LICENSING ITER IN EUROPE: AN EXAMPLE OF LICENSING A FUSION FACILITY

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ABSTRACT

ITER being by definition the way to further power plants, its licensing will provide key issues for the next step facilities. In Europe the licensing process for ITER started before any conclusion on a specific site was made for this first of kind fusion experimental reactor, in parallel with the process of negotiations and the Joint Assessment of Specific Sites. In the framework of licensing ITER in Cadarache, a safety report called "Dossier d'Options de Sûreté, DOS" (Safety Objective File) was submitted for examination to the French Safety authorities in March 2002 by CEA (Commissariat à l'Energie Atomique), to act on behalf of a future ITER organisation. After the corresponding examination the Safety Authorities, in this case DGSNR (Direction Générale de la Sûreté Nucléaire et de la Radioprotection) issued a letter with recommendations in November 2002. The following mandatory safety document, which is under preparation, the "Rapport Préliminaire de Sûreté" (RPrS), must take into account these recommendations.

This licensing process is the first for such a fusion device with an assessment value for the tritium inventory in all the installation of 3 kg to be used for research and development. For the first time too, an operator, ITER, explains to the Safety Authorities specific aspects of plasma physics and tokamak operation and associated specific safety issues. From this dialogue, which is part of all the licensing processes in France, lessons are being learnt on how to manage fusion safety related problems in the regulatory framework and which are the main concerns for the Safety Authorities. Five major requests for further clarification have been underlined in the recommendation letter related to materials and activation products, operational limits, decay heat removal, incidental and accidental scenarios and waste management.

In this paper, the status of the answers to these requests and to other issues that will be detailed in the RPrS is presented from the viewpoint of the European collaboration where EURATOM associations for fusion and EFDA Close Support Units are closely working.

* List of participants is given in [1]

I INTRODUCTION

In the ITER final design report presented to IAEA in 2001 [2], the safety approach was defined for a generic site in Generic Site Safety Report (GSSR). As soon as the Negotiations on ITER Joint Implementing Agreement started four candidate sites where presented [3], Cadarache (France), Clarington, (Canada), Rokkasho (Japan) and Vandellòs (Spain), opening in different ways licensing processes in these countries. The European Counsel of Ministers selected Cadarache for the European site in November 2003; at this moment, in France the achievement of the second step of licensing procedure, which was already well defined, became a priority [4]. Studies accompanying the process have been done under EFDA auspices in the scope of European ITER Site Studies (EISS) and started in 2000. Details of the licensing process will be presented in chapter II, underlying where the generic preliminary report was very appropriated and when mainly due to the specific site more studies have been needed. Chapter III will present the found issues, actions being undertaken and launched R&D for answering to the safety authorities demands, for completing the safety analyses and the implementation of safety functions in the ITER design.

II DESCRIPTION OF THE LICENSING PROCESS

The first step of licensing process in France is the “Dossier d’Options de Sûreté” (DOS), which gives the safety design guidelines to be followed. The main safety approach must: a) define safety functions, b) identify risks, and c) describe means for risk mitigation and minimization.

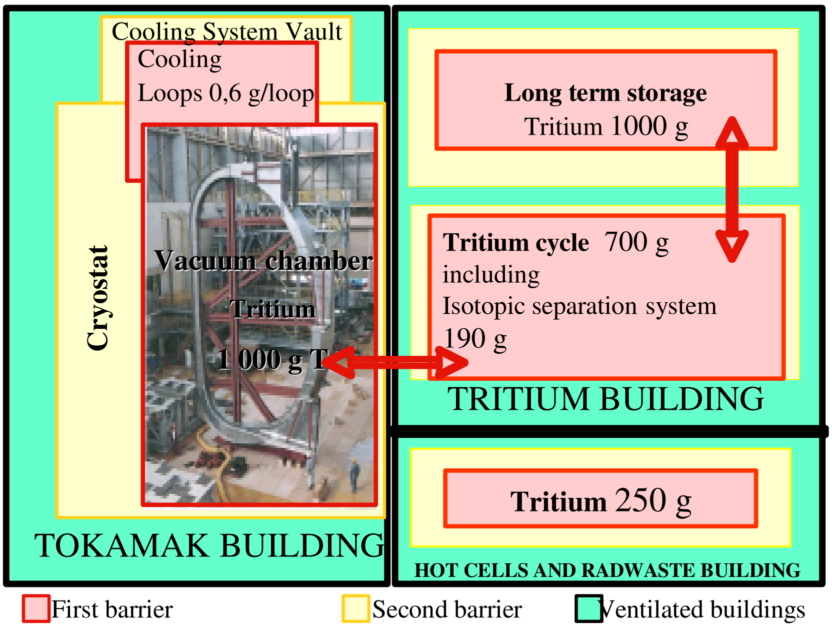

Figure 1: Tritium inventory in the nuclear buildings and scheme of the different confinement barriers

DOS describes briefly the installation and the inventory of radioactive materials: Tritium fuel, neutron activation products in structures and in vessel dust (AP), neutron activated corrosion products in coolant water (ACP), proposes general safety objectives and explains how these are going to be implemented in the installation. This document has been completed at the end of 2001, has been submitted beginning of 2002 by the CEA to the French Safety Authorities who have formally accepted the presented approach and have proposed recommendations for the writing of the Preliminary Safety Report.

Given the total tritium inventory distributed in the different parts of the installation (see figure 1), ITER has been classified as a Nuclear Facility (INB) of the Laboratory or Fuel Plant type in opposition to Nuclear Power Plant. Therefore, the DOS redaction has been done following existing guidance of table of contents for this type of facility. All the information needed was easily found in the existing ITER documentation. As far as general principles were stated, specific issues as external hazards or nuclear buildings distribution and interfaces between them did not needed details at that stage. The safety objectives chosen are lower than ICRP recommended limits values [5] and for the workers and for the public as shown in table 1.

Type of plant situation	**DOSSIER D'OPTIONS DE SURETE (DOS) General Safety Objectives in DOS**		**ITER guidelines**
	Occupational exposure	**For Public and environment**	**Dose to the workers** releases to the environment
Dimensioning situations			
Normal	Annual individual work doses ≤ 10 mSv/a Annual mean value of individual work doses ≤ 2.5 mSv/a	Normal releases below authorised annual limits for the installation ≤ 0,1 mSv/a	**Annual individual work doses** **5 mSv/a** **0.5 mSv/shift** 1g T and 0.1 HTO and 1g AP and 5g ACP Per year
Incidental	10 mSv per incident	Releases per incident below authorised annual limits for the installation ≤ 0.1 mSv/a	1g T or 0.1g HTO or 1g AP or 1g ACP or equivalent combination of these per event
Accidental	Constraints related to the post-accidental management are taken into account	< 10 mSv None counter measures None consumption banning for any vegetal or animal products	< 50 mSv 50g T or 5g HTO or 50g AP or 50g ACP or equivalent combination of these per event
Situations beyond Design			
Hypothetical	No cliff effect	Counter measures limited in time and space	<50 mSv

Table 1: limit doses for the workers and the public as safety objectives taken for Cadarache ITER site.

Cadarache site has adopted for the basis design accidents a dose limit to the public which is 5 times below the ICRP recommendations and for the hypothetical events no cliff effect and counter measures limited in time and space. This would be in agreement with the generic optimised intervention level for temporary evacuation developed by the IAEA [6], which is an avoidable dose of 50 mSv within a period no more than 1 week. One of the safety goals of ITER will be to demonstrate that the safety objectives can be reached and consequently the design must be appropriated for respecting these fixed dose limits.

The second step of the licensing process is the preparation and the assessment of the Preliminary Safety Report ("Rapport Préliminaire de Sûreté, RPrS"). The RPrS consists of a detailed description and a comprehensive safety analysis of ITER. The preparation of the main contents of this document was undertaken at the beginning of 2002. The table of contents which has been chosen follows the guidelines for water pressurised reactor and an effort for adapting ITER to it is ongoing trying to identify strong constraints which could not been necessary for ITER. This could be the first step in a process of developing a specific safety guidance for future post-ITER facilities. The availability of the licensing framework for RPrS writing, the studies that were anticipated for preparing files in support to RPrS are described in [4] and the status of the recent studies are detailed in chapter III.

The licensing process will finish by the "Décret d'Autorisation de Création" (DAC) signed by at least the minister for the environment and the minister for industry and the "Décret d'Autorisation de Rejets d'Effluents et de Prélèvements d'Eau", (DARPE) approved by the ministers of environment, industry and health. The administrative procedures to obtain these authorisations started in parallel to the RPrS at the beginning of 2003.

At each of these authorizations, a Public Enquiry will also be undertaken. It is a consultation process among the local communities within a radius of about 15 km from the proposed site. Issues such as the effect on the environment resulting from the construction and operation of the installation will be described.

It is possible that the CEA, if mandated by the Parties, in direct liaison with the International Team could submit the document and receive the authorization pending establishment of the Organization, and then transfer the responsibility to the Organization without changing the nature of the licensing process.

As part of the Road Map, the ITER project will be submitted to a Public Debate ("Débat Public"), as foreseen in French law. The objective of the debate is to launch an overall countrywide discussion on the socio-economic and/or environmental consequences of the project. A special commission is in charge of surveying this process, which cannot last more than six months. CEA is exploring how and when it would be best initiated.

The following steps to come in the licensing procedure are related to the authorization for operating with radioactive fuel, "Autorisation de Mise en Actif". A temporary authorization can be awarded, "Autorisation Provisoire d'Exploiter", instead final authorization, and before starting operation, which date should be fixed in the authorization of creation DAC. For ITER, this can be the permit for first Tritium tests in tritium building or first injection of Tritium in the tokamak, at low percentage. Technical specifications will then be presented. As for the DAC, this authorization will come after the examination by the Safety Authorities of three different documents which are a Previous Safety Report, "Rapport Provisoire de Sûreté", general rules for the exploitation, "Règles Générales d'Exploitation, internal urgent plan, "Plan d'Urgence Interne" and a summary of quality assurance plan, “Dossier de Synthèse de la Qualité”. In parallel all the permits for Tritium transport and for Tritium handling must be done.

After the temporary authorization, the final authorization will be given and a final safety report, “Rapport Définitif de Sûreté” must be submitted, where technical specifications and general rules could be upgraded.

III MAIN REQUESTS FOR PRELIMINARY SAFETY REPORT

After the examination of DOS, the French Safety Authorities, DGSNR (Direction Générale de la Sûreté Nucléaire et de la Radioprotection) have issued a letter with recommendations in November 2002. The “Rapport Préliminaire de Sûreté” (RPrS), must take into account these recommendations. Five major requests for further clarification have been underlined in the recommendation letter related to materials and activation products, operational limits, decay heat removal, incidental and accidental scenarios and waste management. On the other hand, CEA has accepted the commitments of including other related safety points, which need more detailed development or justification.

III.1. MATERIALS AND ACTIVATION PRODUCTS

Concerning the recommendation on materials and activation products and the associated neutronics in ITER the Safety Authorities have asked to clarify the following points:

- Justification of chosen data, hypothesis and calculation methods
- Make a calculation scheme which represents the real tokamak configuration
- Indicate main material, which can be activated, main reactions giving radio-nuclides which can have a safety or waste impact.
- Precision uncertainties related with calculation method and hypothesis, with cross sections (for transport and activation reactions) for all the elements important for a safety or waste management.
- Status and R&D of used codes and validation including component and structures impurities characterisation

It is well known in the Fusion Community that these issues are very important for ITER and for the future post-ITER reactors. Fusion programme on material activation has started since 30 years and includes not only code qualification but also material behaviour studies under 14 MeV neutron flux. For the design, licensing, construction and safe operation of fusion reactors, materials have to be qualified by radiation exposure in a neutron source simulating the expected fusion neutron spectra and temperatures under fusion relevant conditions. This is the aim of IFMIF, which offers an irradiation test bed that fulfils the required criteria. Nevertheless materials used in ITER are not representative of future fusion reactor and even though an operation of IFMIF in parallel to ITER could help in verifying calculation codes, ITER has to be licensed well before IFMIF could operate and it is necessary to ascertain the quality of the activation calculations which have allowed establishing estimation of waste amount, quality and management strategy.

GSSR refers to the codes, which have been used for this purpose, nevertheless anticipating the SA requirements, in the scope of EISS, few studies have been done in order to constitute the file on activated materials and neutronics: full activated list of radio-nuclides at the end of ITER life, their classification and possible repositories have been provided in [7] and references therein, as well as complementary neutronics calculation [8]. Finally [9] answers partially to the recommendations showing in a first part, the degree of maturity of the libraries and calculation models. In this report an assessment based on the analysis of uncertainties origins allows to conclude that the calculations done so far are adequate. The methodology developed over the past twenty year to assess and quantify the activation characteristics of ITER materials: activity, decay heat, doses, inhalation and ingestion indices and others derived quantities have reached a degree of maturity that allows confidence to be placed in both their level and associated uncertainty. Moreover the demands in term of safety and environmental concerns could be meet if strong, focused program are devoted to generate the acceptable answers in time. Aspects concerning the real tokamak configuration should be continued in ITER R&D programme as well as the validation of calculation codes taking into account impurities in the structures.

III.2. NORMAL OPERATION: OPERATION LIMITS AND INVENTORY HARNESSING

The second recommendation concerns normal operation conditions and control of the activated mobilisable materials. Three points are underlined

- Define the limits of operation consistent with foreseen evolutions of the installation and more particularly maximum power and fluence values for the blankets.
- Show reliability of foreseen provisions in order to respect the limit for tritium in vacuum vessel and cryo-pumps (1000g) and justify mobilisable part in case of accident
- Study how to reduce dust limit in vacuum vessel and on the other hand how to reduce radio-actives materials in cooling system and in particular ACP during operation

For a facility as ITER as for any nuclear facility limits for operation, safety operational limits for physical values triggering safeguards, safety limits for these physical values and design limits must be defined. Moreover for the Safety Authorities it must be shown that maximum foreseen fusion power value is in accordance to power loads to be support by vacuum vessel coiling systems. The consistency of the values that will be presented in the RPrS with the experimental program must be shown. The same approach should also been applied for the maximum neutronic fluence on the blankets which could be reached after 20 years; if as for JET the scheduled experiments would be drawn out, it should be demonstrated that a higher waste generation in activation and in volume will not be produced. The operation domain for ITER should then be reviewed taking into account future modifications of the machine, in such a way that the existing systems would not need modifications of the limits written in RPrS

On the other hand, source term (tritium, AP, ACP) control below foreseen limits is a safety issue closely related with current R&D and R&D that would be in ITER experimental programme itself. Main actions to be continued are research on T-trapping-Removing, erosion-deposition, cleaning of vacuum vessel, associated diagnostics for detecting total amount of dust, methods for reducing activated dust production, verification and validation of associated safety calculation codes and qualification and reliability of proposed solutions. The coherency of the fusion experimental programme and the availability of the results is a basic support to the licensing process; this needs in parallel to the research done a close follow-up and traceability which is been collected in a special file on feedback experience learnt from existing machines and ongoing R&D, which will need to be periodically up-dated for taking into account modification and new qualification and validation.

III.3. COOLING SYSTEM: DECAY HEAT REMOVAL

The following recommendations concerning decay heat removal points out that:

- Provisions for avoiding common mode failure on the two vacuum vessel cooling loops, and ultimate dispositions foreseen in case of loose of both loops.

It can easily be shown that for ITER, in opposition to fission facilities decay heat removal is a non-issue as shown in GSSR and mentioned in [3].

III.4. INCIDENTAL AND ACCIDENTAL SCENARIOS

In the DOS report the safety methodology for incidental and accidental situations was presented and the application of the methodology was provided on an example of double breach in the heat transfer system and in the divertor which is the accident in the design reference with the highest impact: ~250 µSv to the closest inhabitant. In the RPrS all the scenarios must be presented and the following recommendations have been done by the Safety Authorities:

- Present an approach for identification of incidental and accidental situations and result of the analysis justifying chosen hypothesis and consequences. Common modes, human errors, accumulation of internal of external risks, unique aggravating events with threshold effect and risk of cliff-effect specially in the cryostat zone.
- Method for classification by categories and results

- Excluded scenarios and justification for the exclusion.

Complete safety analysis of accidental situations is provided in GSSR volumes 7-11 and studies related studies have been done. Nevertheless further studies will be done for fully answering to the present recommendations and will be included in the RPrS.

III.5. WASTE AND DISMANTLING

Waste and dismantling was not a major issue in the DOS, nevertheless in the dialogue with the safety authorities from the beginning of the process, it was clearly identified as a file to be provided in an accompanying report to the RPrS and the studies were undertaken at the same time that the Cadarache candidature was presented.

Main questions that are asked by the Safety authorities are the following:

- Complete or supply the information related to the definition of waste packaging and foreseen management channels depending on nature and the quantity of this waste
- Explain foreseen actions to guaranty the coherence between the development of waste management channels, including intermediate disposals and ITER operation needs taking into account the characteristics of waste packaging. The operator should clarify the difficulties possibly met in the management of this waste, mainly for tritiated waste or the mixed waste (chemical and radioactive)
- Describe the foreseen installation for characterization, sorting, treatment, conditioning, storing and expedition of waste on ITER's site, and present the safety associated analysis.
- Present design provisions in the perspective of later dismantling, allowing a clear separation between nuclear waste and conventional waste

Almost all these issues have already been solved or are under discussion with the French agency for waste repositories, ANDRA. Few issues as interim repository studies started in 2004 have identified the needs and have provided the input specifications for looking for alternative solutions for T waste repository using detritiation or degasification or gathering beds. Clarification of the final issues of mixted waste containing Beryllium is also in progress. After modification of the design of hot cells and radwaste building the amount of waste generated in operation and after dismantling must be assessed and dismantling of the building but be studied.

III.6. MAIN COMMITMENTS

Commitments are a list of actions and studies to be included in the RPrS. The main ones related with safety analysis and risk studies are

- Confinement systems and barriers justification
- Principles for confinement classification by locals depending on atmosphere and surface contamination in normal and accidental conditions and safety requirement for equipments

- Wind effect in ventilation
- Atmosphere detritiation principles for locals
- Most severe cask related incident or accident study
- Technical options in case of fire showing that no barrier and no detritiation loose will occur.
- Hydrogen, dust, ozone explosion risk study
- Loss of electrical supply study
- Earthquake dimensioning options
- Risk study of an helicopter and water-carrying fire-fighting aircraft in case of fire 5 km near ITER site
- Flood risk study, exceptional grow up of the table water
- Continuous release optimisation in normal operation

Others issues must be presented in the RPrS: safety analyses for file completion as Codes & Standards and safety relevant components, toxic effluent impact of Beryllium on the environment, principles of maintenance programme, human factors incorporation into the design and operation, safety control room, analysis of need of a withdraw control room and survey networks; Assessment after design modifications for auxiliary systems and networks, internal hazards for finalising fire analysis and explosion analyses and taking into account accumulation of events, external hazards as earthquake, aircraft crash and their effects on the specific layout as well as an assessment of the new Tritium, hot cell and radwaste buildings design and their associated detritiation and ventilation systems.

IV CONCLUSION

These recommendations and commitments must be integrated in the RPrS and must lead to actions for the following regulatory files, for the star-up and operation. For some recommendations and commitments, R&D should be carried out in the short term objective (RPrS) for example explosion in vacuum vessel is under study viewing to its exclusion in such a way that this risk could be considered as a residual risk, because of its low probability that should be to be demonstrated or because of a large number of precursor events to be accumulated. Following the precaution principal: prevention, detection, and mitigation systems have to be foreseen. Nevertheless the consequences of such an accident has to be evaluated taking into account realistic hypotheses. The associated R&D needs to study H_2 production, diffusion, inerting approach and other mitigation systems. In the medium term objective (RPS) effective qualification of calculation codes is an example of R&D to be presented. In the long term (start-up and operation) the efficiency and reliability of the remote handling should be one of the objectives of the research. A strong collaboration between designers and safety experts is needed for achieving these objectives. ITER construction and operation and the associated licensing process and the final reports could be a solid base for future reactor licensing process.

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