UPDATED ACCIDENT CONSEQUENCE ANALYSES FOR ITER AT CADARACHE

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Throughout the various phases of the ITER project, extensive safety analyses have been performed to ensure that potential hazards to the public, the environment, and personnel are minimized. This work, done before a location for ITER had been chosen, resulted in a very comprehensive assessment of ITER safety in terms of the impact at a "generic site". By making good use of the favourable safety and environmental characteristics of fusion, a very good outcome was achieved.

Now that the Cadarache site, in southern France, has been selected for ITER construction, it is necessary to re-analyze the impact of postulated accidental releases of tritium and activated material, taking into account the specific conditions of the site. These include regulatory requirements on dose limits and on assumptions to be made in analyses, as well as local environmental factors such as weather conditions, population demographics, and local food production and consumption patterns.

This paper discusses the impact on the ITER safety case of new dispersion and dose calculations for accidental releases, taking into account these site-specific conditions. These indicate that doses arising from the release masses calculated for the most challenging accident scenario in previous generic-site studies will meet the new dose limits by a very large margin.

I. INTRODUCTION

Safety analyses have been an important part of the design activities for ITER throughout the project life. This is to ensure that ITER will be safe in operation, presenting minimum hazard to personnel, the public, and the environment, and also to pursue the objective of demonstrating the advantageous safety and environmental characteristics of fusion. It has also long been understood that safety analyses will form an essential part of the submission to regulatory authorities of the host country for ITER, in order to obtain construction and operation permissions.

Until 2005, studies of safety for ITER had been non-site specific, and were guided by the principle that the ITER design should be capable of satisfying regulators to allow construction in any of the countries that were party to the ITER Engineering Design Activities (the European Union, Japan, USA, and the Russian Federation). Thus assumptions were based on the characteristics of a "generic site". In particular, the ITER Final Design Report of 2001 was supported by a Generic Site Safety Report (GSSR) [1] which described all aspects of safety studies for ITER, based on generalized site assumptions.

The 2001 GSSR contained a full safety analysis of the ITER design including studies of a range of postulated incidents and accidents, chosen to cover all major ITER systems and all perceived hazards. The comprehensive nature of this selection was confirmed by systematic accident identification studies. Conservative analyses of the events demonstrated that the maximum consequences, in terms of releases of radioactive material from the plant, were well within the acceptance criteria adopted by the project for a generic site.

In the five years since the completion of that work, several things have changed that motivate a re-appraisal of the accident consequence analyses. The ITER design has evolved, in several important ways that influence the modelling of the potential release path for material mobilized in an accident. A construction site has been chosen for the project, allowing local conditions to be taken into account in place of generic site assumptions. The requirements of the safety authorities in the host country, responsible for licensing the construction and operation, replace the guidelines adopted by the project when no specific site was specified. In the meantime, the parties to the ITER project have grown to include South Korea, China and India, and one of the existing parties, the EU, has expanded to 25 countries. Thus the ITER design must meet the approval of a wider range of participants, at the same time as satisfying the particular requirements of the French authorities.

Taking account of all these developments, revised analyses of postulated incidents and accidents are to be performed, in support of the preliminary safety report which is planned to be submitted to the authorities at the end of 2007. An important aspect of these new studies are the consequence analyses, i.e. the computation of the impact on the public of an accidental release of active material from the ITER plant. Preliminary calculations of dispersion of released material and dose uptake by individuals have been performed for conditions appropriate to the Cadarache site. These are reported in this paper together with an assessment on the likely impact of the results on the potential consequences of the events studied in GSSR.

To set the assessment in context, an overview is first provided of the licensing process for ITER at Cadarache, highlighting the part played by accident analyses. The anticipated requirements in terms of dose limits are discussed. The selection of "reference event" scenarios is outlined and the outcome of corresponding analyses in GSSR is recalled. The methodology for dispersion and dose modelling is described, and the set of specific assumptions for ITER calculations is explained. A selection of results is presented together with conclusions on the impact these would have on the ITER safety case. Pending a revision of the studies of releases from these postulated scenarios, and confirmation of the dose results by comparison with other models, these results and conclusions are preliminary.

II. ITER LICENSING PROCESS

Preparation for the possible siting of ITER at Cadarache began some years ago, with the writing of the Safety Options Report (Dossier d'Options de Sûreté, DOS) which was presented to the French Nuclear Safety Authority (Autorité de Sûreté Nucléaire, ASN) in 2002. This outlined the safety approach, summarized the ITER design and identified the main hazards associated with operation of the facility, and the measures taken in the design to prevent or mitigate them. After review, the authorities responded with a number of questions and issues that they expect to be addressed in the subsequent safety reports.

After the selection of the Cadarache site for the ITER project, in June 2005, attention has turned to the preparation of the Preliminary Safety Report (Rapport Préliminaire de Sûreté, RPrS), which must be submitted to ASN and accepted by them before a construction permit is granted. Two other documents, Demande d'Autorisation de Création (DAC) and Demande d'Autorisations de Relève et Prélèvement d'Eau (DARPE) must be completed at the same time and will be used as the main input to a Public Enquiry.

The RPrS will contain the preliminary safety case for ITER, including a description of the safety design and justification that this is adequate to meet requirements. An important part of this case is the analysis of the response of the facility to off-normal events, and the potential consequences of postulated accident sequences that could be initiated. The RPrS will also discuss the environmental impact of normal operational, as well as occupational safety, and waste management; these topics are outside the scope of the present paper.

II.A Incident and accident analyses

The analysis of off-normal event sequences to be presented in RPrS will be aimed at demonstrating that the ITER design is adequate to fulfill the safety objectives. Events occurring during operation, or following an unexpected fault, are categorised as:

- **Normal Operation** comprising events and plant conditions planned and required for ITER normal operation, including some faults, events or conditions which can occur as a result of the ITER experimental nature;
- **Incidents**, or deviations from normal operation, comprising event sequences or plant conditions not planned but likely to occur due to failures one or more times during the life of the plant but not including Normal Operation;
- **Accidents**, comprising postulated event sequences or conditions not likely to occur during the life of the plant.

A selection of events will be analysed and presented within RPrS, with full analyses for further events provided in supporting documents, the conclusions summarised in RPrS. Those events included in RPrS itself will be those that provide the "design basis", i.e. which demonstrate the need for design features providing safety functions, or which provide quantitative information on requirements, such as the design pressure limit on the vacuum vessel in the event of a large ingress of cooling water.

In addition to these events within the design basis, it is a requirement that analysis of hypothetical events, beyond the design basis, are presented in order to show that there is no sudden degradation of safety performance as events of decreasing likelihood are considered (a so-called "cliff edge" effect). Such hypothetical event sequences are postulated by adding a series of independent aggravating failures; accordingly, the expected frequency of the overall sequence is extremely low.

II.B General safety objectives

In earlier phases of the ITER project, in the absence of any site-specific requirements, guidelines were adopted for the maximum allowable consequences of incidents and accidents that would satisfy requirements in any of the ITER parties. These were specified in terms of limiting mass releases (in grams) for each of the three main types of radioactive material inventories in ITER:

- Tritium (either as HTO or HT);
- Solid activation products, particularly those in the form of mobilisable dust generated by erosion of the plasma-facing surfaces;
- Activated corrosion products (ACP) in cooling water.

TABLE I. General Safety Objectives as presented in DOS

	General safety objectives	
	For personnel	**For the public and environment**
Situations in design basis		
Normal situations	As low as reasonably achievable, and in any case less than: Maximum individual dose **≤ 10 mSv/yr** Average individual dose **≤ 2.5 mSv/yr**	Releases less than the limits authorised for the installation, Impact as low as reasonably achievable and in any case less than: **≤ 0.1 mSv/yr**
Incidental situations	As low as reasonably achievable and in any case less than: **10 mSv** per incident	Release per incident less than the annual limits authorised for the installation. [i.e. **0.1 mSv** per incident]
Accidental situations	Take into account the constraints related to the management of the accident and post-accident situation	No immediate or deferred counter-measures (sheltering, evacuation) **< 10 mSv** No restriction of consumption of animal or vegetable products
Situations beyond design basis		
Hypothetical accidents	No cliff-edge effect; possible counter-measures limited in time and space	

For each of these a mass release limit was specified for events according to their categorisation (normal, incident, or accident). The analyses of events provided results in terms of grams of off-site release for each of the types of material noted above, and a check of compliance with the guidelines could be made. This approach of working in terms of mass release deferred the assessment of consequent doses to members of the public, the approach to the calculation of which differed between the various parties, and is also dependent on some site-specific information.

Now that the site for ITER has been chosen, at Cadarache in France, a site-specific approach can, of course, be taken. It is now possible to set limits in terms of doses to individuals, and to calculate the consequences of events in such terms.

A set of General Safety Objectives (Objectifs Généraux de Sûreté, OGS) have already been proposed and presented to the regulator, ASN, within the DOS in 2002. These are presented here in Table I. The quantitative limits included in this table, in terms of individual doses arising from incidents and accidents, now replace the mass release guidelines previously used by the project.

There remains a difficulty with the implementation of the objective for accidental situations, “no restriction of consumption of animal or vegetable products”, as neither French nor European regulations include any limiting value for the level of tritium concentration in food products. It is not adequate to simply employ values given as specific activity (Bq/kg) for other nuclides, since the specific characteristics of tritium, such as its short residence time in the human body, need to be taken into account [2].

No quantitative limit has yet been proposed for the beyond-design-basis hypothetical events. The OGS mentions the absence of cliff-edge effects, discussed above, and also the limitation of possible counter-measures. This refers to an objective such as the “no-evacuation” that has long been a requirement adopted by the ITER project, that in no event should there be a technical need to evacuate the public from around the site. This has previously been interpreted as meeting the IAEA guideline for evacuation [3], a 50 mSv dose commitment over a 7-day period, but this is currently under review.

Public doses noted in the right-hand column of Table I are expected to be long-term dose uptakes, including all exposure pathways such as ingestion of contaminated food products. For beyond-design-basis events, only early dose need be considered, including inhalation but not ingestion.

III. REFERENCE EVENT STUDIES

III.A Selection of events

In order to study the potential consequences of postulated accident sequences in ITER, a set of “Reference Events” have been defined, chosen to cover all the main hazards foreseen in the ITER design. The original selection of events [4] was made for the 1998 ITER design, and the selection has subsequently been updated as the design and analyses have evolved [5], to ensure coverage of

- all major systems in the ITER design;
- all significant inventories of radioactive material;
- all initiator types that have the potential to cause releases.

This “deterministic” selection of events has been paralleled by comprehensive Failure Modes and Effects Analyses (FMEA) of all important ITER systems, which was performed at the component-level wherever the design is sufficiently detailed [6]. These FMEA studies have provided comprehensive lists of Postulated Initiating Events (PIEs), indicating all off-normal occurrences that may have a safety impact. For every one of these PIEs, it was confirmed that the potential consequences of event sequences that could be initiated were enveloped by those of an available analysis, usually one of the Reference Event analyses.

As a further check of completeness, these studies were initially complemented by a top-down view using a Master Logic Diagram [7], which confirmed that no additional events were revealed. More recently a PIE Postulated Impacts Table (PIE-PIT) has been constructed [8], which combines the bottom-up view of the systematic FMEA studies with a top-down view which leads to a limited set of Plant States in which an off-site release is possible. This PIE-PIT illustrates a large range of event sequences, and permits the selection of “bounding events” which have the greatest potential to lead to one of the Plant States [9]. This gives an alternative route to the selection of events for analysis [10], and again confirms that the existing set of Reference Events is sufficient.

III.B Source terms and releases

The 25 Reference Events selected for analysis in GSSR were each the subject of computational modelling to assess the maximum releases from the plant under conservative assumptions. In each case the inventory at risk was identified and conservatively quantified. The details of each event sequence were carefully specified, including variations and parameter scans in some cases to establish the worst conditions. The specification included, for example, assumptions to be made about leakage rates through confinement barriers. The computer codes used for the analyses were the subject of verification studies, including a series of experimental tests to provide code benchmarking in some cases.

The outcome of each analysis was a maximum release in grams for each of the three types of active material.

For **tritium**, the release quantities in HTO form and as HT were separately quantified. For this, it was conservatively assumed that all tritium of in-vessel origin is oxidised as HTO.

For **activated dust**, a detailed nuclide inventory was specified based on neutron activation calculations for the plasma-facing surface materials. The dominant source term in terms of consequential doses are the products of activation of tungsten.

For **activated corrosion products (ACP)**, a full nuclide inventory was also specified, derived from modelling of corrosion product behaviour and activation in the water cooling loops.

These mass releases then provide a source term for atmospheric transport to a location where an individual is assumed to be exposed. The location of the release from the ITER buildings depends on the scenario assumed for the Reference Event, and is generally either via the elevated release point at the building roof, 60m above ground, or a "ground level" release, which includes leakage through walls of a height typically ~10m above ground.

The outcome of the analyses was that releases, where non-zero, were always well within the project mass release guidelines explained above in section II.B. Now it is necessary to assess whether, when these mass releases are used as source terms in site-specific dispersion and dose calculations, the resulting doses comply with the dose limits in the OGS (Table I).

III.C Updating of analyses

The Reference Event analyses reported in the GSSR provided a sound assessment of the potential consequences of incidents and accidents in the ITER design of the 2001 Final Design Report. Since then, the ITER design has evolved, some changes have been made and some aspects have become defined in better detail. In the light of these it is necessary to update the analyses of the Reference Events, with complete re-analyses in some cases. Furthermore, additional FMEA studies have been performed, mainly for ancillary ITER systems as their design has evolved. Thus the list of Reference Events is being reviewed, to establish if the 25 of the GSSR is still an appropriate list.

Pending the outcome of this process of updating and re-analysis, the results presented in the GSSR continue to provide the best guide to the maximum releases from incidents and accidents. No major changes are expected, but of course this must be confirmed. But at this stage it is appropriate to use GSSR results as source terms in site-specific dose calculations in order to check, in general terms, if the OGS requirements are likely to be met, or to identify areas of potential difficulty if any exist, particularly if these are likely to lead to design changes.

IV. DISPERSION AND DOSE MODELLING

IV.A Specifications for new calculations

Accident consequences analyses reported in RPrS will be performed by the French dispersion and dose modelling code GAZAXI, which is well-known and validated by the regulatory authority ASN. Calculations with this code are yet to be completed for the site-specific conditions of ITER at Cadarache. In this paper, we use the COSYMA and UFOTRI codes to obtain a first preliminary view of the doses arising from ITER postulated incidents and accidents, using the specifications appropriate for the Cadarache site. The Doury dispersion parameters, used in the French codes [11], have been applied to the extent possible in COSYMA/UFOTRI (see next section).

For a release from the ITER site at Cadarache, the nearest population is the village of Vinon sur Verdon, located some 3.5 km from the site. A closer point is the Château de Cadarache, a guest house at 2.5 km, where there is a family in residence. These are the locations at which the long-term dose, including ingestion, must be evaluated. For early dose (direct exposure, groundshine and inhalation) distances as close as 200 m must be considered, this being the nearest point that the site fence passes to the postulated release point. For an elevated release, depending on weather conditions, the maximum dose may be further away than this, so the variation with distance must be observed to establish the maximum.

Concentration of radionuclides in foodstuff has to be assessed at locations where farming is done to produce products for market. The nearest significant such location is at 15 km.

The composition of the ACP source term is specified according to modelling of the coolant loops, and that of activated dust is at this stage restricted to that of activated tungsten, with a nuclide composition determined by activation calculations. These compositions are given in Table II.

TABLE II. Nuclide composition of source terms

Activated Corrosion Products		Activated tungsten dust	
Nuclide	**Activity Bq/g**	**Nuclide**	**Activity Bq/g**
Cr-51	1.14E+08	Co-60	1.27E+06
Mn-54	9.86E+07	Ta-179	2.74E+7
Mn-56	1.35E+09	Ta-182	1.67E+8
Fe-55	2.07E+09	Ta-182m	2.89E+7
Co-57	2.64E+08	Ta-183	6.40E+7
Co-58	1.06E+08	Ta-184	4.33E+7
Co-60	1.41E+08	Ta-186	6.40E+7
Ni-57	4.52E+07	W-179	2.56E+8
		W-179m	1.02E+8
		W-181	1.43E+10
		W-185	3.72E+10
		W-185m	3.68E+10
		W-187	1.04E+11
		Re-184	1.99E+7
		Re-186	1.97E+9
		Re-188	1.19E+9
		Re-188m	1.15E+8

Two release points are to be considered: the elevated release point above the ITER rooftop, 60 m above ground, and a 10 m high release, which also characterises a ground-level release. In the former case, building wake effects have to be taken into account.

For weather conditions, two definitions are specified, a wind speed of 2 m/s under weak diffusion conditions, and 5 m/s under normal diffusion conditions, the latter to be considered both with and without rain at 10 mm/hour.

Doses are to be calculated for an adult, a 10-year old child, and a 1-year old baby. The early dose is defined as the dose commitment from a 48-hour exposure (excluding ingestion), the long-term dose as a 50-year exposure for adults, 70 years for children and babies. Ingestion is included in the long-term dose and is based on local habits of consumption of locally-produced food, which includes vegetables, fruit and some meat, but no cows' milk, there being no dairy cattle in the vicinity.

IV.B Calculation methods

For these preliminary calculations, the computer program UFOTRI [12, 13] has been used for the dose assessments of accidental tritium releases. Processes such as the conversion in soil of tritium gas (HT) into tritiated water (HTO), reemission after deposition and the conversion of HTO into organically bound tritium (OBT) are considered. For atmospheric dispersion and deposition calculations (dry and wet) the trajectory model MUSEMET implemented in UFOTRI was used. During the time period of the first few days, all the relevant transfer processes between the compartments of the biosphere (atmosphere, soil, plants, animals) are described dynamically. A first order compartment model calculates the longer-term pathways of tritium in the foodchains. All the exchange processes (atmosphere-soil; atmosphere-plant) are based on resistance approaches and are re-evaluated dependent on the prevailing environmental conditions. A photosynthetic submodule calculates the actual transfer rate of HTO in plant water into organically bound tritium, providing a realistic model of the dynamic behaviour of tritium in the foodchains.

Calculations for accidentally released activation products were performed with the version NL/95 of the program system COSYMA [14] (subsystem NL), including extended data sets for activation products [15]. For atmospheric dispersion and deposition calculations (dry and wet) the trajectory model MUSEMET implemented in both COSYMA and UFOTRI was used. It was assumed that the nuclides which appear in aerosol form have a mean diameter of 1 µm AMAD, and the corresponding dry deposition velocity is set to be 1.0E-3 m/s. The doses by ingestion of contaminated foodstuffs are calculated using the food-chain information from the German model ECOSYS [15].

The Doury [11] dispersion parameter set consists of only two different stability categories representing either average or worst case conditions. Since the original Doury dispersion parameters cannot be fully integrated into COSYMA and UFOTRI, as both models require a power function, these parameters are derived as sums. Nevertheless the conversion to a power function is possible resulting in differences of up to 10% compared to the original data.

On the lee side of a building, a turbulent wake zone including a cavity area is present with high turbulence in the wake zone. In case of a release close to a building, the flow is affected by this turbulent zone resulting in higher mixing close to the obstacle. This fast initial broadening of the plume can be represented by simple correction factors as described in detail in Ref. 16. In COSYMA and UFOTRI, the height and the width of the building are taken into account to derive an initial widening of the sigma parameters for the vertical and lateral mixing, respectively. Assuming a Gaussian distribution and limiting the plume to an area where it has dropped to 1/10 of the initial concentration, the vertical initial value of the lateral dispersion parameter can be defined as the height divided by 2.15 and the lateral as the maximum building dimension divided by 4.3. The release is modified to a level of 10 m as the cavity zone drags the flow down to the surface.

V. RESULTS

V.A Preliminary results from new calculations

A selection of illustrative results are presented here. In every case the result presented is the dose in mSv or μSv of a unit mass release, i.e. 1 g of tritium in HTO or HT form, 1 g of activated corrosion products, or 1 g of dust.

V.A.1. Early doses from exposure

As mentioned above, for early dose it is important to observe the variation with distance, in order to establish the maximum dose, for distances above the 200 m to the site boundary. Fig. 1 shows this variation for an elevated release (with building wake effects) in the weak diffusion conditions with 2 m/s wind. Fig. 2 gives the corresponding results for a "ground level" release (assumed equivalent to the 10 m high release). In both cases, the slow variation of doses from HTO at distances below 1 km shows that there is little sensitivity to the distance to the site boundary. It is also notable that, when building wake effects are taken into account for the elevated release, there is little difference in the tritium results for ground-level or elevated release beyond about 300 m.

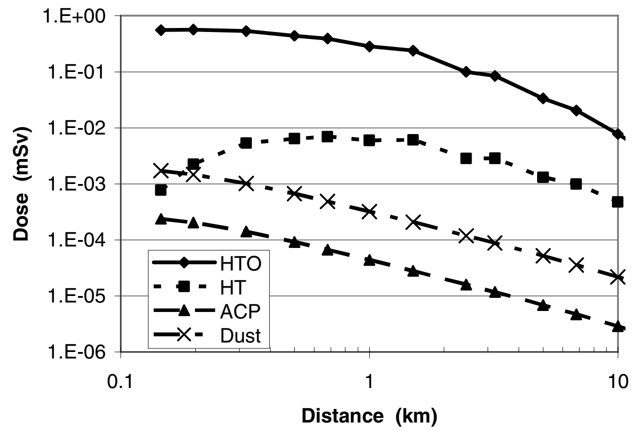

Fig. 1. Early dose for 1g release from elevated release point, weak diffusion, 2 m/s wind speed.

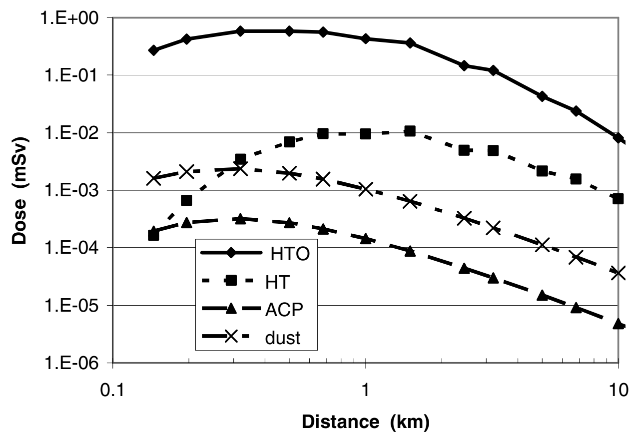

Fig. 2. Early dose for 1g release at ground level, weak diffusion, 2 m/s wind speed.

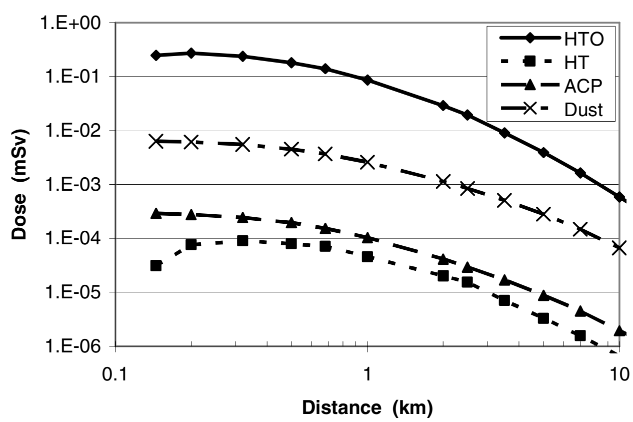

Fig. 3. Early dose for 1g release from elevated release point, normal diffusion, 5 m/s wind speed with rain.

The effect of weather conditions may be observed by comparing the results in fig. 1 with those shown in fig. 3, which is an equivalent case but in normal diffusion conditions, with a 5 m/s wind speed and rain. Tritium doses are smaller in these conditions, particularly as HT, while dust and ACP values are higher. Over about 1 km, the variation with distance follows a similar trend in both weather conditions.

V.A.2. Long-term doses including ingestion

Doses per unit release, including ingestion, at the closest point that this needs to be considered, 2.5 km distant, are summarised in Table III for the various weather conditions. These are doses for an adult; for a child the result is typically 15% higher, for a baby around 40% lower. (Calculations for dust and ACP at 5 m/s wind speed have not yet been completed).

As could be anticipated, the highest dose uptake is from tritium in HTO form, particularly in the low wind-speed weak diffusion conditions.

TABLE III. Long-term doses (micro-Sv) to an adult at 2.5 km from the release point (preliminary results)

Release, 1g	Weather condition		
	2 m/s, weak diffusion	5 m/s, normal	5 m/s, normal with rain
Elevated release at 60 m			
T as HTO	274 μSv	68 μSv	30 μSv
T as HT	9.7 μSv	1.3 μSv	0.06 μSv
ACP	0.6 μSv		
Dust	1.0 μSv		
Ground-level release			
T as HTO	398 μSv	74 μSv	38 μSv
T as HT	17 μSv	1.4 μSv	0.06 μSv
ACP	1.7 μSv		
Dust	2.8 μSv		

V.A.3. Concentrations in food products

Calculations have been performed of concentrations of active materials in food products, namely beef and pork meat, cow's milk, leafy and root vegetables and cereals. In all cases, for a 1g release the tritium concentrations exceed those from dust or ACP releases by at least three orders of magnitude. Furthermore, the concentrations of tritium in leafy vegetables significantly exceed those in other products. Thus this particular result appears as the limiting value, and it is given in Table IV for the various release and weather conditions.

TABLE IV. Concentrations of tritium (Bq/kg) in leafy vegetables grown at 15 km from the release point (preliminary results)

Release, 1g	Weather condition		
	2 m/s, weak diffusion	5 m/s, normal	5 m/s, normal with rain
Elevated release at 60 m			
T as HTO	9.3E4	1.0E5	8.1E3
T as HT	2.7E3	1.5E3	1.3E2
Ground-level release			
T as HTO	6.1E4	1.0E5	7.8E3
T as HT	3.3E3	1.6E3	1.3E2

V.B Implications for Reference Events

The dose results presented above are preliminary and have not yet been compared with equivalent analysis by GAZAXI, which is the one to be used for results presented in RPrS. Nevertheless, they can provide insight into the likelihood of the reference event analyses complying with the OGS requirements of Table I.

As explained in section III.C, this is done by utilising the mass release results of the reference event analyses in the GSSR. The largest such calculated release was that from a postulated double-ended pipe rupture in a large diameter pipe of the divertor cooling loop, within the room that houses the heat exchanger (the "vault"). It is conservatively assumed that this is followed by a second break of the same coolant loop within the vessel, thus providing a bypass through the confinement barriers to the vault. Some in-vessel inventory of tritium and dust thus passes through to the vault, which is assumed to be isolated after some delay, and release to the environment occurs partly through the elevated release point before this ventilation is isolated, and partly by leakage through the building walls. The calculations show an elevated release of 0.78 g T together with a low-level release of 0.72 g T, 0.6 g dust and 0.07 g ACP. All tritium is assumed to be in HTO form.

The site-specific dose values presented above, when multiplied by these generic-site mass releases, provide the total doses in the different conditions. The worst case for the early dose at the site boundary yields 0.82 mSv. For the long-term dose at 2.5 km, the worst case result is 0.50 mSv. Both of these are well below the 10 mSv required by the OGS for an accident. The maximum consequent tritium concentration in leafy vegetables grown 15 km away would be 1.5×10^5 Bq/kg but, as noted previously, there are currently no regulatory limits to compare this with.

This assessment is based on these preliminary dose calculations and also on GSSR 2001 accident analyses, which are due to be updated to take into account design changes as noted above in section III.C. Nevertheless, these initial indications are that the dose limits specified by OGS can be met with a very large margin.

VII. CONCLUSIONS

The extensive safety analyses of ITER based on generic site assumptions demonstrated a high level of safety performance. Now that a site for ITER has been chosen, attention is focussed on site-specific safety analyses, in particular in preparation for licensing submissions to the nuclear safety authorities in the host country, France. This includes updated analyses of the consequences of postulated accidents, taking into account site-specific conditions and also the approach and regulations required by the French authorities.

Dispersion and dose calculations have been performed using the COSYMA/UFOTRI models, which include a treatment of tritium absorption and re-emission and conversion of HTO into organically bound tritium. Also included is a treatment of building wake effects for releases from the ITER elevated release point. Results from these models will be compared with those from the French code GAZAXI, which is validated for use by the regulatory authorities. But pending this, the COSYMA/UFOTRI results have been used to obtain a preliminary insight into the likelihood that accident consequences in ITER will meet the safety requirements.

Based on mass releases from the most challenging accident scenario analysed in previous generic site studies, results indicate that the new dose limits can be respected with a very large margin.

Future work on this topic will include the checking of dose calculations with those to be obtained from GAZAXI, as well as updated analyses of mass releases from postulated accident scenarios.

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