

Liquid lithium, tritium and breeding blankets IDOM FIA 20/10/2022

Main Fusion references

- General Support to the Owner Contract. As member of the Energhia Consortium (i.e., Altran Technologies, Halcrow Group Ltd, IDOM).
- Contract Management support in consortium with ALTRAN.
- Mechanical CAD support in the context of Vacuum Vessel Procurement.
- Support in the area of Civil Engineering Analysis. Lot 1: Seismic analyses. Lot 2: Effects of explosions and impacts. Lot 3: Structural analysis of ITER Buildings.
- Study of three design configurations for HCLL and HCPB Test Blanket Modules.
- Engineering support in the area of TBM systems design and technological demonstration. Lot 1: Design of TBM sets, analyses and design validation.
- Engineering Analysis in the Area of **Fluid Dynamics Analysis**. Lot 2: Fluid Dynamics.
- Update and Completion of the Design of the Front-end Cryopumps Cryodistribution.
- **Neutronics Analysis** Support to ITER Organization. As member of the UNED IDOM Consortium.
- Integration Design of Diagnostics into ITER Ports.
- Provision of **Mechanical Analyses** of ITER Components (2nd in the Cascade Contract).
- Framework Contract for Provision of **Seismic, Dynamic and Structural Analysis**. Lot 1: Seismic Analyses (2nd in the Cascade Contract). Lot 2: Dynamic Analyses (1st in the Cascade Contract). Lot 3: Structural Analyses (2nd in the Cascade Contract).
- Provision of Neutronics Close Support Services.
- Evaluation of the Nuclear Heating Impact on the ITER Vacuum Vessel

- Manufacturing Design using updated C-LITE Blanket Design.
- Engineering Support Services in the Area of **Thermo Hydraulic and Fluid Dynamic Analysis.** Lot 1: Thermo Hydraulic Analysis.
- Engineering Support Services in the Area of **Thermo Hydraulic and Fluid Dynamic Analysis**. Lot 2: Fluid Dynamic Analysis.
- Engineering support in the area of TBM systems design and technological demonstration. Lot 2: Ancillary systems design and analysis.
- Framework contract on-site Mechanical services to F4E.
- Framework contract back office Mechanical services to F4E.
- Framework contract engineering support in the area of thermo Hydraulic and Fluid dynamic analysis.
- Tokamak assembly contract -1 subcontracted for the CNPE consortium.
- Framework Contract for Provision of Seismic, Dynamic and Structural Analysis (3nd in the Cascade Contract).
- Conceptual design for the Hot Cell complex in consortium with ONET and ALTRAN.
- Framework contract for vaccum pipe analysis and stress calculations.
- Engineering and supply of the primary vaccum and cryostat Leak detection systems.
- UKAEA EDS Framework +20 projects
- UKAEA Fuel Cycle Framework
- Other fusion companies +10 projects
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Fusion references



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... but there are many designs

- Inertial laser driven Fusion
- Inertial projectile driven Fusion
- Direct drive fusion
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- Need of a blanket technology
 - Shielding (always)
 - Cooling function (always)
 - Energy multiplication (wanted)
 - Tritium breeding function (depends)

Liquid lithium as coolant and breeder material

- Many designs based on liquid lithium or LLE
 - STEP
 - ITER HCLL
 - FLF
 - TOKAMAK
 - GF
 - ...



- Shielding
- Cooling function
- Energy multiplication (depends)
- Tritium breeding function

- Material compatibility
- Neutronics, activation...
- Thermal hydraulics
- Mechanical analysis



Encapsulated fuel breeding blanket



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Pre-conceptual design of an encapsulated breeder commercial blanket for the STEP fusion reactor

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(54) ENCAPSULATED PEBBLE FUEL

Encapsulated fuel breeding blanket

- Holistic approach
- Multiscale
- Multiphysics







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Liquid lithium issues

Open issues

1. Molten Lithium

- ✓ **Production of cobalt-60 from Ni impurities.**
- ✓ Isotopic purification
- Undesirable corrosive properties on commercially available structural materials at high temperature and high fluid flow rates
- ✓ lithium hydride
 - $Li + \frac{1}{2}H_{2(g)} \leftrightarrow \mathbf{LiH}$

2. Pb-17Li

- ✓ Polonium-210 and mercury-203
- ✓ Presence of gases (He-4)
- ✓ Corrosion influenced by oxygen
- ✓ Chemical behavior determined by Li



✓ Nitrogen reactions with structural materials
 5Li3N + Cr→ Li9CrN5 + 6Li

 $2\text{Li3N} + \text{Fe} \rightarrow \text{Li3FeN2} + 3\text{Li}$

Liquid lithium tritium transport phenomena



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Liquid lithium and tritium properties uncertainties

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HYTRANS system code

- 1+2+3D system code for liquid metals and molten salts
- Transient
- Multi component
- Multi species transport
- All tritium transport (permeation, precipitation, thermal and electromigration, surface effects...)
- Neutronics
- Full PYTHON, so can be coupled and integrated into design loops, even AI



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Q&A

Thank you for your attention

