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Development and Initial Results of a Tracer-Encapsulated Solid Pellet (TESPEL) Injection System on Wendelstein 7-X

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A tracer-encapsulated solid pellet (TESPEL) injection system has been developed and tested on Wendelstein 7-X (W7-X). The TESPEL, which can be considered as a double-layered impurity pellet in a simple term, has been developed at the National Institute for Fusion Science (NIFS) in Japan for the detailed study of impurity transport in magnetically-confined high-temperature plasmas. The distinctive structure of the TESPEL allows us to release specified impurities at a well-localized radial position directly in the core plasma. In the high-density operation of W7-X, the island divertor of W7-X is expected to effectively screen the influx of intrinsic as well as externally injected impurities in the scrape-off-layer (SOL). Therefore, tracer impurities being injected for impurity transport studies, e.g. by laser blow-off or gas puff, might not penetrate deep enough to reach the confinement region. However, TESPELs can easily solve such a problem by direct deposition of the tracer impurities (e.g. Fe, Ti, V, Mo, W, …) inside the core plasma. The TESPEL injection system usually consists of a TESPEL injector, a differential pumping system, and a diagnostic system for the ablation of the TESPEL. Since the plasma size of the W7-X is comparable to that of the Large Helical Device (LHD), the size of the TESPEL for the W7-X will be the same as those for LHD: the outer diameter of the TESPEL ranges from 0.7 mm to 0.9 mm. The TESPEL ejected from the injector by pressurized helium (about 3 MPa) travels along straight guiding tubes, and enters then the plasma vessel. The propellant He is effectively pumped out by the differential pumping system. The penetration depth of the TESPEL can be estimated by combining TESPEL ablation cloud diagnostics and time-of-flight measurement of the TESPEL velocity.

This contribution reports the initial experimental results that are obtained in the operational phase OP1.2b of W7-X along with the experimental data by the other impurity injection methods as well as the detailed design and the achieved performance parameters of the injection system on W7-X.

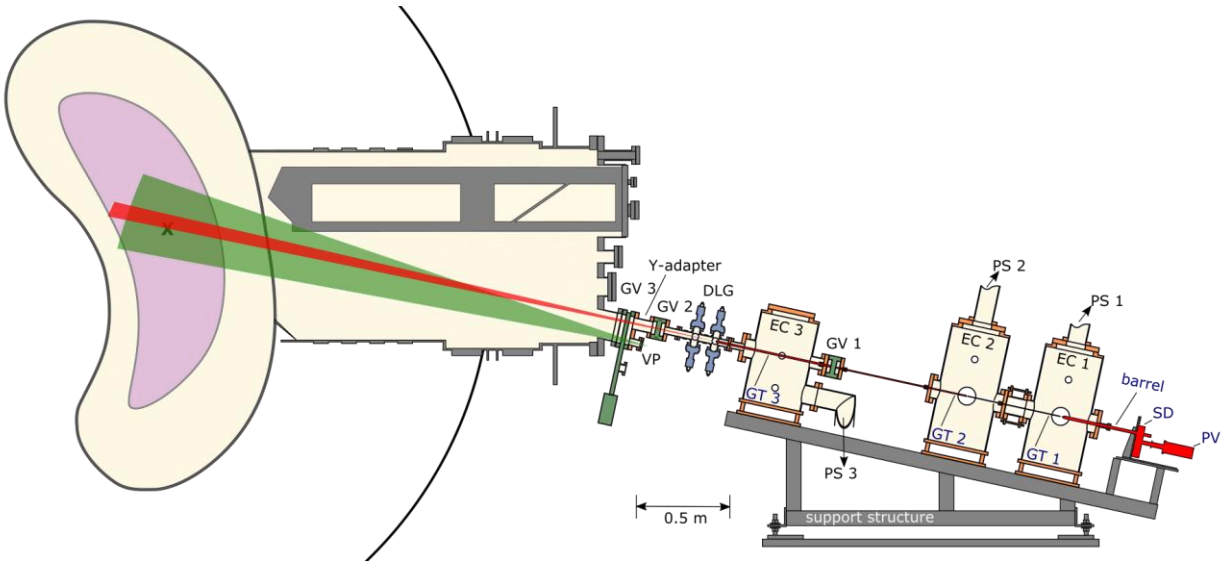

Figure 1: Schematic diagram of the TESPEL injection system, attached to W7-X. (EC 1 .. EC 3: expansion chambers; PS 1 .. PS 3: pumping systems; GV 1 .. GV 3: gate valves; DLG: dual light-gate; VP: viewport; components of the actual injection system PV: propulsion valve; SD: TESPEL storage disk; GT 1 .. GT 3: guiding tubes)