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Analysis of High Nickel Alloys Partially Submerged in a Ternary Chloride Salt

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SAND2022

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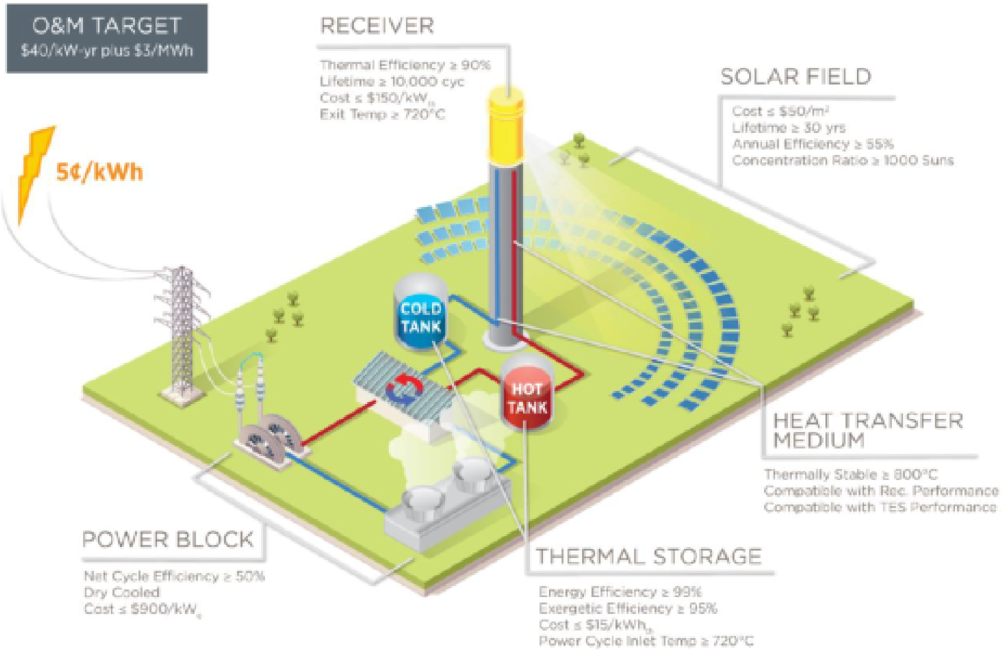
U.S. DEPARTMENT OF ENERGY

NNSA

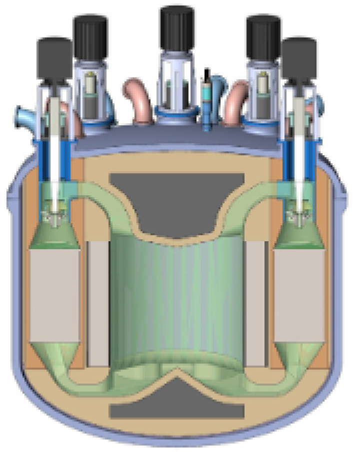
Project Background: 750°C Molten Salt Valve: Key Challenges

- DOE SETO focus of developing thermal transport systems capable of operating temperatures > 720°C and integration with advanced, high-efficiency power cycles.
- Materials & Manufacturing - Solutions to reduce cost & risks of CSP components.
  - "Receiver & components: piping, pumps, tower structure, insulation, heat tracing, headers, and valves"
- Materials compatibility up to 750°C
- Proper Controls and Ullage Gas System Integra
- Higher-than-expected salt vapor pressure
- High salt vapor freezing phenomena



Nuclear Applications

TerraPower
A Nuclear Innovation Company



MCFR conceptual design

HAYWARD TYLER

Southern Company

ELYSIUM
INDUSTRIES

HT Salt Pot Materials Compatibility Studies

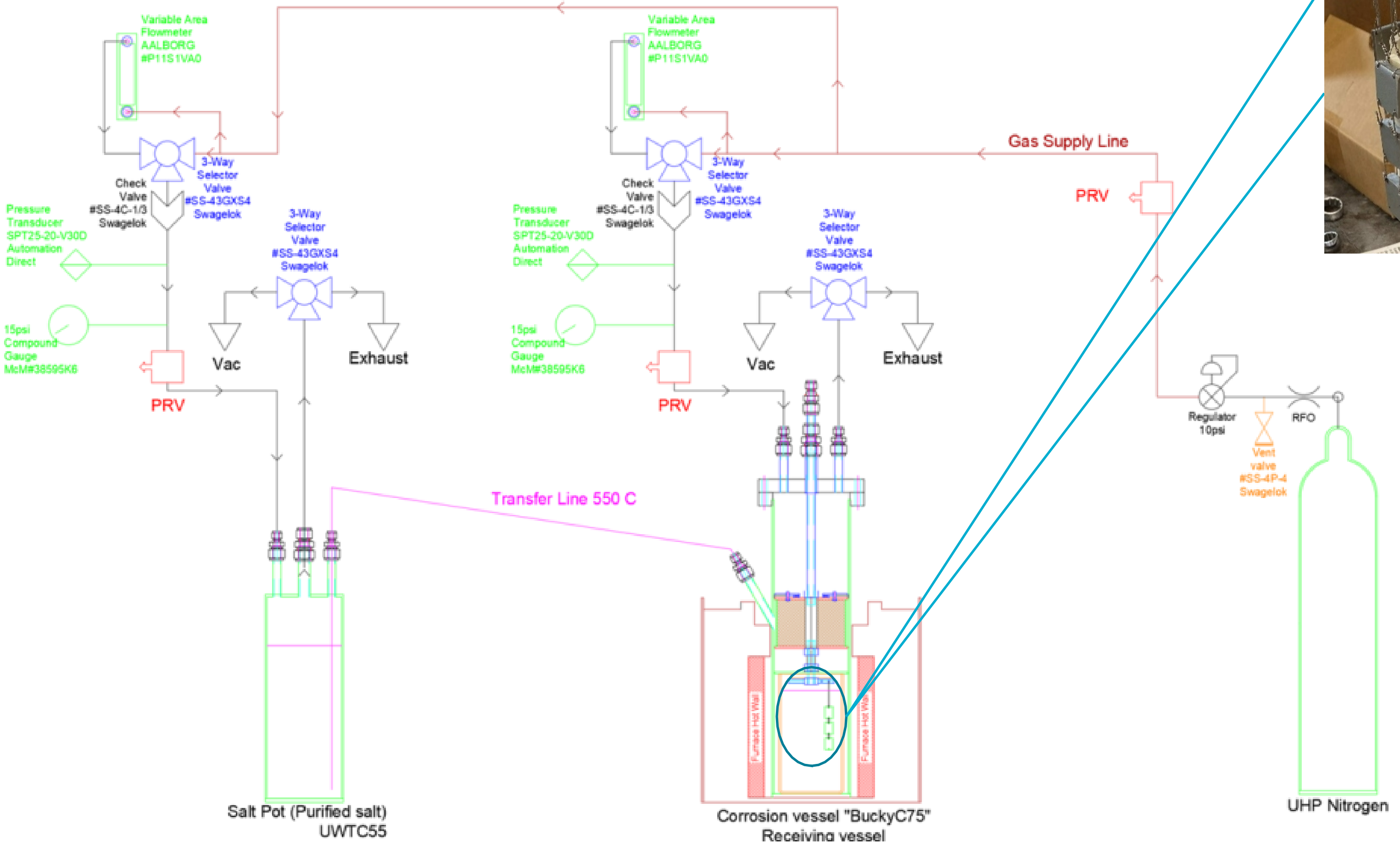
Components to be Studied
- Valve body, bonnet, gaskets, packing, bellows, welds, impellers.
- Gaskets and Seals

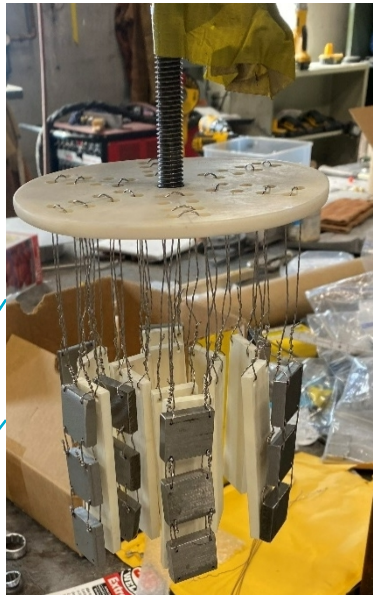
Materials being studied
- Alloys: SS316H (CF8M), SS347H, Haynes 282, Haynes 230 (or Inconel N06230), C-276, SS304H Incoloy 800H, Inconel 617, Inconel 625, (potentially combined with nickel and cobalt based cladding such as Colmony 5, Alloy200, 740H.
- Seals: Ceramics, Mica, Thermiculite, graphite.
- Weldments

Salt Pot Work
- Nitrogen gas, vacuum pump, & gas condensation lines detachable via VCR fittings for lid removal
- Addition of a Liner or cladding
- Re-making lid out of $Al2O_3$/SiC
- Ullage Gas systems

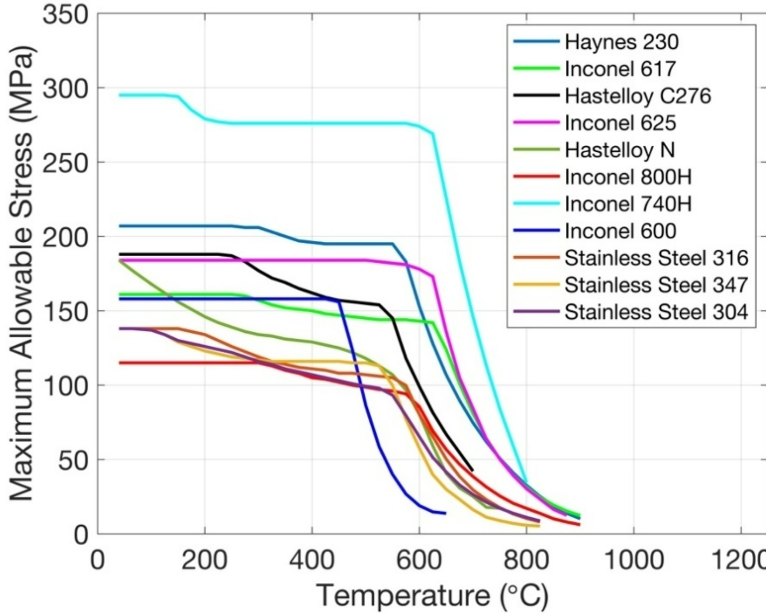
Post-Test Analysis
- Scanning Electron Microscopy/Energy Dispersive Spectroscopy (microscopic structural changes and elemental analysis, XPS)
- Mass loss measurements
- Corrosion analysis

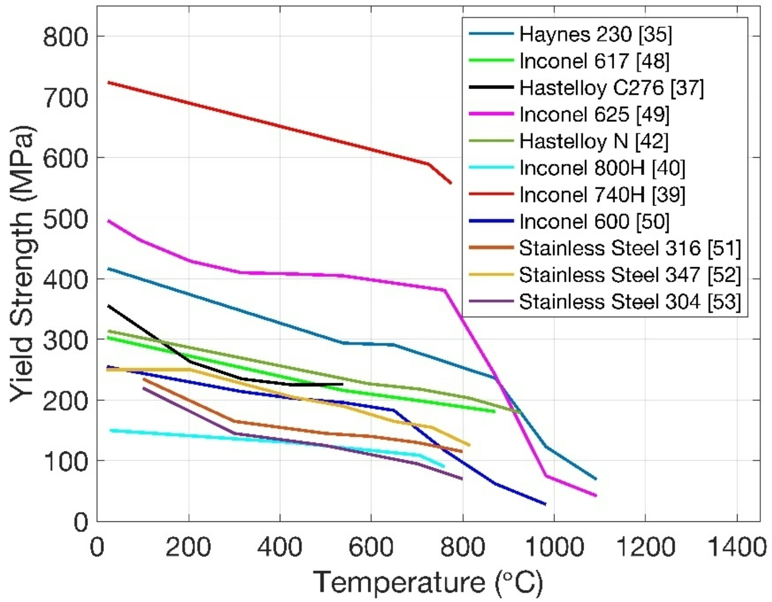
Test Configuration

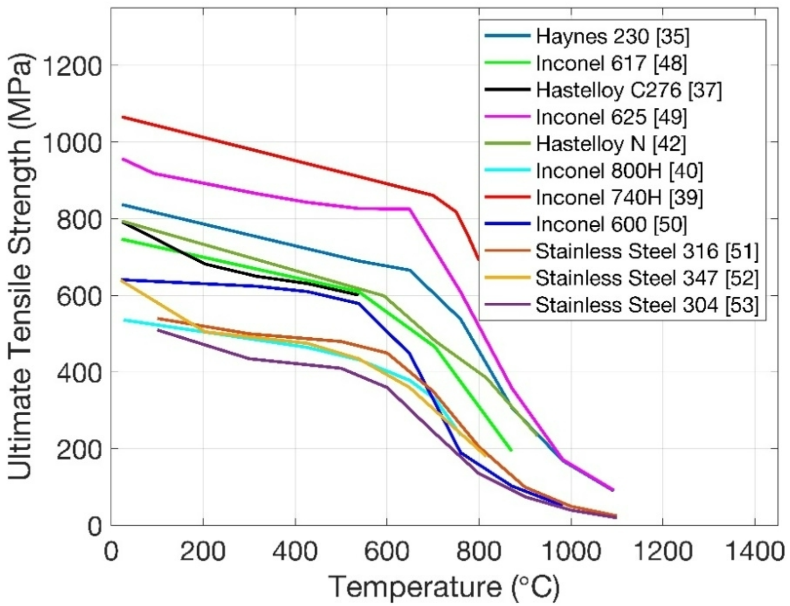




Why High Nickel Alloys?



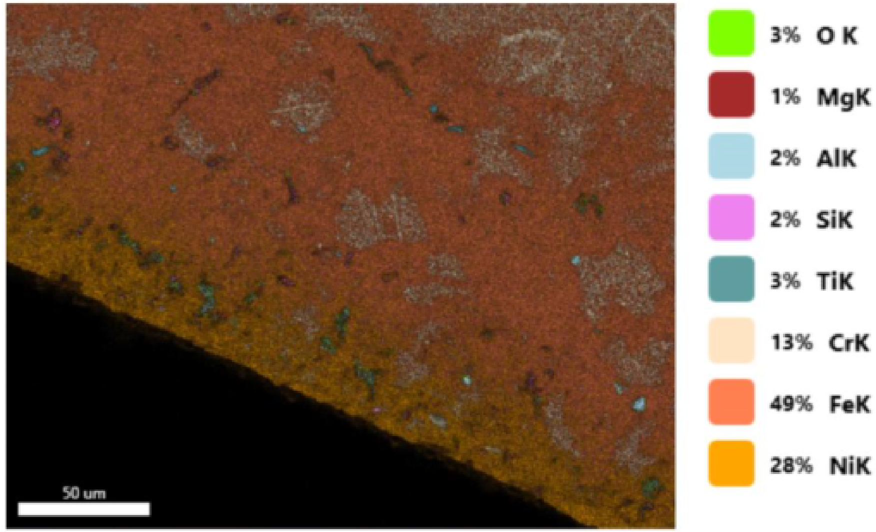


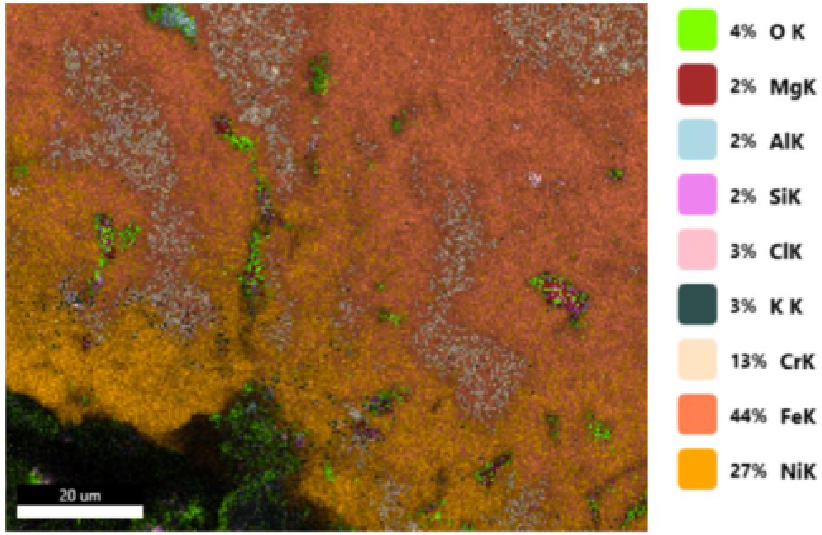


Fully Submerged Samples v.s. Partially Submerged

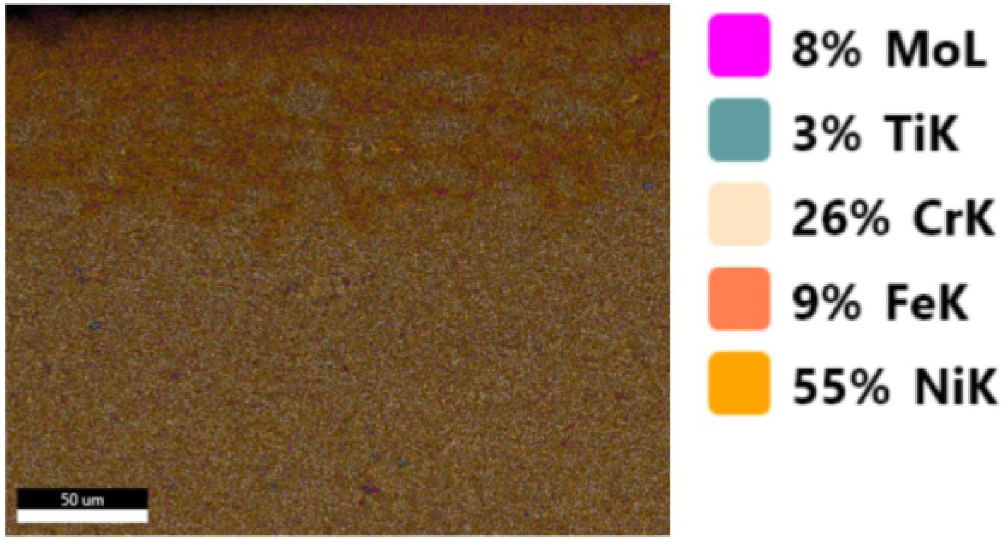
Sample	Corrosion Rate (µm/year) Partially Submerged	Corrosion Rate (µm/year) Fully Submerged
Inconel 800H	397	246.2
Inconel 625	-2	35.68
Inconel 617	53	85.5
Hastelloy C276	37	42.93
Inconel 740H	41	37.67

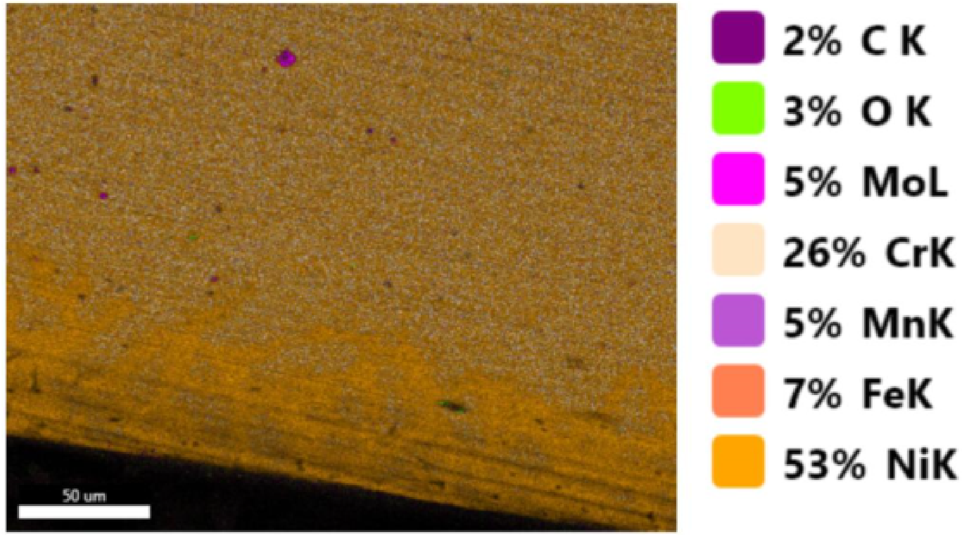
SEM/EDS Inconel 800H



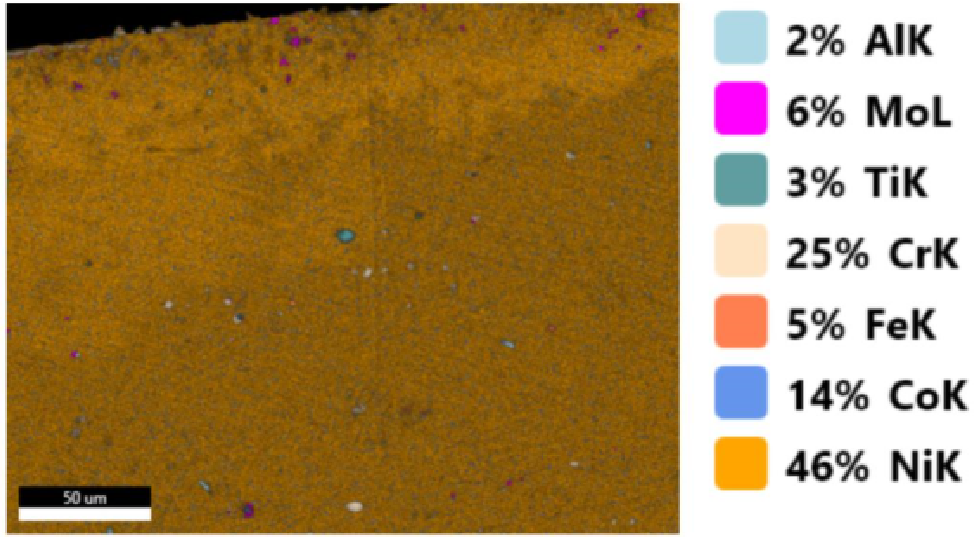


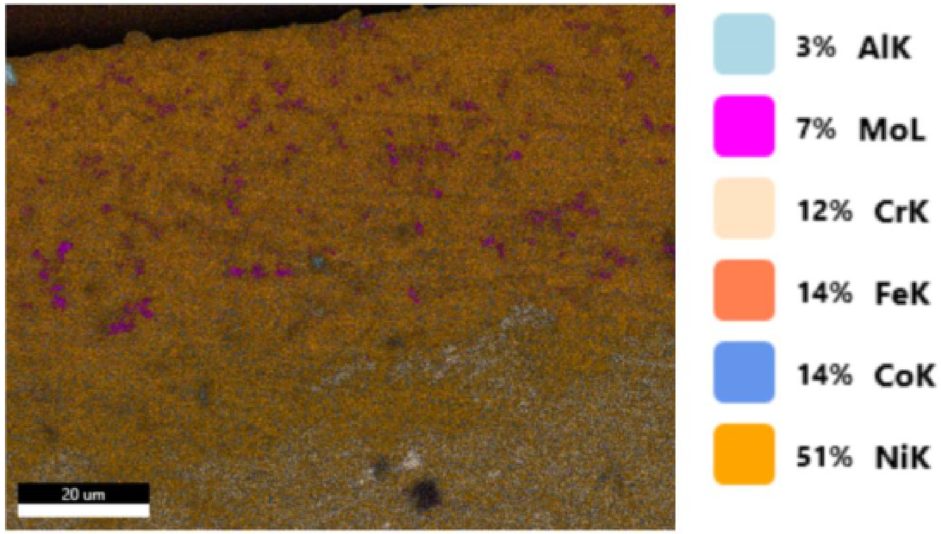
SEM/EDS Inconel 625



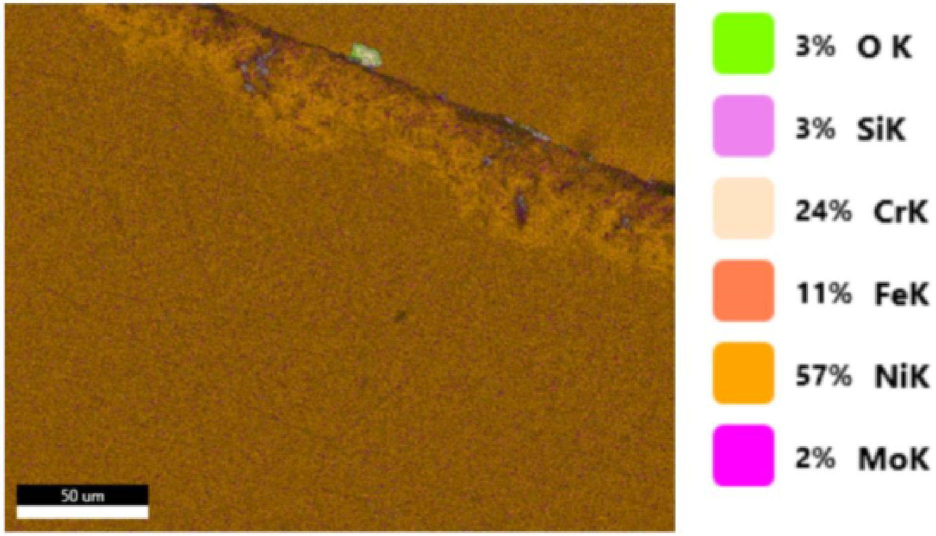


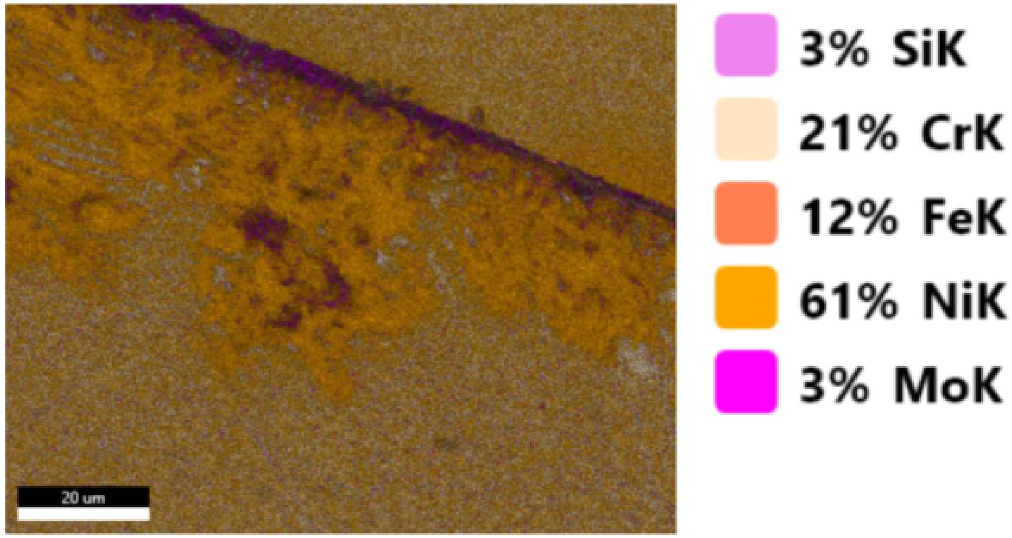
SEM/EDS Inconel 617



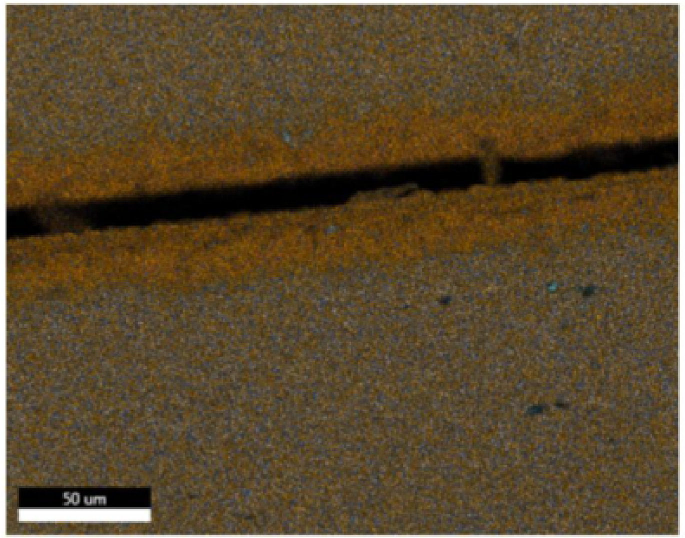


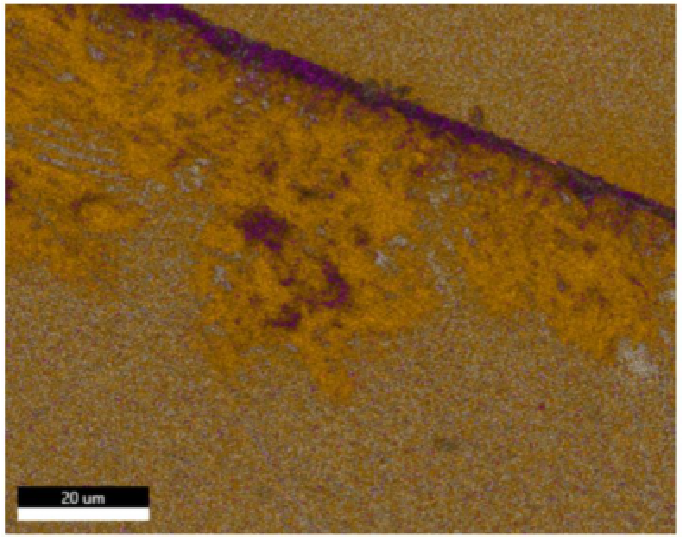
SEM/EDS Hastelloy C276





SEM/EDS Inconel 740H





Conclusion/Future Work

- Partially Submerged materials show more pitting corrosion above the liquid line in the vapor space
- Harmful for piping, pumps, valves, and storage containers
- Further studies are being conducted with samples completely in the vapor space