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Post-Irradiation Examination of ISIS Target: A Proposal

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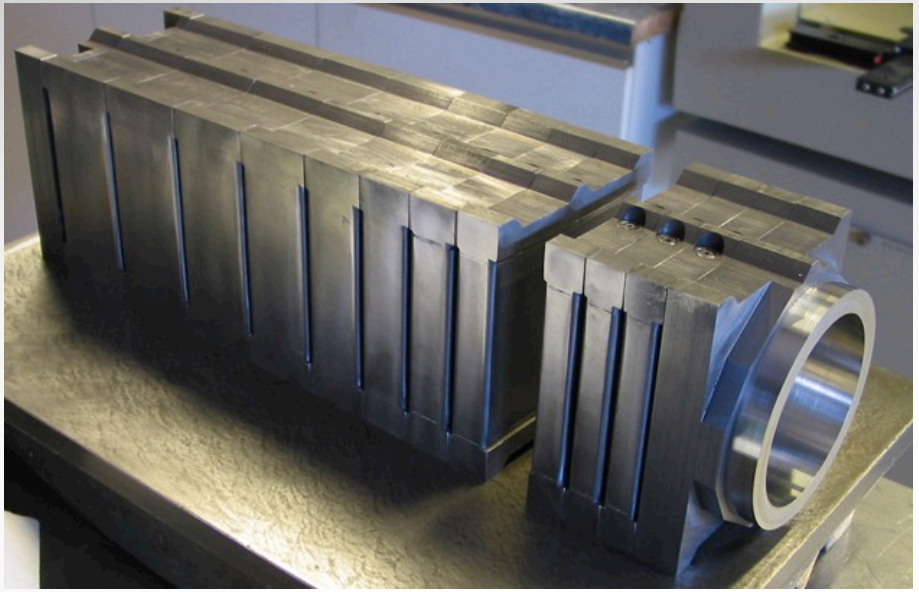
Background

- Scope and cost estimates were prepared for disassembly and post-irradiation examination of ISIS TS-1 and TS-2 targets per specification provided by RAL



TS-1 Target with coolant manifolds removed

TS-2 Target

Receipt

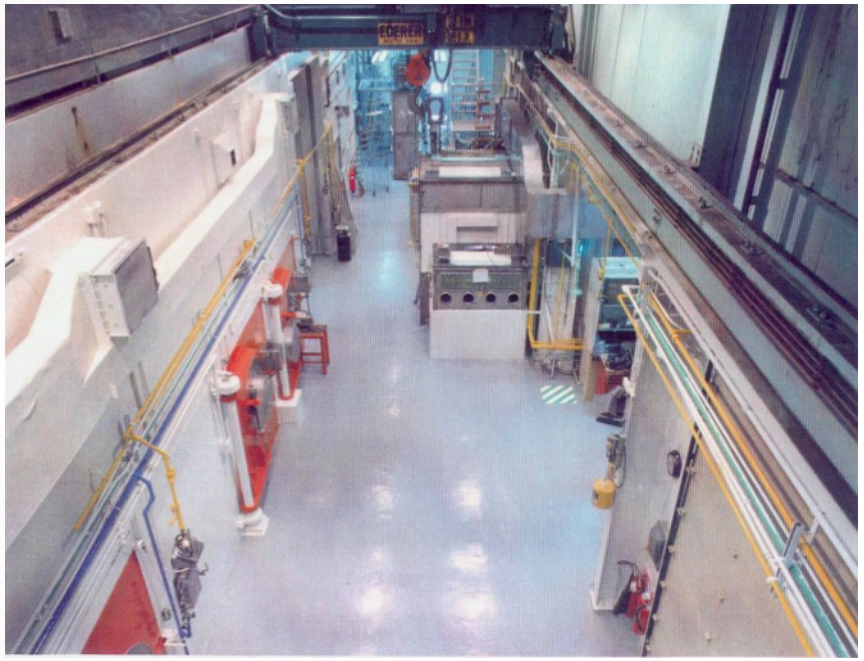
- Target size and activity will likely require the use of a shielded cask
  - Largely due to Ta-182 activity
  - Extraction of the tungsten core before shipping to PNNL would save significant cost – may allow shipping in a Type A container
- PNNL has experience with a number of US NRC licensed casks, most recently the NAC LWT and the GE-2000

NAC LWT

GE-2000

Initial Size Reduction

- The targets would be received into the Radiochemical Processing Laboratory (RPL) - High Level Radiochemistry Facility (HLRF)
  - High-density concrete shield walls (1.2 m thick)
  - Viewing provided by six lead-glass windows (total thickness 1.2 m) optically coupled with mineral oil
  - Each window has a pair of heavy-duty Model E manipulators
  - A-cell – Used for receiving – 4.5 m wide x 2.6 m deep x 5.2 m tall
  - Horizontal loading through 0.5 m diameter port
  - B-cell and C-cell – Used for size reduction – 1.8 m wide x 2.6 m x 5.2 m
  - New capability (e.g. band saw) would be required for efficient size reduction



Initial Size Reduction

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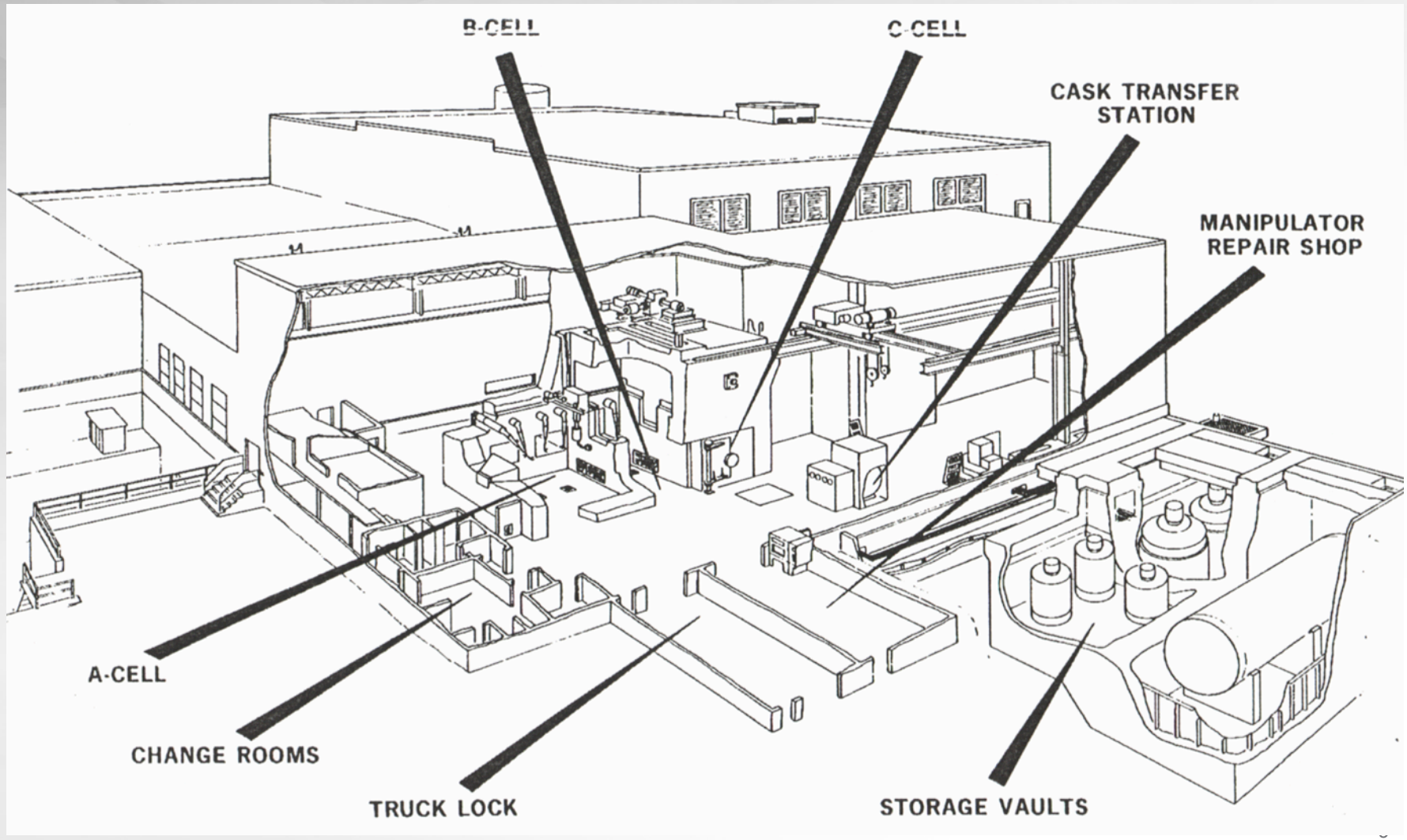


Visual Examination

- During disassembly/size reduction, visual examinations are routinely conducted using high-resolution photography and videography
- Cameras mounted in-cell or positioned with manipulators

High-resolution in-cell photograph of failed fuel rodlet with centerline thermocouple

High-resolution video capture of a zircaloy-clad fuel rodlet with Pb-Bi eutectic on the exterior, held in manipulator fingers

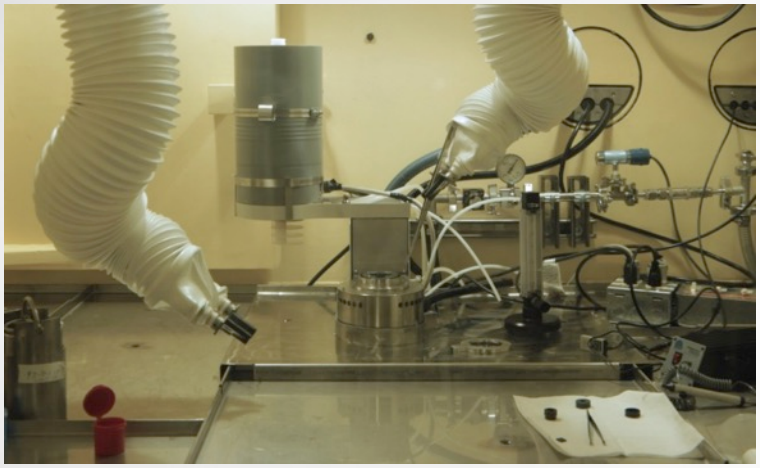
Precision Sectioning

- Precision sectioning to extract samples would be conducted in either the Shielded Analytical Laboratory or a modular hot cell, depending on activity and availability
- New capability would be required for efficient sectioning of complex shapes from large pieces (e.g. EDM)
- Shielded Analytical Laboratory (SAL)
  - Six interconnected hot cells
  - 1.7 m wide x 1.7 m deep x 5.2 m tall
  - Shield walls are 1 m thick concrete and steel
- Modular hot cells
  - Two cells 1.7 m wide x 1.5 m deep x 3.7 m tall
  - One cell 3.0 m wide x 1.5 m deep x 3.7 m tall
  - One cell 2.1 m wide x 1.5 m deep x 3.7 m tall
  - Shield walls are 30 cm steel
  - Large access doors for easy equipment installation/removal

Thermal Properties

- Thermal property measurements are routinely conducted, with individual capabilities located in SAL and modular hot cells
- Thermal diffusivity (α), specific heat (c_p), and density (ρ) data are combined to provide thermal conductivity (k)

$$k = \alpha c_p \rho$$



Thermal Diffusivity via Laser Flash Analysis
Netzsch LFA 457

Specific Heat via DSC
Perkin Elmer Pyris 1

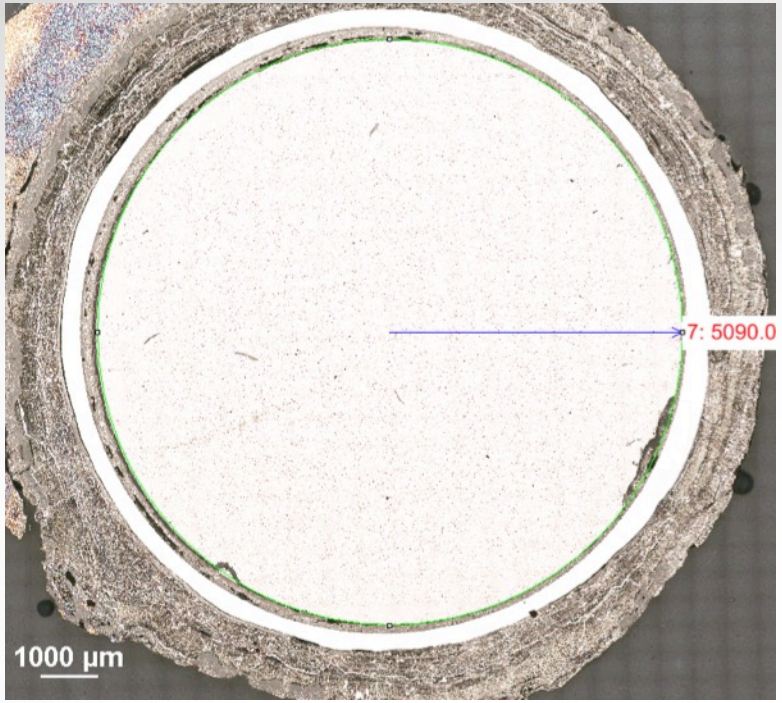
Density via He Pycnometry
Micromeritics AccuPyc 1300

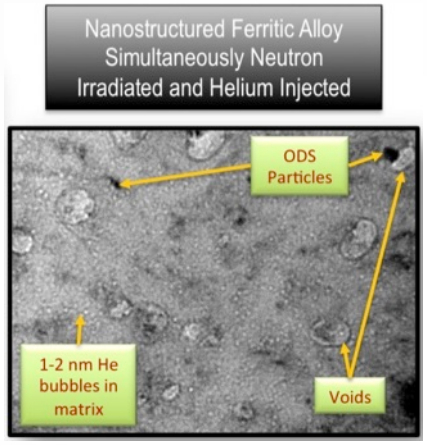
Mechanical Properties

- Bulk tensile properties could be obtained using an existing load frame currently installed in one of the modular hot cells
  - Instron 8800
  - 9800 N and 98,000 N load cells
- If desired, micron-scale hardness and elastic modulus could be obtained via atomic force microscopy (AFM) using a capability currently being developed
  - Nanosurf LensAFM attachment on a Nikon E400 POL microscope
  - See talk by DJ Senor on 20 May

Microscopy

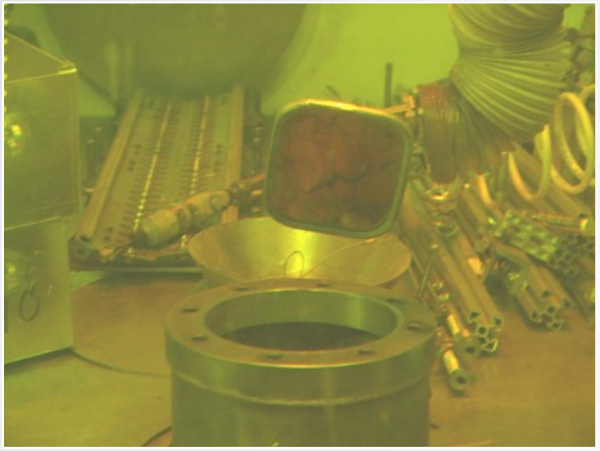
- Optical and scanning electron microscopy would be used to evaluate grain size and general microstructural features
- Features of interest could be isolated and removed via FIB for TEM examination
- Relevant microscopes available for use on irradiated materials
  - Fully-automated and remote-operated Nikon 200MA optical microscope
  - FEI Quanta250 FEG SEM with EDS/WDS/EBSD
  - JEOL 7600 SEM with EDS/WDS/EBSD
  - FEI Helios 660 Nanolab dual focused ion beam (FIB) SEM
  - FEI Tecnai 330 keV TEM with EDS and Gatan ORIUS digital camera
  - JEOL ARM 200CF aberration-corrected TEM



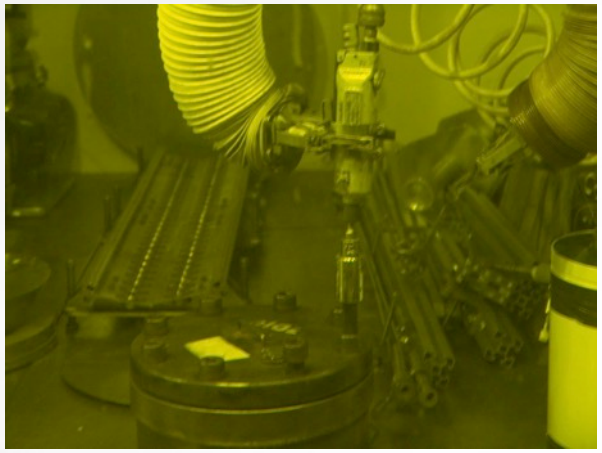


Waste Disposal

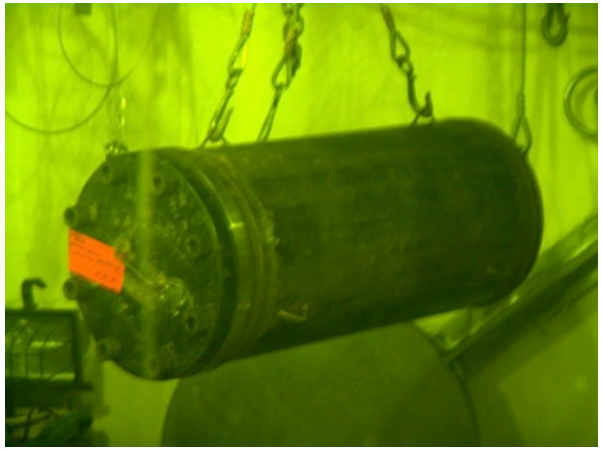
- Two shielded waste cask assemblies would be required for waste disposal upon completion of PIE
- Hot cells are typically cleaned after project completion to return them to their initial state



Loading Primary Container with Waste



Securing the Lid on Primary Container



Positioning Loaded Container for Removal from Hot Cell