

An overview of tritium inventory management progress and challenges, and the role of the UKAEA – Eni H3AT facility in supporting the fusion community

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Tritium inventory management is a critical challenge for the fusion community.

Firstly, it is important to understand the quantities of tritium required to operate a fusion power plant, along with its distribution within the fuel cycle, and its physical and chemical forms. This knowledge will support effective and proportionate regulation of fusion facilities. Moreover, the necessary improvements to predictions of tritium's behavior in systems and materials supports the optimization of system requirements and sizing.

Secondly, accurately assessing tritium quantities across systems facilitates minimization of tritium inventory in fusion facilities. This is essential for reducing cost, enhancing safety and facilitating the development and implementation of regulations, as well as ensuring that start up inventory demand does not exceed supply.

Whilst critical, understanding inventory requirements is a significant technical challenge. This talk will explore the nature of this challenge and review the range of estimates found in the literature, commenting on assessment methods employed. The approach to this problem taken by UKAEA will also be explored.

In addition to understanding inventory requirements in advance of deployment, fusion facilities will also need to track tritium migration through various systems once they are operational. There are four main reasons why this is necessary:

- Process control
- Safety
- Environmental protection
- Non-proliferation

Each of these areas will have differing requirements in terms of measurement accuracy, uncertainty and frequency. Additionally, safety, environmental protection and non-proliferation all fall under regulatory oversight. Given the immaturity of regulatory environments for fusion, defining precise analytical requirements for tracking tritium remains challenging.

Further complicating this issue, many of the diverse environments within the fusion fuel cycle require specialized measurement techniques, necessitating the development and validation of multiple technologies. Current understanding in this area will be presented along with suggestions for further work to address knowledge and technology gaps.

In order to address key challenges in fusion fuel cycle development, UKAEA is constructing the UKAEA-Eni H3AT Tritium Loop facility at its Culham site in partnership with Eni and supported by collaborations and contracts with ITER Organization and AtkinsRealis, respectively. The 100g tritium inventory pilot plant scale facility will for the first time demonstrate a closed loop, continuous flow system, enabling testing of subsystem technologies, including dynamic responses, as well as validation of UKAEA developed fuel cycle models. Additionally, the facility will include substantial experimental capacity for off-loop tritium research. An update will be provided on the facility's progress and its anticipated benefits for the fusion community will be outlined, including in addressing the challenges of inventory management.

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