Operational Experience using the Combined Electrolysis and Catalytic Exchange (CECE) Tritium Compatible Rig

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System Overview

Design Intent

• Operate a small scale Combined Electrolysis Catalytic Exchange (CECE) rig for active materials testing while under operational conditions.
  • Recombiner catalyst
  • LPCE catalyst
  • Cell materials
    • Proton Exchange Membranes, Electrode Catalysts
• Maximum concentration of 1000 Ci/kg water
• Small closed loop system
System Overview

Secondary Enclosure Glove Box

- Secondary Enclosure: Inert Atmosphere positive pressure Ar Glove Box
- Continuous moisture monitoring - dewpoint transmitter
- Continuous tritium measurements using 1L ion chamber
- Automated atmosphere control using a PLC
System Overview
Secondary Enclosure Cleanup (SEC)

• Molecular Sieve bed
  • Cycles through to maintain a user defined dewpoint

• Ti bed
  • Cleanup of O\(_2\) (decrease atmospheric formed HTO)
  • Cleanup of T\(_2\), N\(_2\)

• Ni bed
  • Cleanup of Organically Bound Tritium
System Overview

CECE-T Rig: Simplified

- Welded tubing with VCR connections where necessary
- Gravity fed water supply
- Tritium compatibility
- Metal bellows pump
- Closed loop system (cell«»recombiner)
System Overview

Electrolyser Cell

- Proton exchange membranes
  - Nafion® (reference material)
  - CNL Tritium Compatible Membrane
- Membrane Electrode Assembly (MEA)
  - CNL prepared electrode catalyst
  - MEAs pressed on site
- Cell operation @ 60 °C
System Overview

Electrolyser Enclosure

- Electrolyser is the most likely leak point within the rig
- Low point
- Enclosure allows for gas cycling through molecular sieve beds to trap tritiated water in the event of a cell leak/rupture
System Overview

Tritium Injection Method

- Uranium bed loop for elemental tritium introduction
Inactive Commissioning Findings

Electrolyser Cell - Deficiency

- Secondary cell enclosure does not allow for leak monitoring.
- Forced to monitor rig water levels for leaks.
- During inactive commissioning, found standing water inside the enclosure.
Inactive Commissioning Findings

Electrolyser Cell - Solution

- Modified faceplate to clear polycarbonate with a gasket.
- Able to tighten cell components following cell conditioning.
- Able to visually inspect for leaks.

- Discovered water was diffusing slowly from the cell
Inactive Commissioning Findings

Electrolyser Cell

- PEEK capping layer
- Tight tolerances ensure a tight fit of fully hydrated MEA
- Thickness of PEEK film designed to be slightly smaller than a fully hydrated MEA
- In plane expansion is minimal
Inactive Commissioning Findings

Bellows Pump Vibration

- Pumps are solidly mounted on common base within the GB
- Results in excessive noise, and vibration to the rig
- Direct hard-pipe connections changed to flexible hose
- Rubber mounts installed on the base
Active Commissioning Findings

Tritium Injection Method

• To initiate active commissioning, a small amount of tritium was added from tritiated gas mix.
• Found this to be preferred tritium injection method.
• Elemental tritium introduced to the rig using a calibrated volume loaded with gas from tritium gas dispensing system. Fill to less than atmospheric pressure
• Removal of uranium bed/heater.
  • Remove the permeation hazard
  • Removed elemental tritium hazard
Active Commissioning Findings
Glove Atmospheric Conditions Assessment

- Removal of uranium bed, Ti, and Ni beds
- Hazard in the GB is HTO only, originating from the rig (very low elemental inventory - < 1 Ci)
- Knowing the concentration of HTO in the rig (1000 Ci/kg)
- The GB atmospheric HTO can be regulated by controlling the dewpoint. This controls the overall system emissions.
  (Actual total inventory of tritium is ~200 Ci)
Active Commissioning Findings
Glove Atmospheric Conditions Assessment

Calculated Atmospheric Tritium Concentration vs. Dew Point Values

<table>
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<tr>
<th>Dewpoint (°C)</th>
<th>Water (PPM)</th>
<th>Concentration (mCi/m³)</th>
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Dewpoint (°C) vs. Dew Point (°C)
Continuing Work

CECE-T Rig

- Step up concentration to 1000 Ci/kg
- Materials testing of PEMs, and CNL proprietary membranes over long term
Thank you

Questions?

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