation de Rejet et de Prélèvement d'Eau).

This process of decision is the finalisation of an administrative procedure which includes the examination of safety documentation by the safety authorities and a local public enquiry.

But the process is mainly based on the continuous dialog between the operator and the Safety Authorities.

This dialog begins by the "Dossier d'Options de Sûreté" (Main Safety objective of the project), which defines ITER safety objectives, the major risks and the proposed means for control or ambiguity them. It will be followed by the "Rapport préliminaire de Sûreté" (Preliminary Safety Report) which represents the main accompanying document before the construction and consists of a detailed descriptive and comprehensive safety analysis of the installation.

The CEA in collaboration with the help of other European Associations has already sent the DOS and is preparing all the elements for the RPrS.

3. Main content of the DOS an (Dossier d'Options de Sûreté)

The DOS is not a mandatory documentation but it is a key file for starting the technical discussion with the Safety Authorities.

DOS briefly describes the installation, proposes general safety objectives and explains how it is planned to implement them in the installation. In particular, objectives on effluents an liquid releases are defined for normal incidental and accidental events. In addition a preliminary evaluation of the impact of these releases on the population has been made and it will be verified that they are under the project limits. Besides, it must be shown that no cliff effect will evolve from an off-dimension situation. This report also presents a preliminary strategy for tritium transport, the management of the produced during machine operation as well as in the foreseen steps for decommissioning and dismantling of the installation at the end of life.

This document has been completed at the end of 2001 and has been submitted by the CEA to the French Safety Authorities from whom an advice is expected by the end of year 2002. Recommendations which will follow which will be useful for preparation of the Preliminary Safety Report.

The description and the safety approach are based on the documentation, which has been provided by the ITER international team at the end of the Engineering Design Activities in July 2001.

The safety analysis in this documentation has especially showed that three safety functions have to be fulfilled in the ITER Installation :

- the confinement function of any radiological species,

- the limitation of any radiation exposure,

- the extraction of residual heat.

The confinement issue is always recognised as main safety function in a fusion installation and the design of ITER has set up for this purpose successive barriers. These include the vacuum vessel, the cryostat, and the active atmosphere conditioning systems with filtering and detritiatium systems.

In addition the safety analysis has the objective to demonstrate that these systems are effective to strictly release to the environment has low as reasonably achievable (ALARA) for normal operation as well as accidental events.

The integration of this features in the installation is not always obvious as we have to show that this function is even fulfilled at on adequate level whatever any internal or external hazard my occur.

For example, in the case of a fire it is necessary to define fire sectors with limited releases, as well as proceeding evacuation routes for workers.

Withregards to the radiation protection function the main issue is related for ITER to the minimization of the doses to the workers when performing any maintenance task.

The intensive use of remote handling equipments associated with a careful work preparation of all the tasks will help to satisfy the ALARA objective of the radiation doses.

Finally the heat extraction of residual heat is easily satisfied in ITER with the redundant system of the heat extraction and especially the passive cooling systems of the increase vessel.

The presentation of the safety analysis in the DOS has already confirmed the safety functions and the generic ways to fulfil then but has put in the light that a great attention has to be devoted for the detailed implementation.

4. Preliminary evaluation of the environmental impact

A preliminary evaluation has been done taking into account the proposed implementation of the facility at the vicinity of the current Cadarache fusion installation (TORE-SUPRA).

This evaluation is based on the expected releases given by the generic documentation.

For gaseous releases the total estimated values given for ITER, (70 TBq/a of tritium as HT and 20 TBQ/a as HTO and 0.25 g/a of activation products AP (SS316), and 0.1 g/a of activated corrosion products (ACP)) were taken as the source-term for a global radiation dose evaluation in normal conditions.

The different isotopes have been deduced from ITER data and the total annual releases for different radionuclides corresponding to the choosen source term have been taken as input for the site-specific dose calculations.

Population distribution around Cadarache, weather conditions, food habits and others parameters defined for Cadarache site have been used. The annual effective doses for an adult in the closest habitation near Cadarache have been estimated to be about 1 μSv per year after 10 years of continuous D-T operation for the given source-term.

The source term for the annual liquid releases is also taken from ITER references. (This corresponds to the total estimated values of liquid releases : 0.14 TBq per year tritium and 0.77 g per year of activation corrosion products). Based on this source term the total annual releases for different radionuclides corresponding to the estimated liquid releases are taken from ITER data for

dose impact calculation. For Cadarache site the maximum annual effective dose after 50 years was calculated to be about 0.1 μSv per year in the nearest village (Saint-Paul lez Durance).

For the most severe accident taken as reference event the calculated dose for the nearest adult inhabitant is 0.1 mSv. As a comparison the background impact in the area is about 2.4 mSv per year.

5. Waste Management

ITER will produce waste both from operational activities (component replacements, process and house keeping wastes) as wall as the decommissioning phase. There are mainly two sources of activity for this waste. Firstly the fusion reaction, produces 14 MeV neutrons implying material activation. Secondly activated materials can lead to contamination.

For the generic design the strategy developed was already working on the volume reduction of wastes by the choice of materials and an adequate design which allow for example to replace only. The plasma facing material and sent all the component.

The implantation of ITER on a specific site requires to review all the wastes and to determine which repository is appropriate as a function of the site regulatory practice and to define more precisely the waste management strategy.

Three levels of waste have to be taken into account in the ITER case.

- **TFA waste** (Très Faible Activité : very low level waste) which are consider by the regulatory practice in France to avoid any dispersion of nuclear material.

- **A waste** (low and Medium Activity with short half life).

The disposal for this hand of waste in France is the CSA Centre de Stockage de l'Aube.

B Type waste (Medium Activity and long half life).

Studies are currently performed in France to define the best strategy for **B type waste** disposal management. Geological disposal is one of the studied possibilities. The expected activation of materials and estimation of contamination allows us to identify the classification of each part.

The sharing of the expected waste for ITER is described in Table 1.

This sharing confirms that most of the waste resulting from ITER operation and dismantling is of very low level, which would be under clearance level when considering IAEA criteria.

The waste management optimisation will be based especially on waste treatment and conditioning, as the analysis has shown that a few time of temporary repository does not allow a significant declassification.

One interesting waste treatment would be the decontamination process of corrosion products in order to declassify water-cooling systems. In addition the detritiation of components metallic would present a great interest for the declassification as to decrease the potential gaseous release from the waste.

The second aspect of the strategy is to define to best conditioning process, taking into account compacting possibilities, and characteristics of the packaging. It is clear for example that on adequate performance should be defined to the packaging when considering tritium and beryllium contamination of waste.

Therefore special attention should be devoted during operation and dismantling phase to minimise the contamination of the waste.

6. Lessons burnt for the future Fusion Power Plants

The positive safety assessment of ITER will give a very good message for the safety of fusion in general. However all the safety aspects of a future fusion power plant are not covered by the ITER safety analysis. The major differences are related to the higher neutron fluence in the power plant which would be partly counter balanced by an optimised choice of low activated structure materials.

Nevertheless lessons for the future should be taken from the ITER safety analysis.

The major result is related to the main safety functions : the detailed implementation of the confinement function in the design should be studied carefully. Then into account all the associated risks which my endanger the barriers

Once confinement is defined, the management of accidental events is much easier even for hypothetical events provided that a few safety features are in place as the pressure suppression system to cope with in vessel leaks.

The implementation of the ALARA principle with regard to the doses for workers would be different in the industrial environment of a future power plant in comparison with the experimental context of ITER.

Nevertheless it would require a careful analysis of all the planned tasks in order to define adequate protections and develop when possible remote handling equipments.

Finally the development and the validation process of all the calculation codes which has begin for ITER, will have to continue. This is related as well for the neutronic calculation, the thermohydraulic and mechanical codes, and in general the tools used for the safety analysis.

7. Conclusion

The process of licensing construction and operation of ITER has begun in France and the safety analysis is discussed in details with the Safety Authorities and their technical experts.

A key issue is the implementation of the main safety function, which is the confinement as it affects as well the accidental consequences and the environmental impact.

When careful design provisions are taken, the ITER safety assessment and moreover the operational experience of ITER will offer a sound basis for the promotion of the fusion energy as a safe and reliable option for the future generations.

Table 1:

	TOTAL expected	**TFA percentage**	**A percentage**	**B percentage**
Operational waste	1 400	20	75	5
Internal components replacements	740	-	-	100 %
Decommissioning	30 000	60	20	10