



Development of a Fusion Power Plant Safety Framework

IAEA - Synergies between Fission and Fusion (July 2022)

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This presentation will cover

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2. **TECDOC 1:** A Collection of Current Practices on the Regulatory Frameworks for Existing Fusion Facilities and any Planned Changes to these Regulatory Frameworks for future Fusion Energy Systems such as Fusion Power Plant (FPP).
3. **TECDOC 1:** Table of Contents and Progress to Date.
4. **TECDOC 2:** A Review and Collation of Safety Assessment and Safety Design Practices for Fusion Power Plant – a description of a questionnaire and a progress report.

Introduction (1)

1. Over last few years the pace of development of the transition from experimental fusion facilities such as EAST (China), Wendelstein 7-X (Germany), JT-60A (Japan), JET (UK), NIF (US), etc. to fusion energy systems such as fusion power plant (FPP) has increased very rapidly, with particularly ambitious programmes from many private sector companies.
2. In view of this acceleration from experimental fusion facilities to potential fusion power plant the IAEA decided to create two TECDOCs surveying and collecting the current approaches for (1) the Regulatory Framework for Fusion Power Plant (**TECDOC 1**) and (2) the Safety Design of future Fusion Power Plant (FPP) (**TECDOC 2**).
3. Although ITER (currently under construction in France) is not an FPP its design of systems, structures and components is much closer in terms of size and power rating to those of future FPP than existing fusion facilities so experience from its design and regulation will provide an important contribution to these documents.
4. The current work on TECDOC 1 in particular will be informed by the UK's Office for Nuclear Regulation (ONR) and Department of Business, Energy and Industrial Strategy (BEIS) survey undertaken in 2019 on national regulatory practices used in IAEA member states for fusion facilities (published in 2020). Further context for TECDOC 1 is also provided in this presentation based on the following:
 - A UK government consultation document published in October 2021 proposing a regulatory framework specifically for fusion power plant.
 - Several US Nuclear Regulatory Commission public domain meetings held in 2021 and 2022.
5. This presentation provides an overview of the two TECDOCs.

Introduction (2)

TECDOC 1

A Collection of Current Practices on the Regulatory Frameworks for Existing Fusion Facilities and any Planned Changes to these Regulatory Frameworks for future Fusion Power Plant (FPP)

TECDOC 2

A review and collation of current Safety Assessment and Safety Design Practices for Fusion Power Plant (FPP)

The purpose of the two TECDOC is to collect an accurate snapshot of the current status of fusion facility regulation and safety design practices.

IAEA TEDCOC 1

Results from UK Survey in 2019

This slide is based on (1) a UK Survey of IAEA member states Regulatory Practices for Fusion Facilities undertaken in 2019, (2) a UK Government Consultation on the Regulation of Fusion Power Plant in 2021.

Radiation Facilities
(Hospitals/Accelerators etc.)

Bespoke FPP
Regulatory Framework

Nuclear Installations

Regulatory Spectrum

Current UK
Consultation
Position on FPP

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Current French and
Canadian Regulatory
Position on ¹FPP

Current Position on
the Regulation of
Experimental Fusion
Facilities Internationally

In this direction for FPP and how far?

Regulation of ITER



IAEA TECDOC 1 - Progress to Date

1. Table of Contents planned.
2. IAEA Internal process for the document in progress
3. Collecting the updated information from Member States on regulatory experiences for existing fusion facilities and planned regulatory approach for future fusion facilities, based on the UK early survey and other available information.

UK has provided text for most of sections 2 and 3 (section 2.3 still to be provided).

Next steps:

Consultancy Meeting is planned in September to review the information from Member States and to identify common challenges and approach to regulation



IAEA TECDOC 2

1. The objective of this TECDOC is to provide a collection of the current knowledge and experience on the safety design aspects of Fusion Power Plant (FPP).
2. A key input to TECDOC 2 will be the detailed responses to a questionnaire sent to (1) FPP Designers and Developers, (2) Regulators and (3) Technical Support Organisations. The questionnaire will also collect information from existing and shutdown fusion devices and future fusion experimental and demonstration projects in relation to the safety aspects that are applicable to FPPs.
3. This presentation covers the questionnaire giving some UKAEA insight into what it is trying to achieve for TECDOC 2. The final slide is a brief progress report on TECDOC 2.
4. The twin pillars of TECDOC 2 for safety are:
 - i. Safety Assessment
 - ii. Safety Design

IAEA TECDOC 2 – An important questionnaire

Questionnaire

Part 1 General Safety Design Approach for FPPs in view
of their Safety Characteristics

Part 2 Specific Design Safety Aspects and Safety
Analysis Relevant to FPPs Planned and Under
Development in both the Public and Private Sectors

Overall Safety Assessment Context

IAEA TECDOC 2 Part 1 Questionnaire

Part 1 General Safety Design Approach for FPPs in view of the Safety Characteristics

Q1 Does IAEA Document SF-1 Apply?

Q2 Use of Quantitative Acceptance Criteria?

Q3 Approaches to Identifying Main and Supporting Safety Functions?

Q4 Views on the Categorization of Plant States?

Q5 Views inherent safety of the FPP fusion reaction in the context of the design of confinement barriers ?

Q6 Application of the IAEA concept of Practical Elimination to FPP design?

Q7 Application of Defence in Depth to FPP?

Q8 Views on Applying General Design Requirements to FPP?

Q9 Approach to Qualifying Items Important to Safety?

Q10 Consideration of External Hazards in the Design of FPP?

Questionnaire Part 1

Part 1 General Safety Design Approach for FPPs in view of the Safety Characteristics

Q2 Use of Quantitative Acceptance Criteria?

- Q2 Addresses the question of ‘how safe is safe enough?’.
- Often expressed in numerical criteria such as the following two hypothetical examples:

Accidents in the frequency (f) range $10^{-3} > f \geq 10^{-5}$ will have a dose to the most exposed member of the public of $<1\text{mSv}$

Accidents in the frequency (f) range $10^{-5} > f \geq 10^{-7}$ will have a dose to the most exposed member of the public of $<20\text{mSv}$

- Such quantitative criteria can and often are split into acceptance limits (red box) and more aspirational target values (green box) (both hypothetical examples).

Accidents in the frequency (f) range $10^{-3} > f \geq 10^{-5}$ will have a dose to the most exposed member of the public of $<2.5\text{mSv}$

Accidents in the frequency (f) range $10^{-3} > f \geq 10^{-5}$ will have a dose to the most exposed member of the public of $<0.1\text{mSv}$

Questionnaire Part 1

Part 2 Specific Design Safety Aspects and Safety Analysis Relevant to FPPs Planned and Under Development in both the Public and Private Sectors

Q1 Description of the Fusion Device?

Q2 Radioactive Inventories and Source Term?

Q3 Identification of Physical Barriers?

Q4 Approach to Deriving Postulated Initiating Events?

Q5 Systems, Structures and Components (SSCs) – General Concepts ?

Q6 Approach to the Safety Classification of Systems, Structures and Components (SSCs)?

Q7 Application of Internal Hazards and External Hazards?

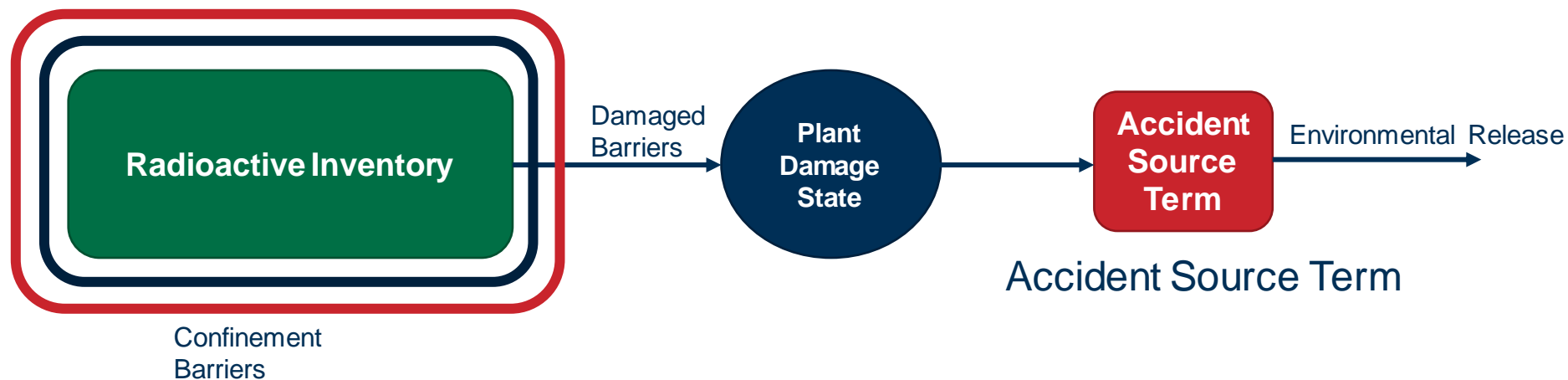
Q8 Application of Radiation Protection Requirements?

Questionnaire Part 2

IAEA TECDOC 2 – Part 2 Questions (Q2 in more detail)

Part 2 Specific Design Safety Aspects and Safety Analysis Relevant to FPPs Planned and Under Development in both the Public and Private Sectors

Q2 Radioactive Inventories and Source Term?



1. The above diagram shows the principles of the accident source term analysis that the questions seeks further information about from contributing member states.
2. The question also addresses normal operational source terms covering aspects such as source terms for worker doses during maintenance operations and also public doses from routine discharges of radioactive isotopes.

Questionnaire Part 2

IAEA TECDOC 2 - Progress to Date

1. A first draft was produced early in 2022 ahead of the questionnaire, its contents helped to formulate the questions in the questionnaire.
2. The contents of this first draft are largely based on ITER. Much of the existing information can be used as ITER's response to the questionnaire.
3. Information will be sought from private sector companies and from other public sector projects outside of the ITER project (e.g. DEMO and the UK STEP project).
4. Views from the regulatory authorities and TSOs (for example IRSN and GRS) will also form an important input to this TECDOC.

Next steps:

Consultancy Meeting taking place in July 2022 to analyse the responses collected from the questionnaires already circulated

Concluding Remarks

1. TECDOCs 1 and 2 described in the previous slides are the starting points of a journey in creating a path from where we are now on the regulation of experimental fusion facilities to the ultimate destination of an internationally harmonized framework for the safety of fusion energy systems such as fusion power plant.
2. We hope to have broad involvement in the production of TECDOCs 1 and 2 from many countries and from multiple organisations within each country such as regulators, TSOs, FPP designers, fusion science and technology laboratories etc.
3. Views from public and private sector organizations are welcomed.



Any Questions