Topic: OV

30th IAEA Fusion Energy Conference 13 – 18 Oct 2025 in China

The Divertor Tokamak Test project: progress towards the initial operation

F Romanelli on behalf of DTT contributors

DTT S.C. a r.l., 00044 Frascati, Roma, Italy

Corresponding author e-mail address: Francesco.romanelli@dtt-project.it

Overview Synopsis

As discussed in the "European Research Roadmap to the Realization of Fusion Energy" [1-2], one of the main challenges towards the construction of a fusion power plant is the development of credible solutions for the heat exhaust. This requires a facility capable of producing plasma conditions in the plasma core and the divertor similar to those in ITER and DEMO. To address this challenge the Divertor Tokamak Test (DTT) facility [3-4] is presently under construction. This paper provides an overview on the state of the construction and of the preparation of the research program.

DTT will achieve ITER and DEMO relevant heat loads, through a combination of substantial amount of additional heating (up to 45MW) and compact dimensions (R=2.19m, a=0.70m, B=6T, I_p=5.5MA). DTT is a long-pulse superconducting tokamak, equipped with full-tungsten, actively cooled plasma-facing components. The start of operation is foreseen around the end of this decade, a few years in advance of the start of ITER operation, making DTT an ideal test bed for the preparation of ITER exploitation.

DTT has been designed with sufficient flexibility to investigate advanced magnetic configurations that allow large divertor wetted areas and advanced plasma facing components technology. The core-edge integration will be a crucial part of the research program with the investigation of high-confinement, high radiation regimes via impurity seeding. Finally the potential of liquid metals for plasma facing components is foreseen to be an important part of the DTT program. The first version of the DTT Research Plan has been released in 2024 and has been elaborated with the active involvement of a number of scientists from the Eurofusion laboratories. The main outcomes of this elaboration will be presented and discussed with emphasis on those that may facilitate the start of ITER operation.

DTT will be equipped with the same combination of plasma facing material of ITER. The first DTT divertor will consists of 54 modules of 6.4° of toroidal span each, separated by a gap of 0.5 mm. The monobloc design is ITER-like and the cooling is guaranteed by water circulating in CuCrZr tubes. Following the completion of the design in collaboration with Eurofusion, the qualification activities have been carried out with performance exceeding the requirements and the series construction is starting.

The DTT magnetic system has performance that will go beyond those of ITER. All the Nb3Sn strand for the 18 Toroidal Field (TF) coils (6 T at 2.14 m) has been procured, the conductor for 11 of the 18 TF coils has been delivered (with the cable for other three coils ready to be jacketed) and the first winding pack has been realized at the end of 2024. The TF power supply and protection system have been delivered and initially located in the Coil Cold test Facility where all the Nb3Sn coils will be tested. The call for tender for the poloidal field (PF) coils, consisting of 6 coils, 2 of which in Nb3Sn and the others in NbTi, is ongoing. The Nb3Sn for the top coil (PF1) and the central solenoid will be procured through a specific call for tender presently in the adjudication phase whereas the Nb3Sn strand for the bottom coil (PF6) is already available and the dummy conductor already fabricated. Also all the NbTi strand for the other four coil is available and the dummy conductor has been produced. The design solution for the central solenoid – a particularly stressed component in DTT - has been defined and tests are ongoing to confirm the decision and progress with the tender phase. The DTT is equipped with three sets of in-vessel coils for: (i) the control of the X point position and of the field in the divertor region, (ii) the plasma position control; (iii) the ELM control and error fields suppression (3 arrays of 9 non-asymmetric coils). The power supplies for each of these systems are under construction and are expected by the end of 2025.

The call for tender for the double-wall, 316LN, vacuum vessel (VV) is presently completing the adjudication phase. The VV has 82 ports that will allow significant access for diagnostic and heating systems. Borated water between the two walls of the vessel carries out a neutron moderating action.

Also the heating combination foreseen in DTT is similar to that of ITER. In its final configuration the DTT additional heating systems will deliver up to 45 MW power to the plasma. The first half of the 32 MW/170GHz ECRH system – required for the first phase of operation - is under manufacturing after the successful test of the pre-series gyrotron. The first half of the 8 MW ICRH solid-state transmitters is under construction with the final delivery expected at the beginning of 2026. The 10 MW/510keV NBI system - planned as an upgrade to be carried out in the middle of the next decade – is presently in the design phase.

During 2024 the conceptual design of the diagnostic systems has been completed. DTT will be equipped with a large number of systems in order to fulfill its scientific mission. At the moment the conceptual design has involved 52 packages with about 20 foreseen for the initial operation. The conceptual design has been reviewed by an international panel and the realization phase is starting.

The DTT Remote Handling system consisting of a pair of HYper Redundand Manipulators (HyRMan) and the divertor Cassette Mover is presently under construction with delivery expected at the beginning of 2026. A dedicated test facility is being prepared near Naples for the test of all the RH operation and the training of the dedicated personnel.

The critical path of the project is represented by the availability of the experimental hall. In 2023-24 the detailed design of the buildings has been completed and verified by an independent authority and the call for tender is presently being launched. Also the design of the electrical distribution system, that consists of the transmission line from the 150-kV grid switchyard under realization by TERNA (the Italian – transmission system operator) to the substation, the replacement of the 150kV/20kV substation in the ENEA center and the 20kV distribution line to five substation powering the DTT systems, has been completed. The design of electrical distribution system is currently under verification by an independent authority and the call for tender is expected to be launched in 2025.

[1] F. Romanelli "Fusion Electricity. A roadmap to the realization of fusion energy". European Fusion Development Agreement, EFDA, 2012, ISBN 978-3-00-040720-8.

[2] "European Research Roadmap to the Realisation of Fusion Energy ", Publisher EUROfusion Programme Management Unit, 2018, ISBN 978-3-00-061152-0.

[3] R. Martone, et al., (editors), "DTT - Divertor Test Tokamak - Interim design report", (2019), https://www.dtt-project.enea.it/downloads/DTT_IDR_2019_WEB.pdf.

[4] F. Romanelli, Nucl. Fusion **64** (2024) 112015.