Tritium Science and Technology at AWE
Tritium Focus Group Meeting – 3-5 Nov 2015

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About AWE

- The **Atomic Weapons Establishment** has been at the forefront of the **United Kingdom’s nuclear deterrent** programme for more than 60 years.
  - *Continuous At Sea Deterrent.*
  - *National Nuclear Security.*
  - *Support non-proliferation and CTBTO.*
- AWE works under contract to the **Ministry of Defence** in a government-owned-contractor-operated (GOCO) arrangement.
- Operation of the sites is through **AWE (ML)** made up of three equal shareholders – Jacobs Engineering Group, Lockheed Martin Corporation and Serco Group.
- Operates from two main sites in Berkshire, **AWE Aldermaston** and **AWE Burghfield**, with additional facilities at **Blacknest** and **RNAD Couplort**.
Our Commitment and Values

Building on our **proud** heritage, our **excellent** people and technologies, we will create a unique and **internationally recognised**, **trusted** partner to UK Government, delivering **innovative** and integrated national nuclear security solutions.

- A distinguished history of safeguarding the Nation for almost 60 years
- Nuclear know-how and technical expertise, past, present and future
- At the forefront of non-proliferation and counter-terrorism strategies
- Positioning ourselves at the heart of government as the leading national nuclear defence contractor
- World-leading technology and ground-breaking science, expanding the boundaries of our core mission
- AWE has a history of working with tritium dating back to the 1960’s.
- The tritium research facility in the photograph is now a parking lot!
- Environmental testing for tritium.
- Bio-assay for tritium.
- Fundamental tritium-materials research and $^1\text{H}/^2\text{D}/^3\text{T}$ isotope effects.
- AWE set up and ran the UK Tritium Users Group from 2003-2014.
Tritium Science and Technology

- Tritium may be used in **modern warheads**.
  - **Reduces** mass of fissile material required.

- **Stewardship** of the inventory.
  - Historic R&D **legacy management**.
  - Analysis and recovery.

- **Fundamental R&D**
  - Collaboration with Systems Engineering and Systems Assessment and Integration Group.
  - Salford University key interaction on behaviour of **hydrogen in metals**.
  - Interactions with civil sector in support of wider UK tritium programmes.

- **Bespoke capabilities**
  - Interaction of hydrogen isotopes with materials.
  - Tritium processing, handling and safety
  - Assay and analysis techniques.
To undertake work on tritium programmes in support of CASD.

Purpose built science facility with consent to operate from NII (now the ONR) Dec 2002.

Key Design Features.
- Distributive Control System to monitor plant condition.
- Monitoring of workspace, containments and discharges.
- Remotely operated process lines.
- HVAC system.
- Inert gas gloveboxes.
- Gas Clean Up Plant.
Tritium Science Facility (cont.)

Major Engineering Systems

Air

Air

N₂

Waste Store
Gas Clean Up System Overview

GCUS – Discharges from all gloveboxes and lines, including Mass Spec & House Vacuum

Dump Dryer
Mol. Sieve based long term storage
Baseline capability

- Processing tritium.
- Preparing gas mixtures.
- H/D materials research.
- Determining activity ‘hold up’ in waste.
- De-tritiation of glove-box effluent.
- Analysing gas mixtures by mass spectrometry.
- Measuring stored inventory by calorimetry.
Capability uplifts

- Tritium thermodynamics glovebox.
- Isotope separation capability.
- Hydrogen laboratory upgrade.
- Furnace ‘watch-dog’ systems.
- Hi-Res mass spectrometer.
- Raddec Pyrolyser.
- Packard 308 Oxidiser.
- Acid Dissolution Line.
Tritium Calorimetry

- Large twin-cell design.
  - Accommodates a wide range of samples in secondary containment.
- Utilises heat-flow method.
  - No requirement for additional cooling
  - Measurement time 2-4 days, dependant on packaging.
- Measurement range 0.5mW – 5W
  (~0.55TBq – 5500TBq = 15Ci – 150kCi)
- Excellent relationship with the manufacturers (Antech) due to proximity to site.

High resolution mass spectrometry

- Gas composition analysis pre- and post-processing.
  - High resolution required to separate species with same nominal mass (e.g. $^4$He & HT).

- Double focussing, magnetic sector instrumentation.
  - VG 30-38.
  - Nu Instruments Evolution (to be commissioned).

- Regular updates to US community via the Gas Technology IMOG.
Combustion Techniques

- Underpinning method for ‘soft’ waste assay to determine contamination levels (legislative compliance).
- RJ Harvey OX500 & Packard Model 307.
  - Small sample size, high throughput.
  - Packard undergoing method development.
- Raddec Pyrolyser.
  - 6 tube furnace with 3-zone programmable temperature control.
  - Larger sample masses, wider range of materials.
- Samples assayed using Perkin Elmer Tricarb liquid scintillation counters.
Acid Dissolution*

- Total tritium content of metals to support waste sentencing.
- In-house design to replace a previous all-glass system (with issues).
- Small scale system to be used in parallel with higher throughput combustion methods.
  - Commissioning with stainless steel.
  - Spiked and un-spiked samples used to determine process efficiency.
- Samples assayed using Perkin Elmer Tricarb liquid scintillation counters.

* To be presented at Tritium 2016
Liquid Scintillation Counting

- Current systems - TriCarb 3170 TR/SL LSA’s.
  - BGO detector guard for ultra-low level counting.
  - Very low background – longer count time.
  - Max. Capacity ca. 400 vials each.
  - Upgrade to Quantulus GCT completion is imminent.

- Hidex.
  - 3 PMTs enables TDCR counting.
  - No internal/external source needed.
  - Batch screening.
  - Max. Capacity 50 vials.

- Triathler.
  - High throughput screening.
  - Single vial capacity.
Hydrogen (and Deuterium) Laboratory

- Rubotherm Magnetic Suspension Balance.
- Dilatometer.
- Differential Scanning Calorimeter.
- Simultaneous Thermal Analyser.
- Atomic Force Microscope.
Legacy and Waste Programmes

- Decommissioning of plant and equipment.
- Legislative and regulatory compliance.
- BAT for some items is disposal via third party.
  - Tritium removal and discharge.
  - Passivation (and segregation where appropriate).
  - Cementation for long term storage.
- New techniques constantly being developed.
Summary

- Active tritium science and technology teams.
- Capability investments in:
  - Facility Engineered Systems.
  - Science equipment.
- Current topics of work.
  - Properties of Pd with H & D.
  - Materials research.
  - Helium release from uranium solid storage.*
  - Helium release and effects on Pd/T.
- Interactions with US counterparts is important in validating our research.

* To be presented at Tritium 2016