Summary Topic 2
ITER TBMs and Needed Blanket R&D Facilities Toward DEMO

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TBM's on ITER

The TBM programs within ITER member states have allowed a strong blanket R&D infrastructure to be developed

- Solid and liquid breeder expts, manufacture
- Structural material development and qualification
- Coolant expts
- Hydrogen behavior expts
- Manufacturing, joining, prototyping

The additional activities by the IO TBS Project Team, ITER members and others has facilitated the integration of the TBM's into a burning plasma fusion facility

- Coolant/fluid services
- Tritium monitoring and handling
- Remote maintenance
- Safety, licensing and waste and hot cell handling
- Worker safety, neutron streaming, and activation

Procuring members have been well-prepared for new expanded programs on DEMO and much will be learned by operation on ITER

Challenges Beyond ITER

Plasma and neutron exposure durations leading to much larger fluences
    Pursue adv RAFM alloys

Larger neutron and plasma fluxes to plasma facing FW

Tritium breeding and recovery

Functional materials database, including potentially non-low-activation materials

Li-6 and beryllium quantities

Large changes in throughputs of fluids and tritium

Improvement and optimization of the tritium plant, and all associated tritium handling and accounting

Diagnostics and control, and requirements of inspection and maintenance

Ex-core systems for liquid breeders (T-extraction, HX, cleanup)

What are the R&D facilities beyond those required for the ITER TBM - 1

Neutron irradiation facilities to access higher fluence (dpa) > 50 dpa_{Fe}/500 $appm_{Fe}$ He on structural materials, plasma facing materials, and functional materials …. and material characterization

Fusion-like neutron spectrum exposure facility(s) (e.g. IFMIF, DONES, A-FNS, FPNS, ….)

Continued access to high flux fission facilities for high fluence exposures, in particular with techniques to introduce He into the matrix and simulate fusion regime

Take advantage of ion irradiations to high fluence to simulate the damage/He/H effects of fusion neutrons, with appropriate translations to neutron exposures

"Volumetric" fusion-like neutron exposures (KO, IBTF) if these can be developed, expose materials and components

What are the R&D facilities beyond those required for the ITER TBM - 2

Plasma exposures to high fluence for plasma facing materials of the blanket FW, heat and particle flux associated with the FW environment (particle energies, fluxes, radiation, etc.), including transients (ELMs & Disruptions)

HHF experiments, only provide heating surrogate, multiple source options, can test materials and integrated components

Linear plasma facilities can provide combined heat and particle flux, but heat flux is constrained, and these typically simulate divertor environment rather than FW

Can neutral beams (particles + heat) be used to create the FW environment?

Transients like ELM and disruptions do not affect the integrated cooling systems, only very narrow layer of plasma facing material … dual heating expt, one heater to bring temprature to steady state and a second heater to provide the transient

With limiters or without limiters can significantly change the loading prescription

What are the R&D facilities beyond those required for the ITER TBM - 3

Tritium extraction experiments from fluids (PbLi, He/coolant, H_2O coolant, He purge, …)

Tritium breeding "confirmation" experiments (e.g. FNG), to enhance our confidence in projecting TBR from neutronics calculations

Tritium apparatus and processing/handling systems development "fuel cycle pilot plants" (hydrogen separation, hydrogen isotope separation, storage, purification, permeation barriers, etc.)

Safety testing (off-normal events) experiments (in-box LOCA, Be reactions, high temperature reactions, PbLi-water, etc.)

Integrated blanket multi-physics testing platforms (non-nuclear or nuclear, fluids, B-field, heating, pressures, etc.), including electromagnetic testing and ferromagnetic materials … e.g. CHIMERA

Integrated blanket surrogate testing in nuclear environment (e.g. RAFM/PbLi/SiC/He in fission reactor)

What are the R&D facilities beyond those required for the ITER TBM - 4

Non-nuclear solid breeder and neutron multiplier production and testing (fabrication methods, heating, mechanical, corrosion, hydrogen recovery)

Blanket cooling / fluid behavior and HHF (thermofluids) experiments (He, H_2O), corrosion products (activated) and cleanup

PbLi thermofluids, corrosion, and nuclear (into fission reactor) flow experiments, including heat exchanger and cleanup/control

Magnetic field is critical

Blanket specific remote handling

Energy extraction from blanket fluids

Advanced RAFM alloy development and material qualification

Topics Raised that are Important – Potential Expts

Very high B-fields: effects on PbLi, materials, mechanics (ferromagnetics), corrosion products

Li-6 enrichment: approaches

Be resources for high Be:Li blanket designs (100's of tons per plant)

Component and integrated system reliability

Power plant level technologies

- Large scaleup (inventories, flow rates, etc.) in virtually all systems (e.g. coolant flows, solid breeder production, etc.)

Material and component qualification for licensing

- Critical to establish material database and handbook for structural and other materials

Manufacturing/fabrication, joining, quality

Diagnostics development, inspection approaches and remote handling specific to blankets

What is the acceptable level of material irradiation before proceeding with a component on the DEMO/Next Step?

Cyclic pulsed operation on blankets (CHIMERA B-field pulsing)

Internal control coils and conducting shells

Poster presentations provide insights into design choices and technical planning toward the DEMO

- Poster presentations:
  - Numerical analysis for optimization of circulation power in first wall of Indian helium cooled solid breeder blanket using He-CO2 gas mixture
  - Qualification of EUROFER97 for TBM: contribution of the EUROfusion project within 2021-2025
  - Reactor studies of two-phase lithium ceramics in Kazakhstan
  - Capabilities and status of the IFMIF-DONES project
  - An approach for the pathway towards the development of high performance breeding blankets
  - Overview of the R&D of materials intended for DEMO and DONES at Lithuanian Energy Institute
  - Exploration of a compact DEMO reactor: constraints on shielding materials and HTS magnets from parameter-space scans
  - CPAF linear device for plasma materials exposure experiments