DTT - An experiment to study the Power Exhaust in view of DEMO.

R. Albanese¹, F. Crisanti², B. P. Duval³, G. Giruzzi⁴, H. Reimerdes³, D. van Houtte⁴, R. Zagorski⁵

1) CREATE – Napoli – Italy
2) ENEA – Via E. Fermi – 00044 Frascati – Italy
3) EPFL/CRPP – 1015 Lausanne – Switzerland
4) CEA – Cadarache – France
5) IIPLM – Warsaw – Poland

In the recent EU Fusion Roadmap, the power exhaust issue has been highlighted as a potential showstopper for a fusion power plant and it was proposed to treat this area with increased emphasis within the EU Fusion Programme. Since it is uncertain whether the conventional divertor solution, based on the single null magnetic configuration also adopted for ITER, will extrapolate to the considerably more severe exhaust requirements in DEMO, several non-conventional magnetic configurations (e.g. snowflake divertor, X divertor, double nulls) as well liquid metal divertor targets are considered as alternatives. As none of the present day or planned machines can address the Physics and Technology integrated exhaust scenario of DEMO for these alternative, the EU Fusion Roadmap foresees the possibility of constructing a dedicated Divertor Tokamak Test (DTT) facility, capable of integrating as many of all the possible main aspects of the DEMO power and particle exhaust. A scaled experiment capable of reproducing exactly the integrated DEMO scenario would be impossible, so a compromise must be chosen within that respects the boundary conditions (e.g. available budget, strategic timeline) whilst exercising the highly complex exhaust problems. A prioritization, within the complete list of its possible target parameters, is necessary. A tritium compatible machine must be excluded to limit the complexity and cost. This affects only marginally the power exhaust problematic as helium linked problems can be simulated by injection and neutron compatible materials can still be tested under large power flux. As a DTT facility should explore and propose power exhaust solutions for DEMO, the parameter \( P_{\text{sep}}/R \geq 15 \text{ MW/m, where } P_{\text{sep}} \text{ is the power flowing through the plasma boundary and } R \text{ is the major radius} \) provides a general estimation of the target DEMO power flux conditions. Ideally, all tests of DEMO solutions should be performed under edge conditions as close as possible to DEMO in terms of the temperature and the dimensionless collisionality \( v^* \), plasma pressure \( \beta^* \) and ion gyro radius \( \rho^* \). A further requirement is that all solutions/approaches should also be compatible with DEMO bulk plasma performance in terms of dimensionless parameters. A Kadomtsev like approach will be employed to scale the DEMO machine main parameters (e.g. major radius \( R \), toroidal magnetic field \( B_t \), plasma current \( I_p \), heating power \( P_{\text{heat}} \)) to “optimize” the DTT experiment to comply with these general constraints. Once the main parameters have been selected, simple 0-D and 1-D codes will be used to assess their compatibility with the desired targets. Some of the important issues, related to the power exhaust problem (e.g. materials, first wall, steady state), will not be considered in the preliminary definition of the machine key parameters, but some (e.g. pulse length, plasma wall interaction), will be examined with the goal of deriving a proposal compatible within a given cost constraint. The resulting main machine parameters will be proposed and illustrated, together with a concept of the full machine.