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Fusion technology — Experimental magnetic confinement fusion facilities — Supersonic molecular beam injection fuelling technique for fusion devices

Technologie pour installations de fusion — Installations expérimentales de fusion par confinement magnétique — Technique d'alimentation en combustible par faisceau moléculaire supersonique pour machines de fusion

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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Introduction

The plasma fuelling system is integral to magnetic confinement fusion devices, including DEMO and other fusion facilities. Supersonic molecular beam injection (SMBI) is a key candidate for fuel injection, offering high efficiency with reduced wall retention of gases. SMBI has demonstrated good fuelling efficiency in many medium and small-sized devices, with higher efficiency compared to conventional methods. Although its fuelling efficiency may attenuate in large-scale equipment, long-pulse discharges in superconducting devices have shown that the good directionality of SMBI can significantly reduce wall retention[1]. This reduction in wall retention is particularly significant for the utilization of tritium in future fusion facilities.

Unlike conventional gas fuelling systems that utilize gas diffusion and are susceptible to wall retention, leading to unpredictable plasma density changes and possible facility shutdown, SMBI, with its high beam velocity, effectively mitigates such risks. Comparing to fuel pellet injection, SMBI has lower fuelling efficiency, but provides significant system stability. Currently, tritium pellet technology is not yet sufficiently mature. Therefore, as technology advances, SMBI can be considered as a complementary component of an effective fuelling system for future fusion facilities, alongside pellet injection.

Fusion technology — Experimental magnetic confinement fusion facilities — Supersonic molecular beam injection fuelling technique for fusion devices

1 Scope

This document specifies the methods and the requirements for the supersonic molecular beam injection (SMBI) fuelling technique used in experimental magnetic confinement fusion facilities. It outlines the SMBI system components, specific requirements, and inspection procedures to ensure the effective and controlled injection of plasma fuel into fusion devices such as international thermonuclear experimental reactor and demonstration power plant.

This document applies to the formation of supersonic molecular beam (SMB) and usage of the SMBI technique on the fusion devices, including the specification of gas pressure adjustment, beam characteristics and injection rate requirements, as well as the procedures for verifying these parameters.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 16646, *Fusion installations — Criteria for the design and operation of confinement and ventilation systems of tritium fusion facilities and fusion fuel handling facilities*

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
supersonic molecular beam injection
SMBI
method of fuelling by generating a supersonic molecular beam through the adiabatic expansion of gas into a vacuum, maintained by a sufficient pressure differential across a Laval or Laval-like nozzle

3.1.2
beam structure
structure of the beam injected by the *SMBI* (3.1.1) system, which features a quiet zone as well as a Mach disk and other characteristics

Note 1 to entry: Figure 1 shows the beam structure.