Nuclear Waste Technical Review Board Meeting

August 24, 2021

Rebecca Smith
Staff Engineer

Drying of ASNF Surrogates

ASNF Extended Dry Storage Project

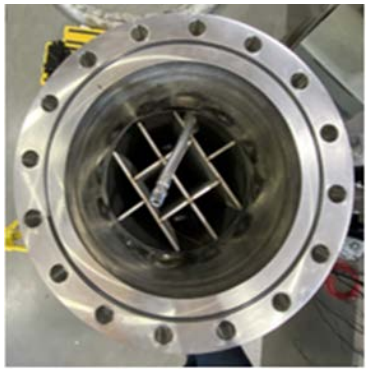
Collaboration with:

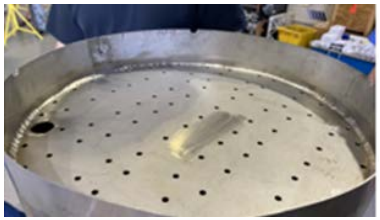
**Idaho National Laboratory,
Savannah River National Laboratory,
Holtec International, and
University of South Carolina**

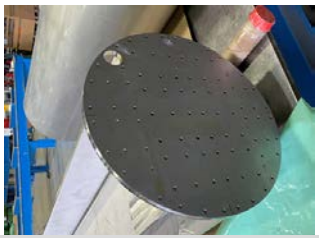
INL Idaho National Laboratory

Task 5 Overview: Engineering Scale Drying Experiment

- Objectives (Recipe for Drying)
  - ASNF Extended Dry Storage (vent v. seal)
  - Remove water (bulk, physisorbed, chemisorbed)
  - Compare forced helium & vacuum processes
- Participant Roles (Collaborators)
  - **INL**
    - planning & coordination
    - chemistry surrogate
    - HPC resources, model integration
  - **University of South Carolina**
    - experiment design
    - instrumentation & analysis
    - objective oversight of testing
    - modeling & validation
  - **Holtec**
    - fab work for major components
    - training facility space and operation
    - industry experience



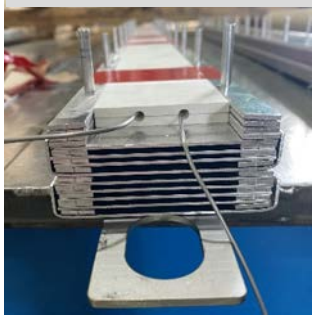




Basket & False Bottom for improved mass transfer

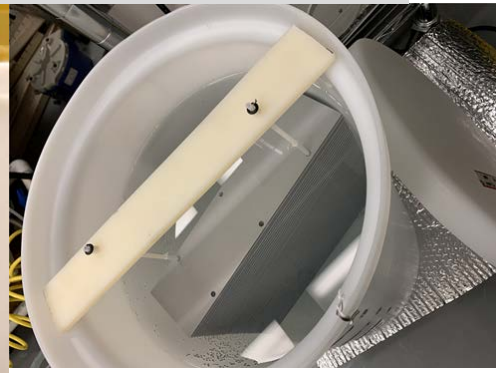
Experiment Concept

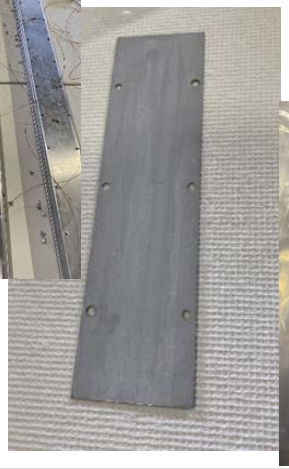
Simulated Decay Heat



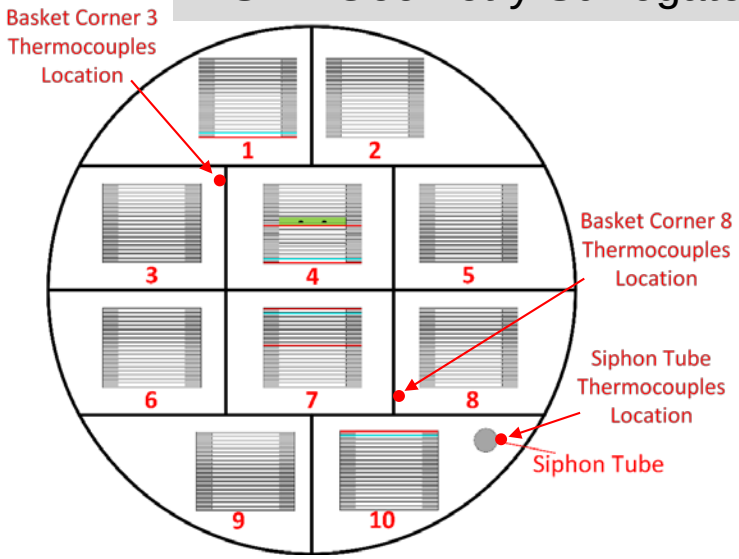
Bulk Water added by syringe

ASNF Chemistry Surrogate suspension & immersion





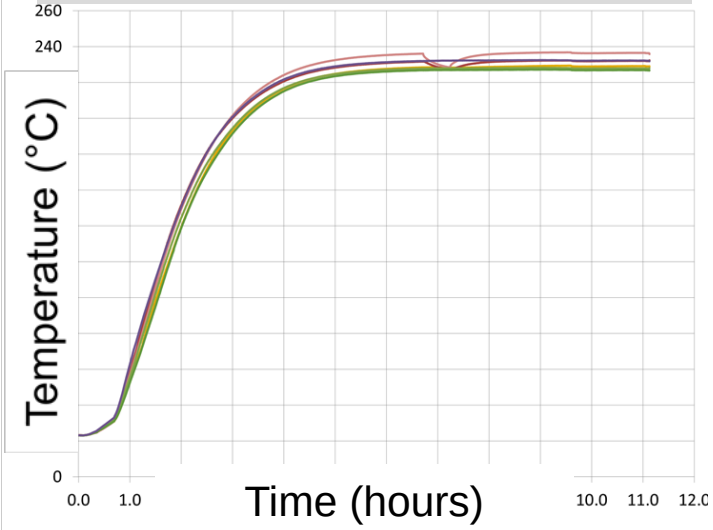
ASNF Geometry Surrogate



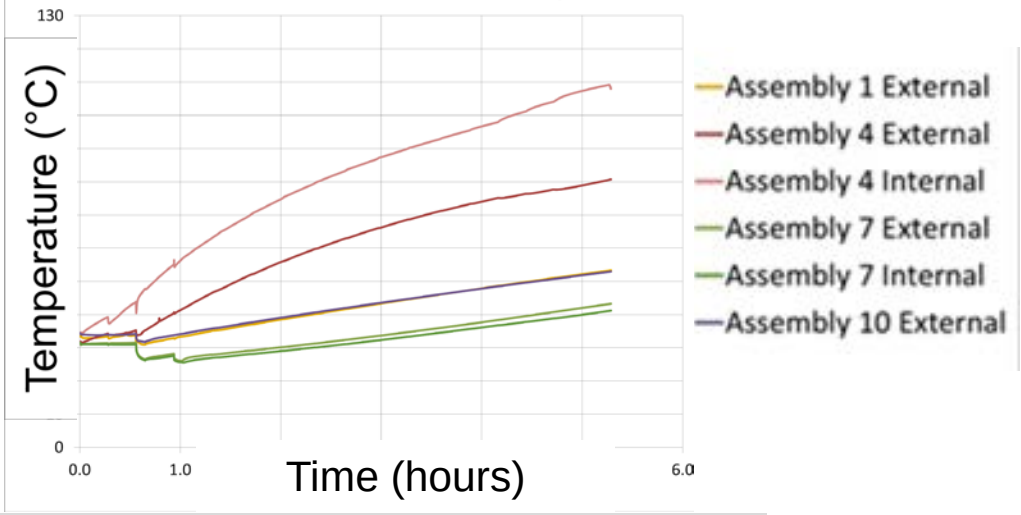
Mapping instrument data & chemistry surrogate performance against models

Comparison of Thermal Performance

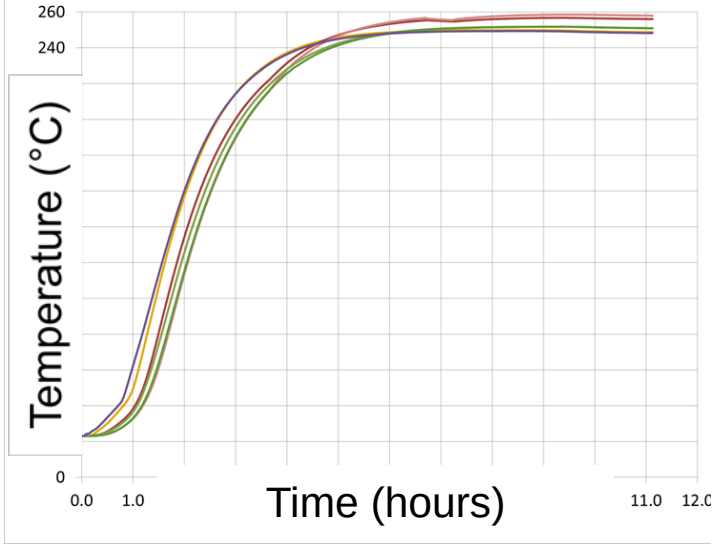
FHD Test 7 Assembly Averages



Vacuum Test 8 Assembly Averages

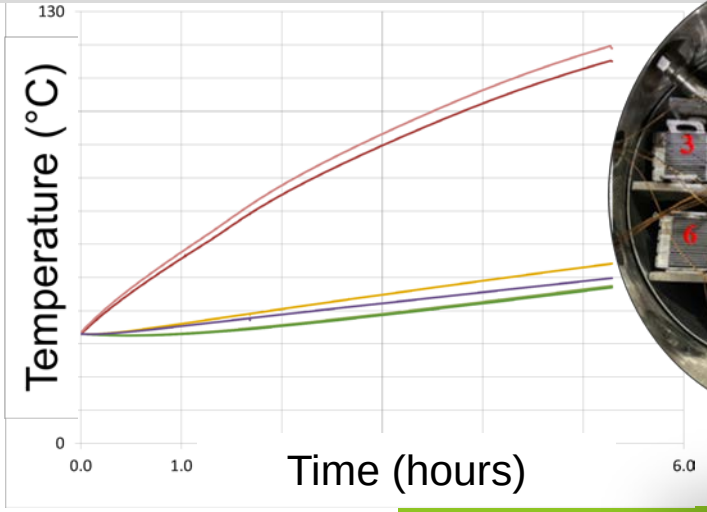


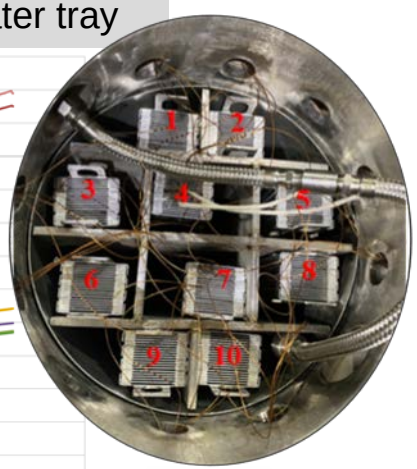
FHD Model, 239°C Inlet, 260°C Wall



Vacuum Model Assembly Averages

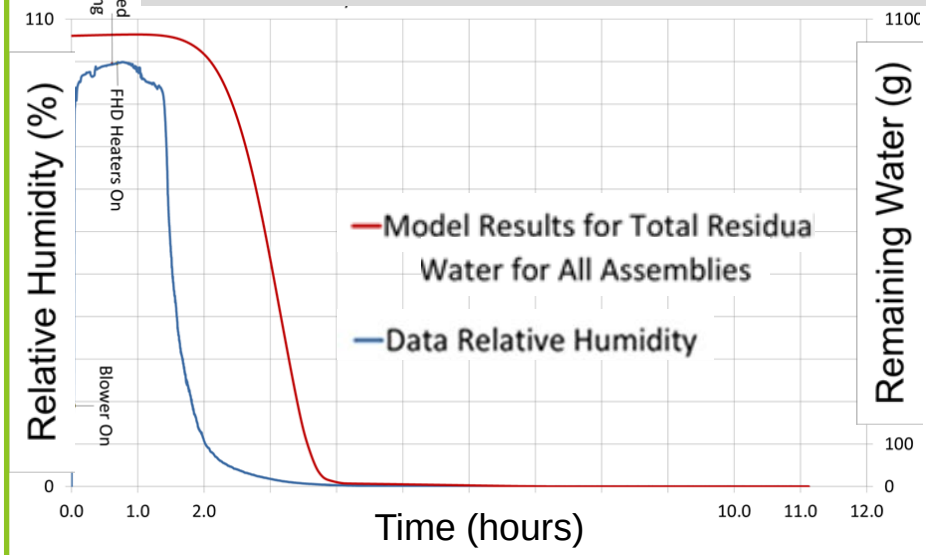
15-minute holds, 100°C wall, no water tray





Comparison of Internal Vessel Moisture

FHD Test 7 Data & Modeled Humidity



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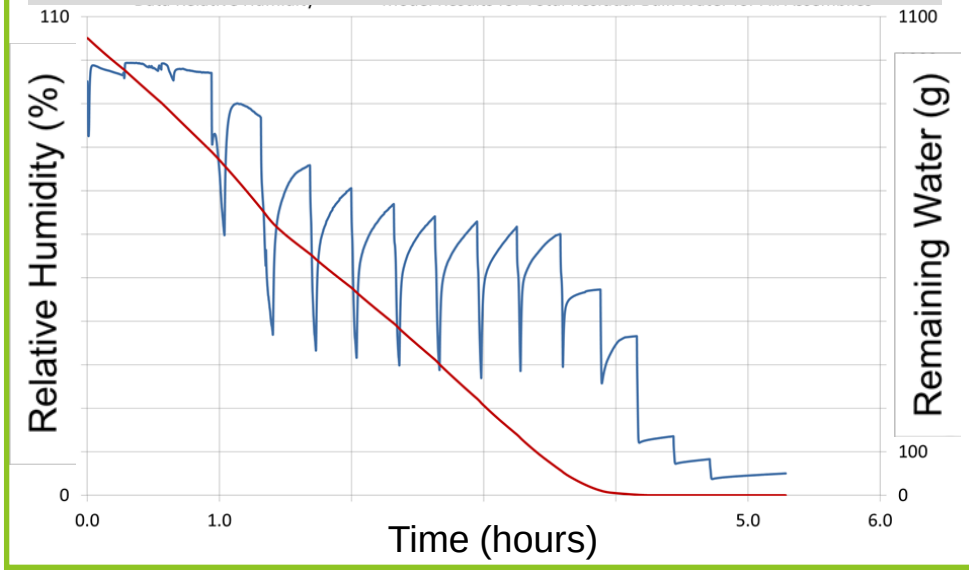
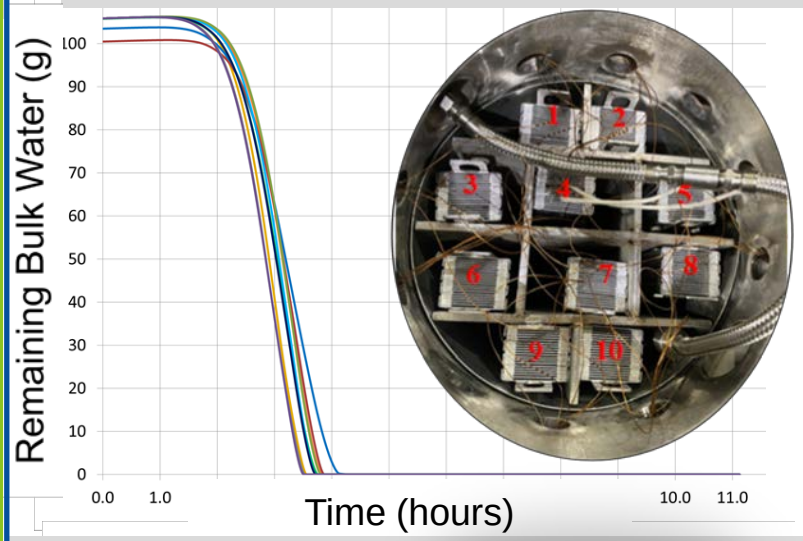
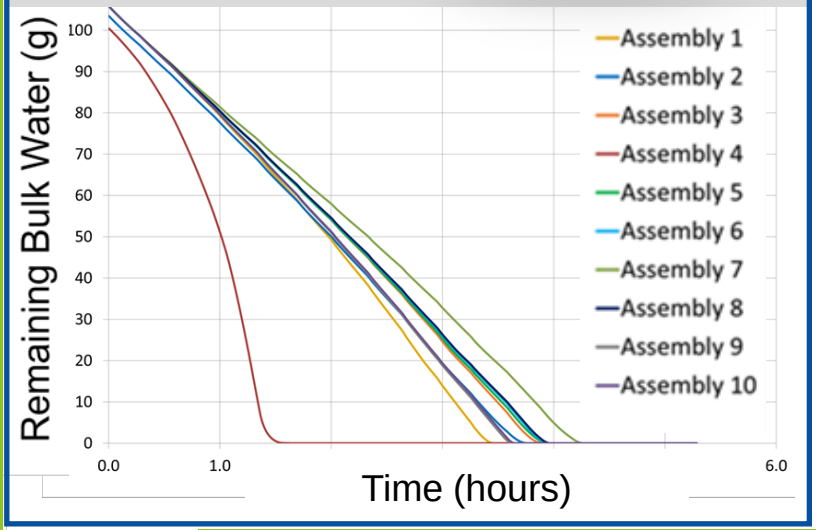


FHD Test 7 Residual Bulk Water



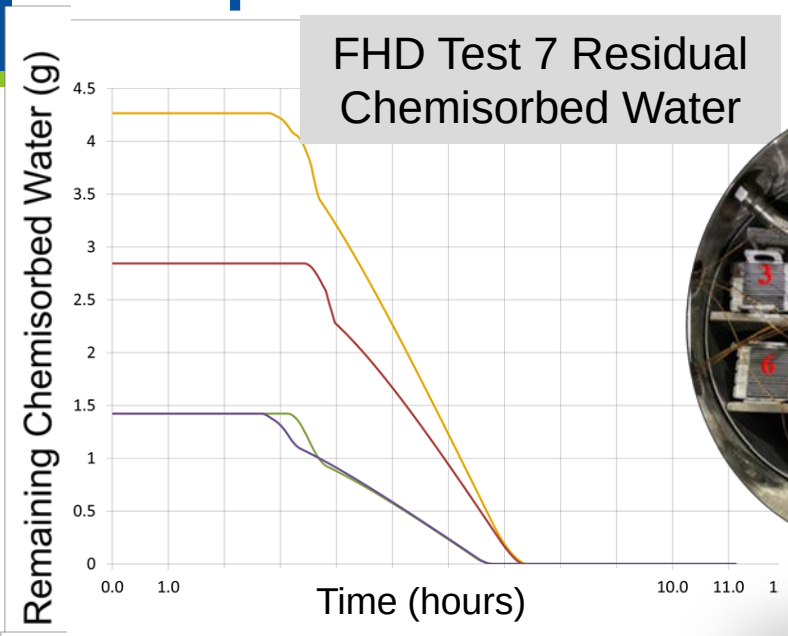
Vacuum Test 8 Residual Bulk Water

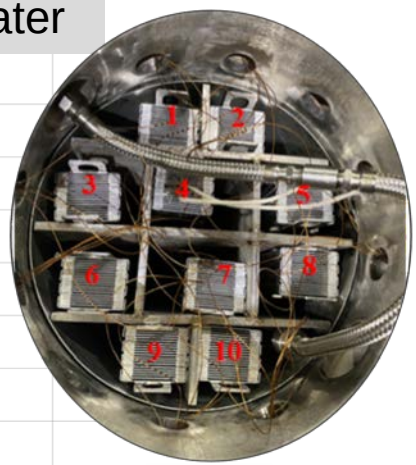


Comparison of Residual Moisture (continued)

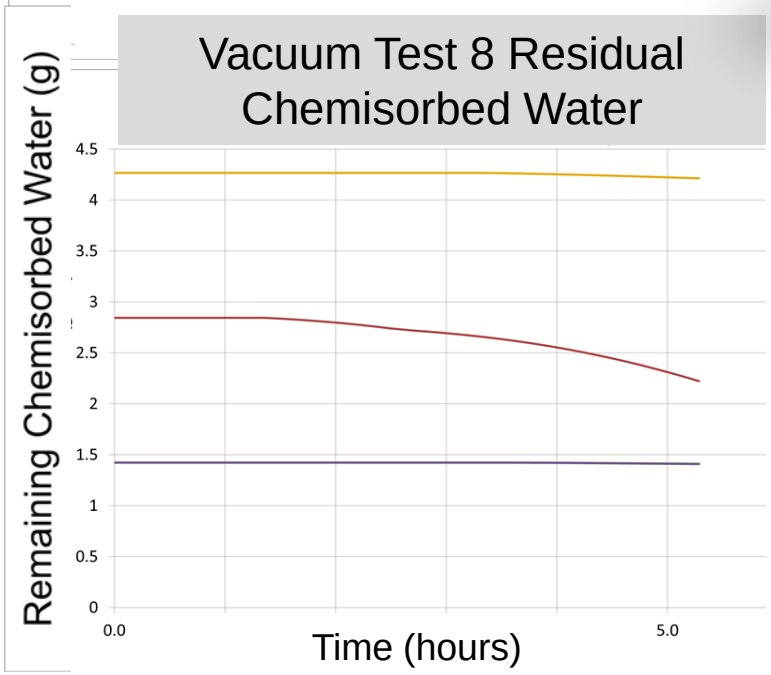
Empirically Modeled Chemisorbed Water

FHD Test 7 Residual Chemisorbed Water





Vacuum Test 8 Residual Chemisorbed Water



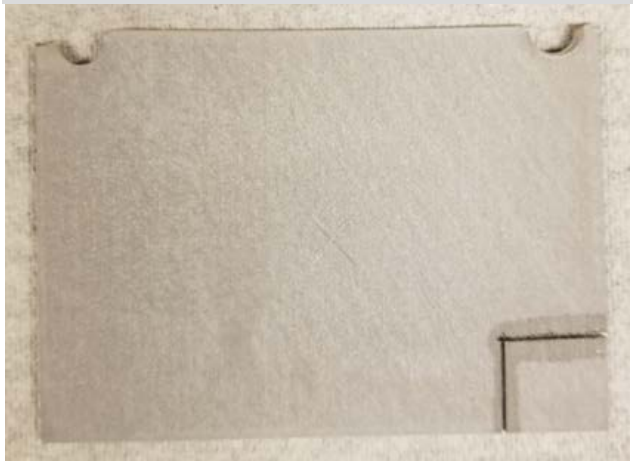
Total Chem Water for Assembly 1

Total Chem Water for Assembly 4

Total Chem Water for Assembly 7

Total Chem Water for Assembly 10

Specimen Sized for Analysis

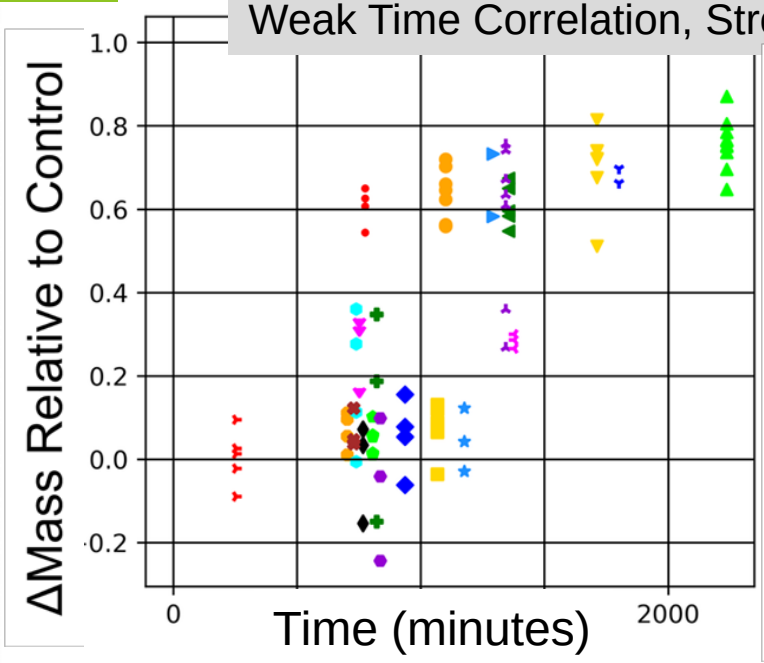


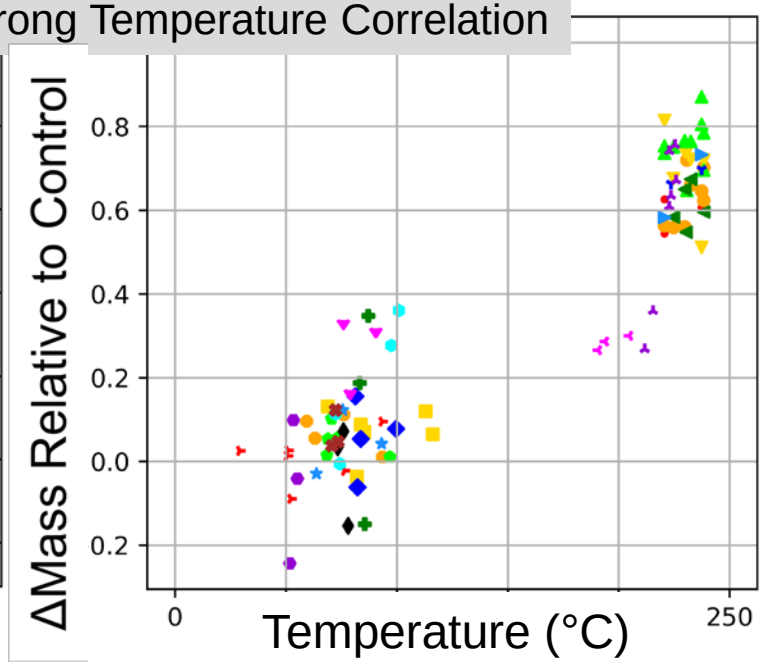
Specimen Loaded for TGA

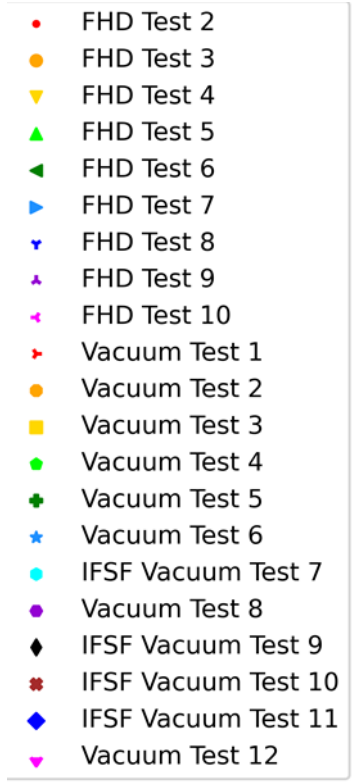
Weight Change and SEM Results

TGA Weight Change Results For All Drying Tests

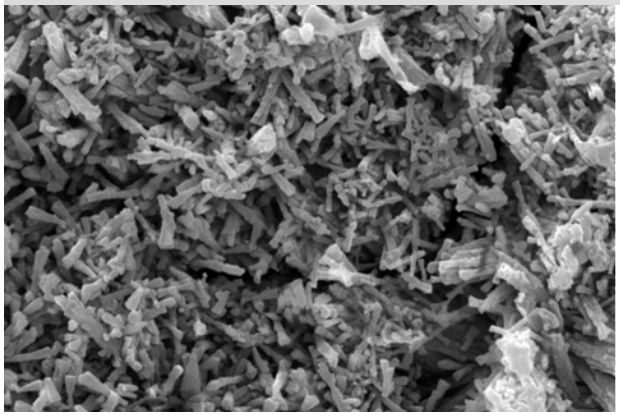
Weak Time Correlation, Strong Temperature Correlation

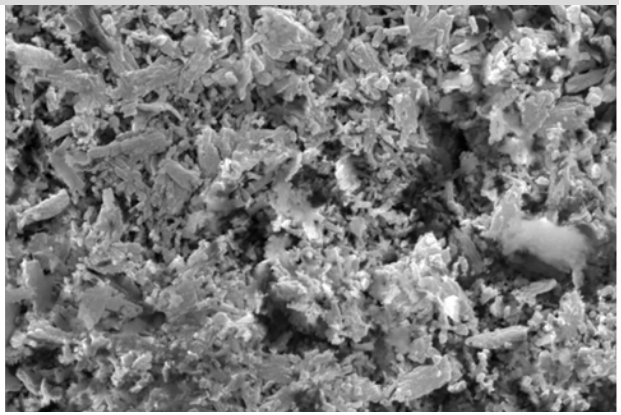




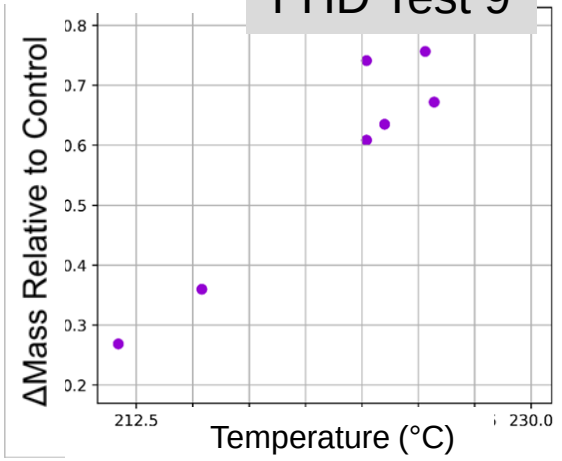


Somatoid Morphology (left) Fuses upon Drying >220°C (right)





FHD Test 9



Future Work (Outstanding Issues)

- Recommendations
  - Confirm performance with optimal siphon tube location
  - Refinement of vacuum drying model
  - Use of chiller during FHD operation
  - Improve heat supply to vessel wall
  - Include spacer disk & bulk water trays in model
  - Consider fuel assembly orientation (model asymmetrical load)
  - Additional validation work to narrow differences between the models and experiments

- Project schedule? Nominally a two-year effort to address all of the above.

Conclusions

- Removal of chemisorbed water is relatively insensitive to the duration of drying (FHD and Vacuum Drying TGA results do not correlate particularly closely with run durations tested)
- Removal of chemisorbed water is very sensitive to temperature, particularly approaching 220°C
- Consequently, FHD is significantly more effective at the removal of chemisorbed water
- Drying process models provide better predictive data for FHD than for Vacuum Drying and there are opportunities for improvement

Acknowledgements

This work was completed in collaboration with many partners.

- Recognition of select contributors
  - UofSC
    - Prof. Travis Knight (Experiment Design)
    - Nate Cooper (FHD Modeling)
    - Robert Demuth (SEM & TGA)
    - Jonathan Perry (Conduct of Experiment, Vacuum Drying Model, Validation of Models)
  - Holtec Government Services
    - Nick Parisi (Project Manager)
    - Garrick Stafford (Engineering Support)
  - INL
    - Alex Abboud (Modeling Consultant)
    - Tim Yoder (Production of Chemical Surrogate)
- Review and consultation on this endeavor by Bob Sindelar and Anna d'Entremont of Savannah River National Laboratory

References

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Questions?

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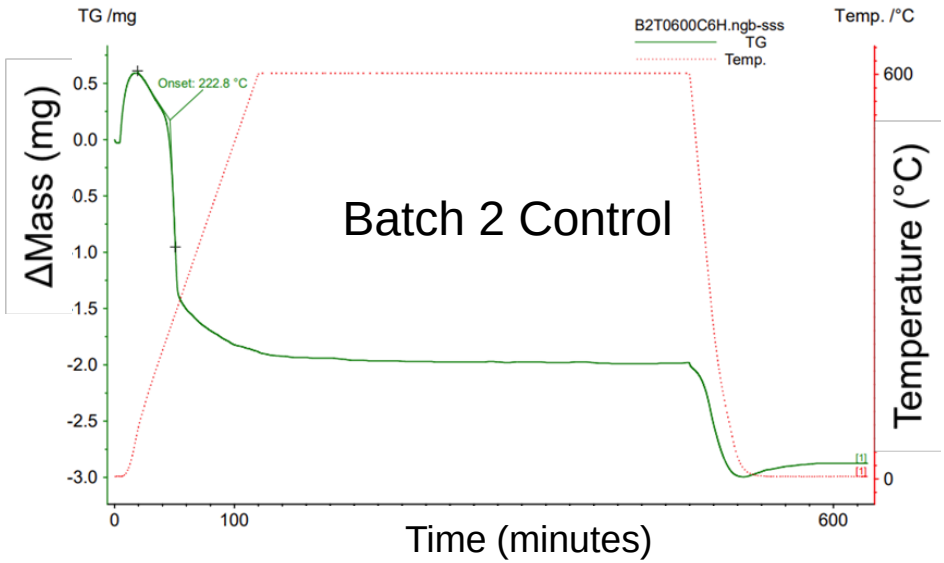
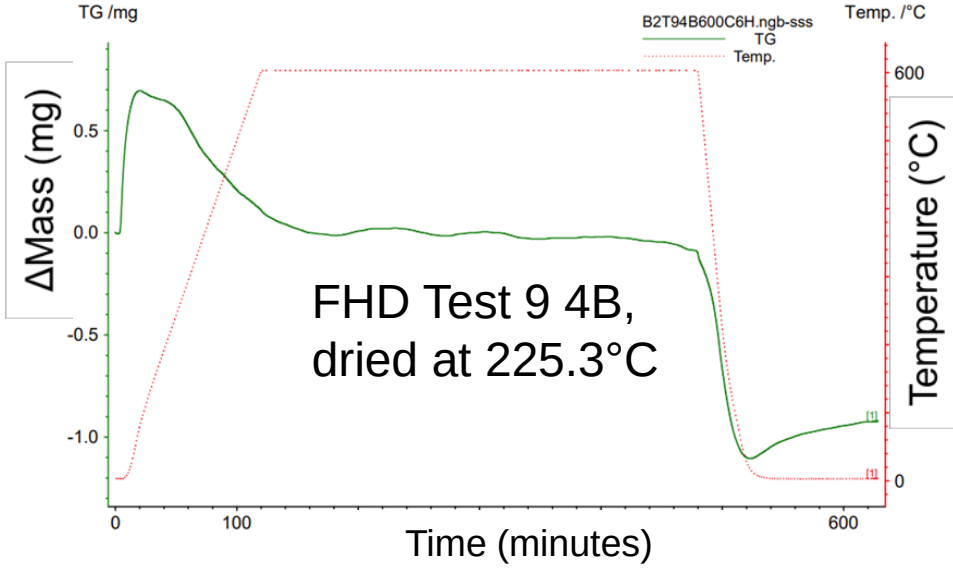
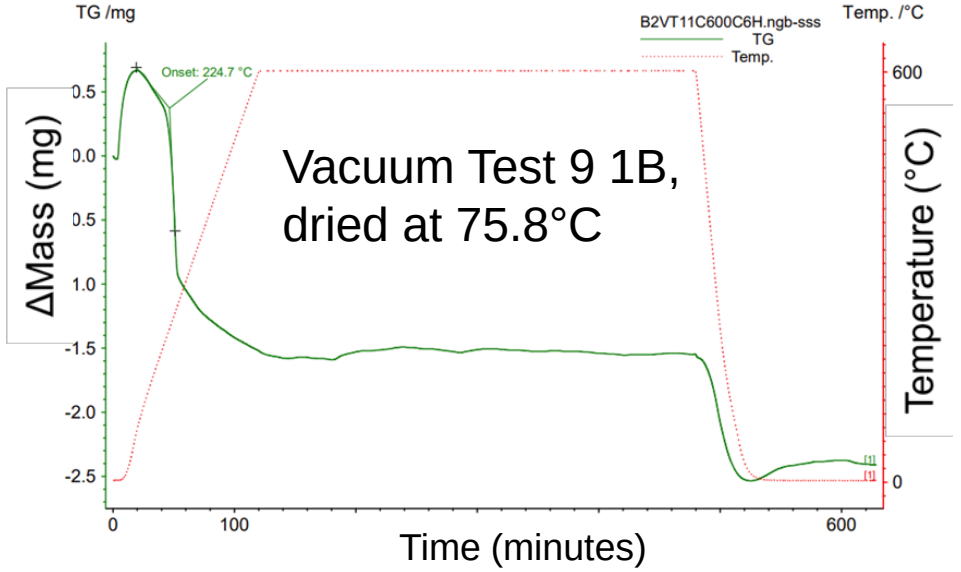
Alternate Views & Extras

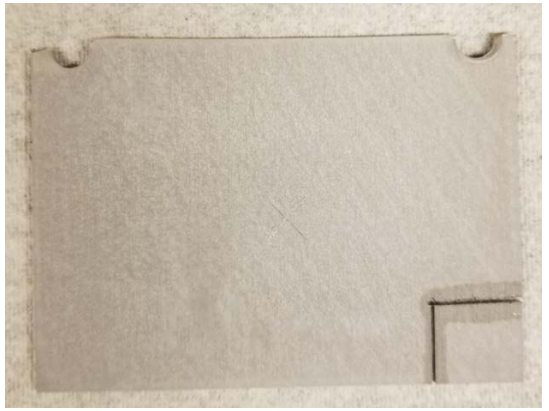
TGA Results

- Control and Vacuum Test show same TGA trend
- FHD Tests (for >220°C) show less chemisorbed water remains

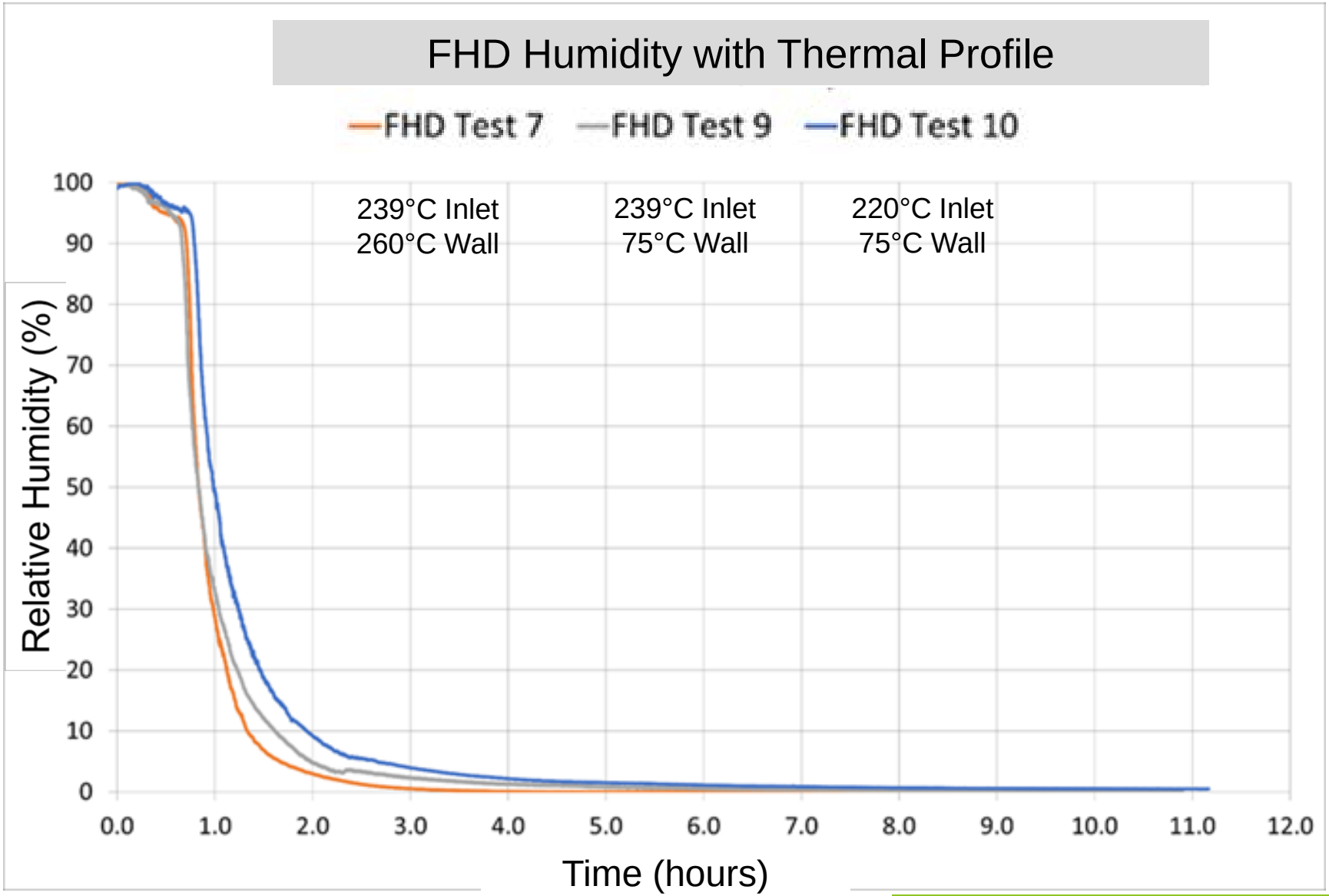






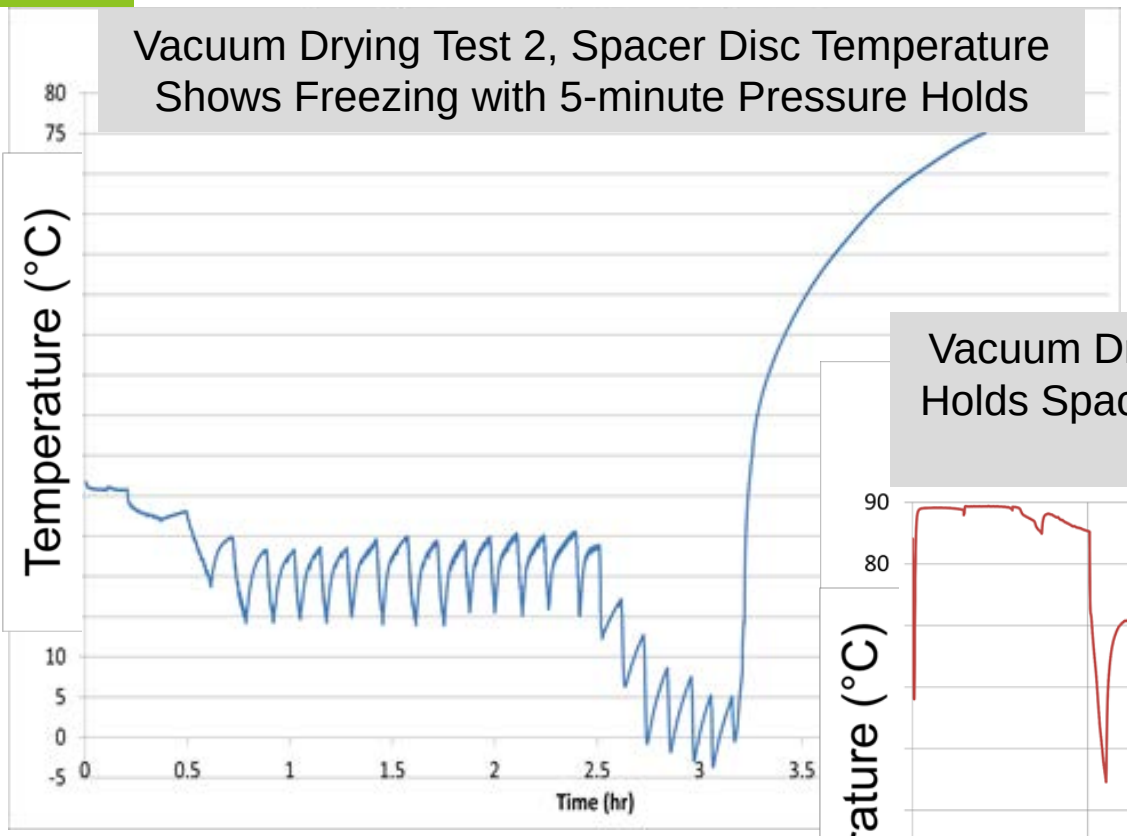


FHD Drying Behavior

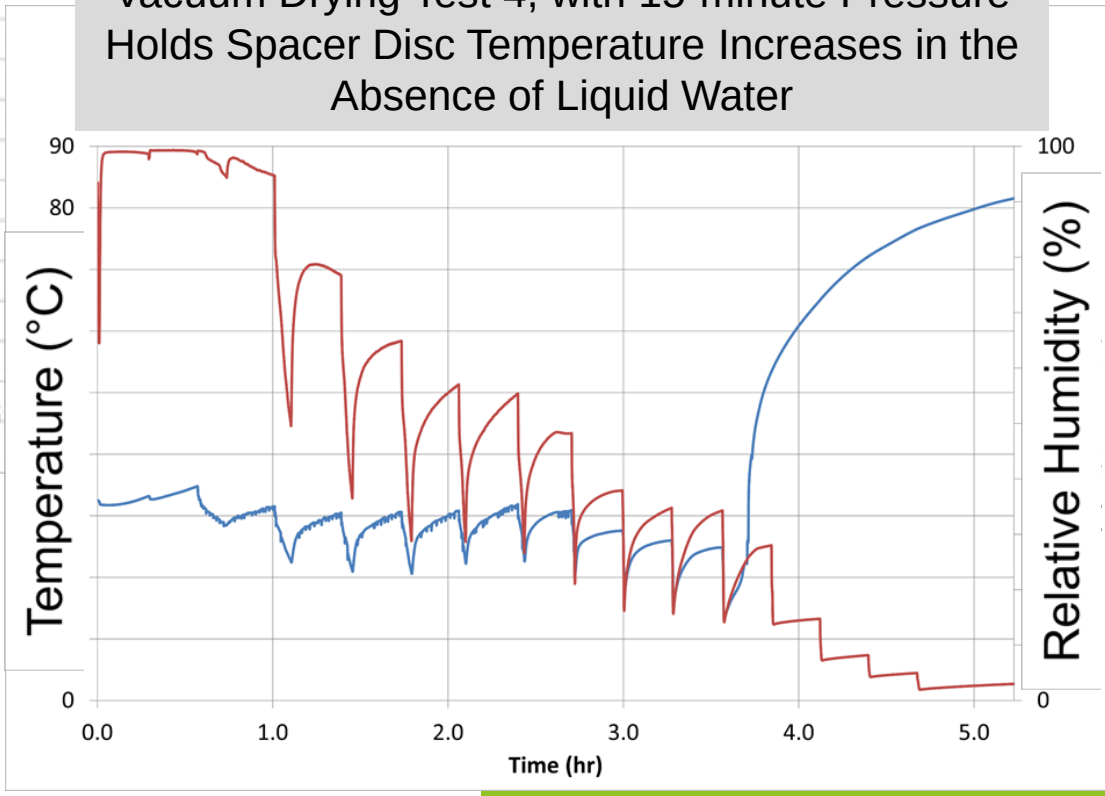


Vacuum Drying Behavior

Vacuum Drying Test 2, Spacer Disc Temperature Shows Freezing with 5-minute Pressure Holds

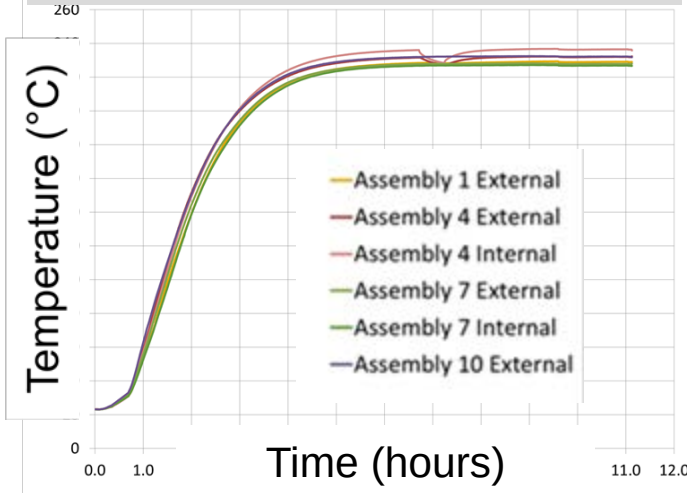


Vacuum Drying Test 4, with 15-minute Pressure Holds Spacer Disc Temperature Increases in the Absence of Liquid Water

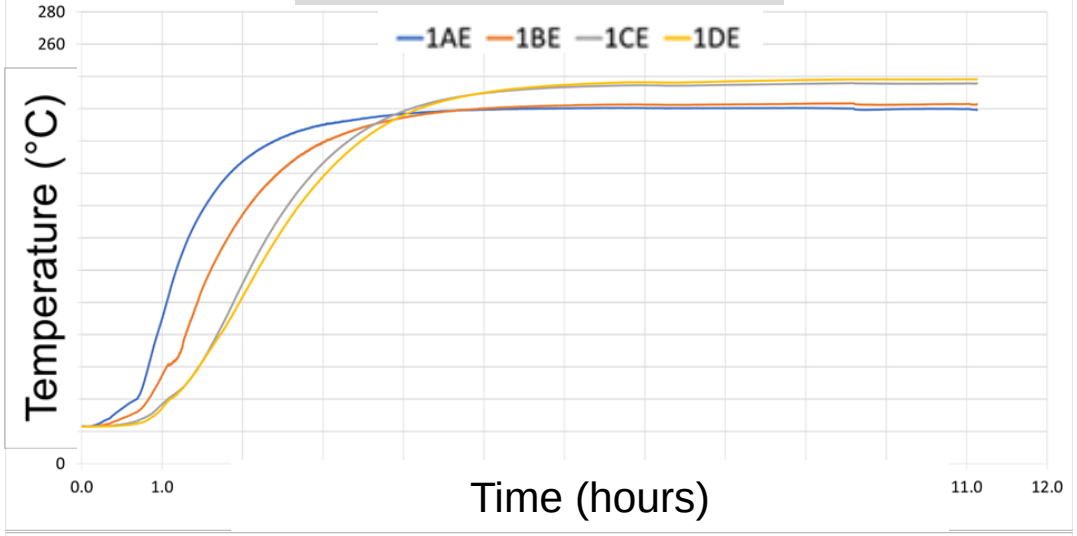


Comparison of FHD and Model – Thermal

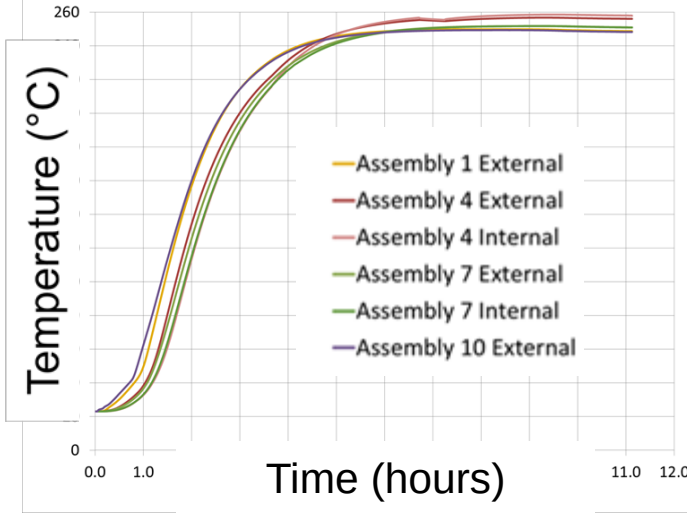
FHD Test 7 Assembly Averages



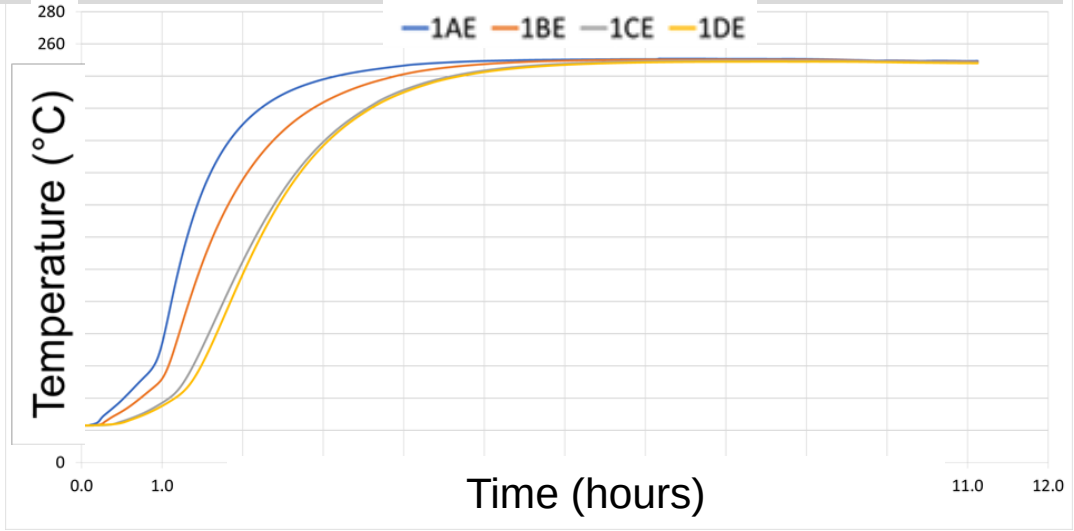
FHD Test 7 Assembly 1



FHD Model, 239°C Inlet, 260°C Wall

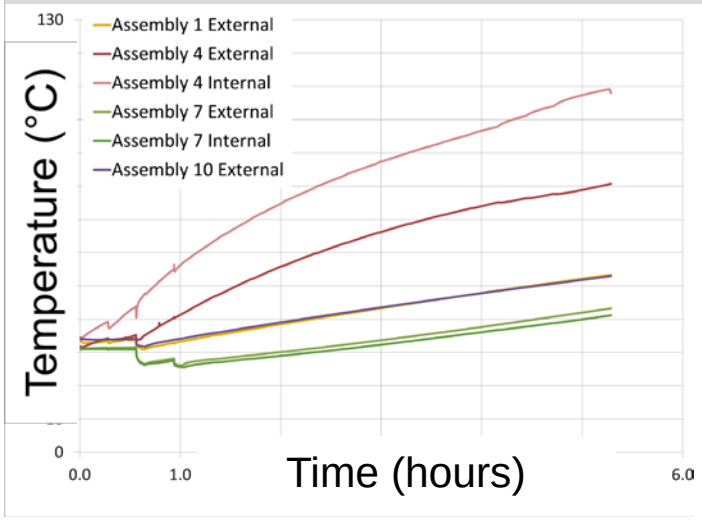


FHD Model, Assembly 1, 239°C Inlet, 260°C Wall

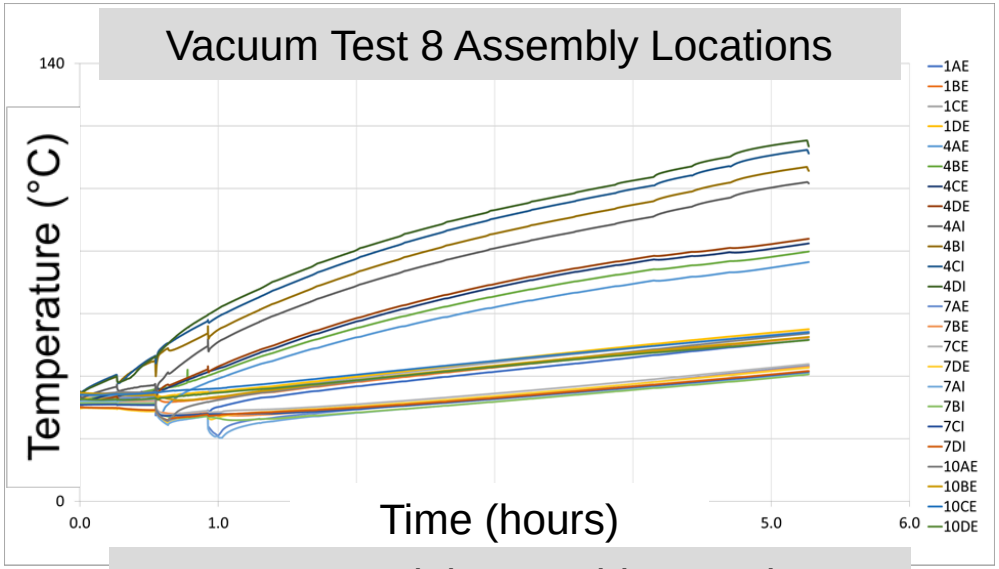


Comparison of Vacuum Drying & Model – Thermal Performance

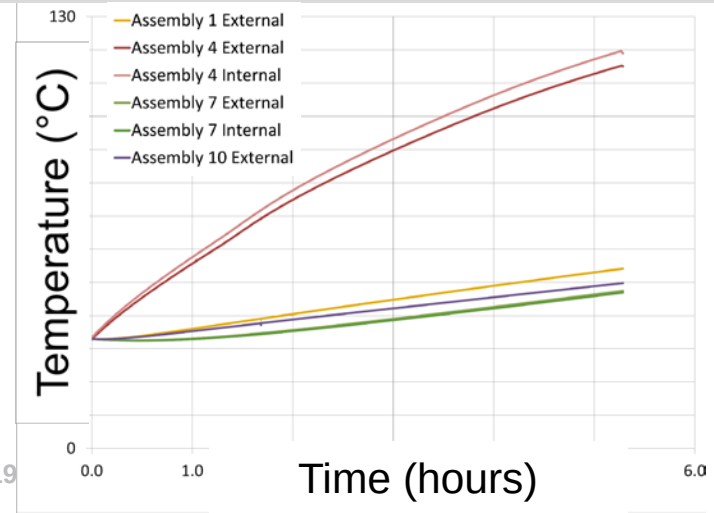
Vacuum Test 8 Assembly Averages



Vacuum Test 8 Assembly Locations



Vacuum Model Assembly Averages
15-minute holds, 100°C wall, no water tray



Vacuum Model Assembly Locations
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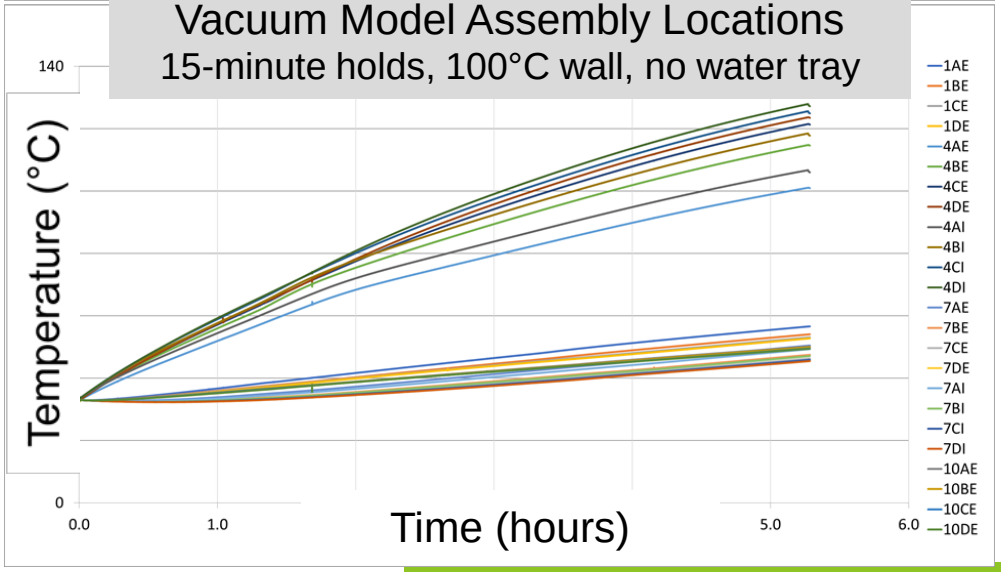
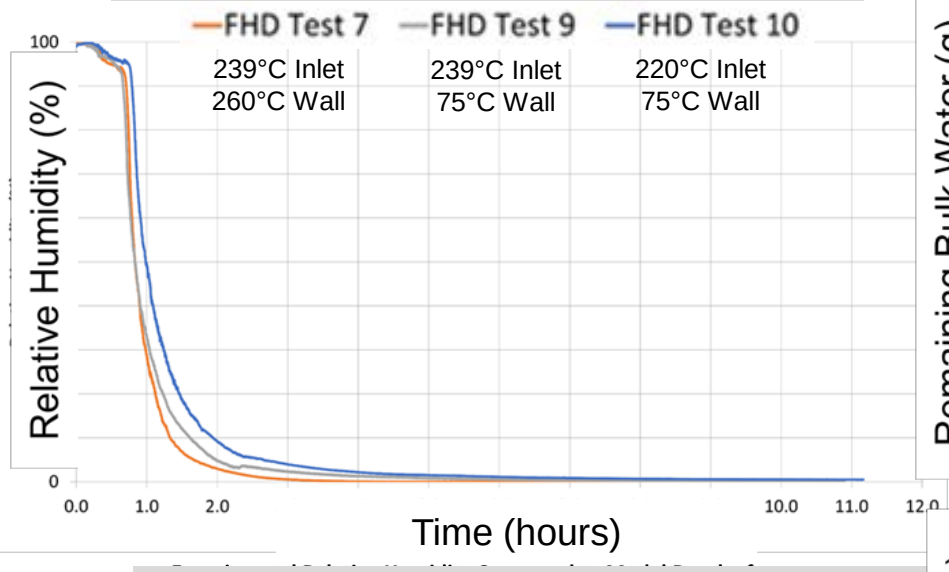
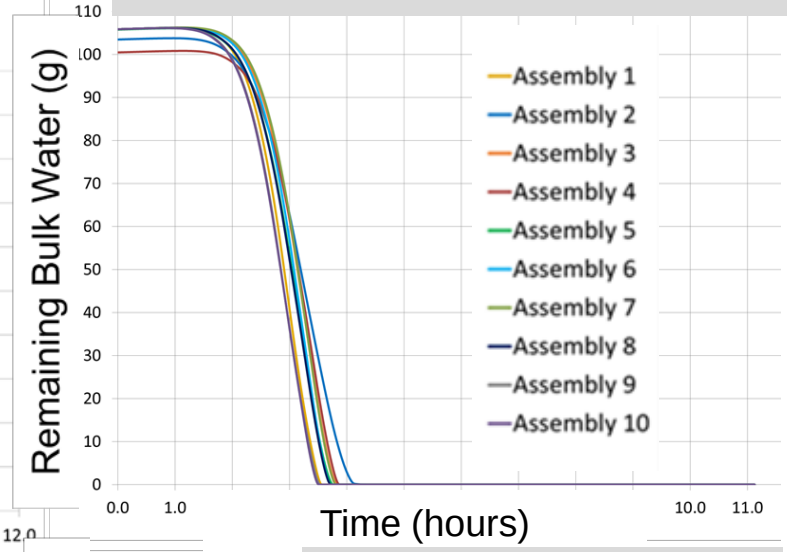


Comparison of FHD and Model – Moisture

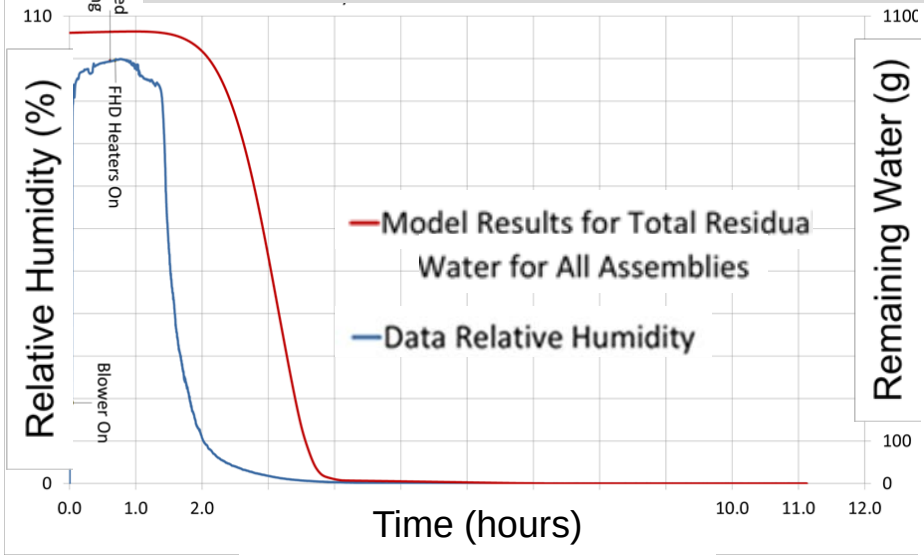
FHD Humidity with Thermal Profile



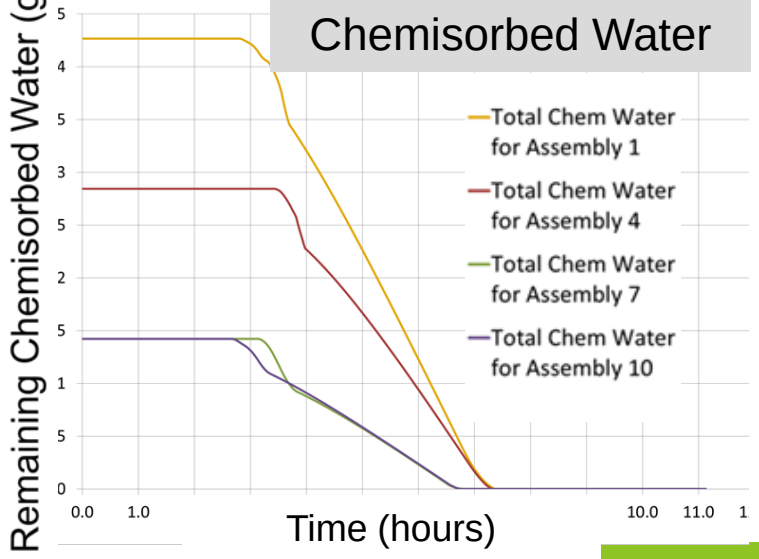
FHD Test 7 Residual Bulk Water



FHD Test 7 Data & Modeled Humidity

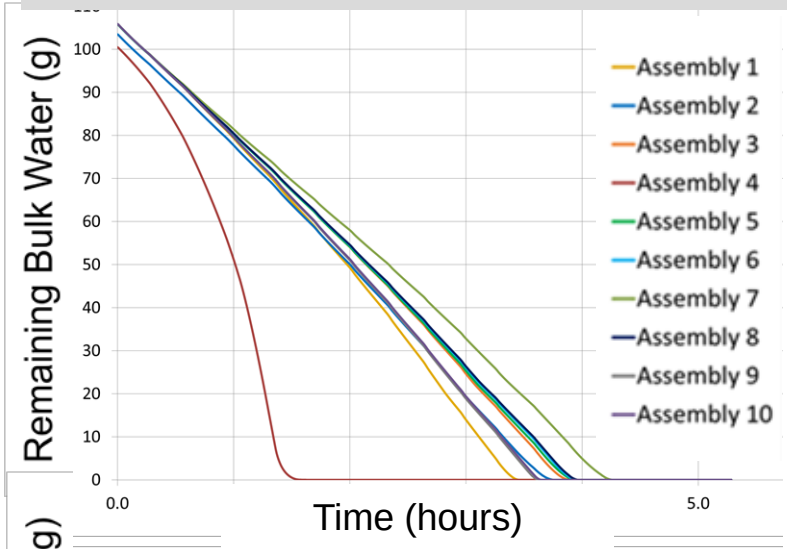


FHD Test 7 Residual Chemisorbed Water



Comparison of Vacuum Drying & Model – Moisture

Vacuum Test 8 Residual Bulk Water



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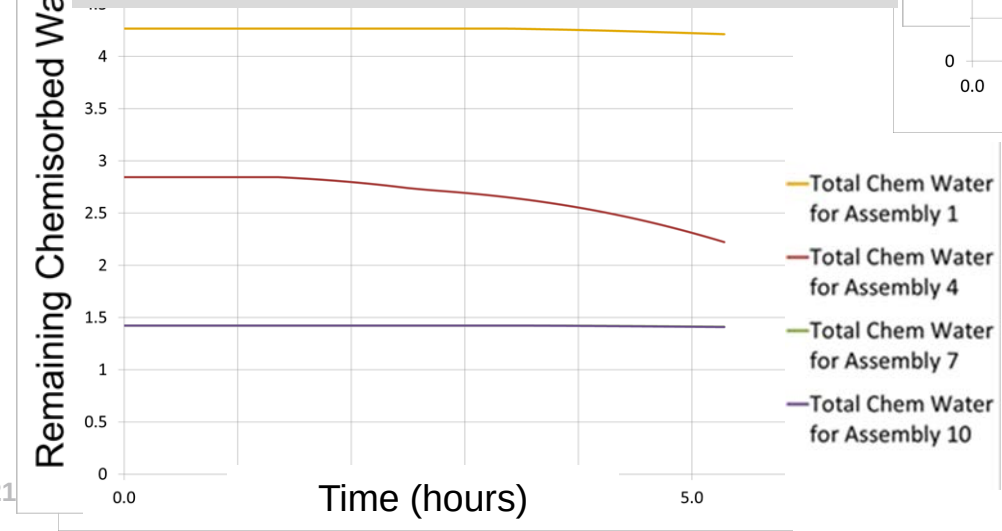

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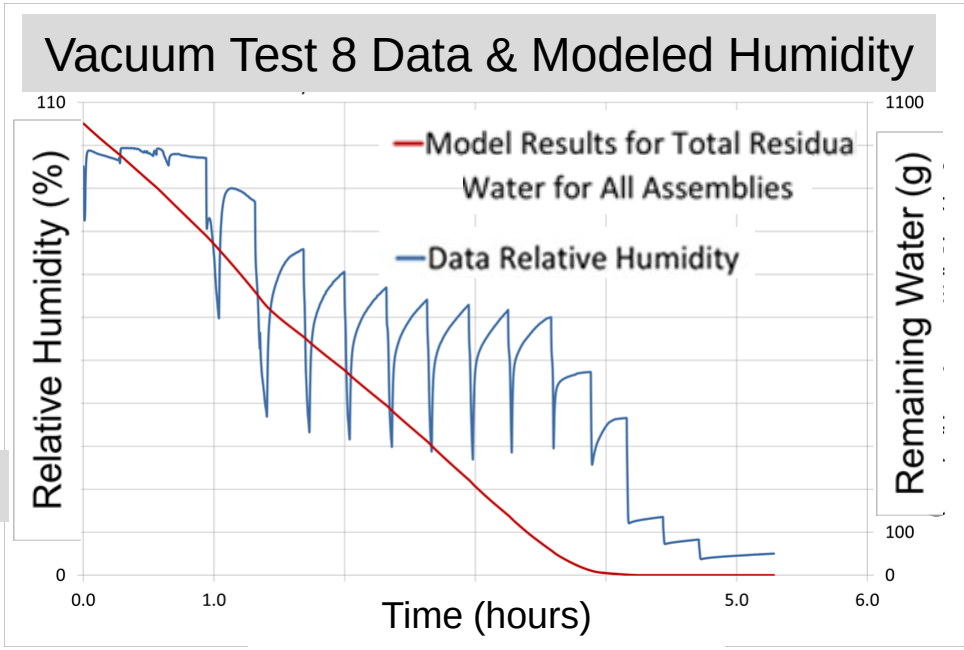
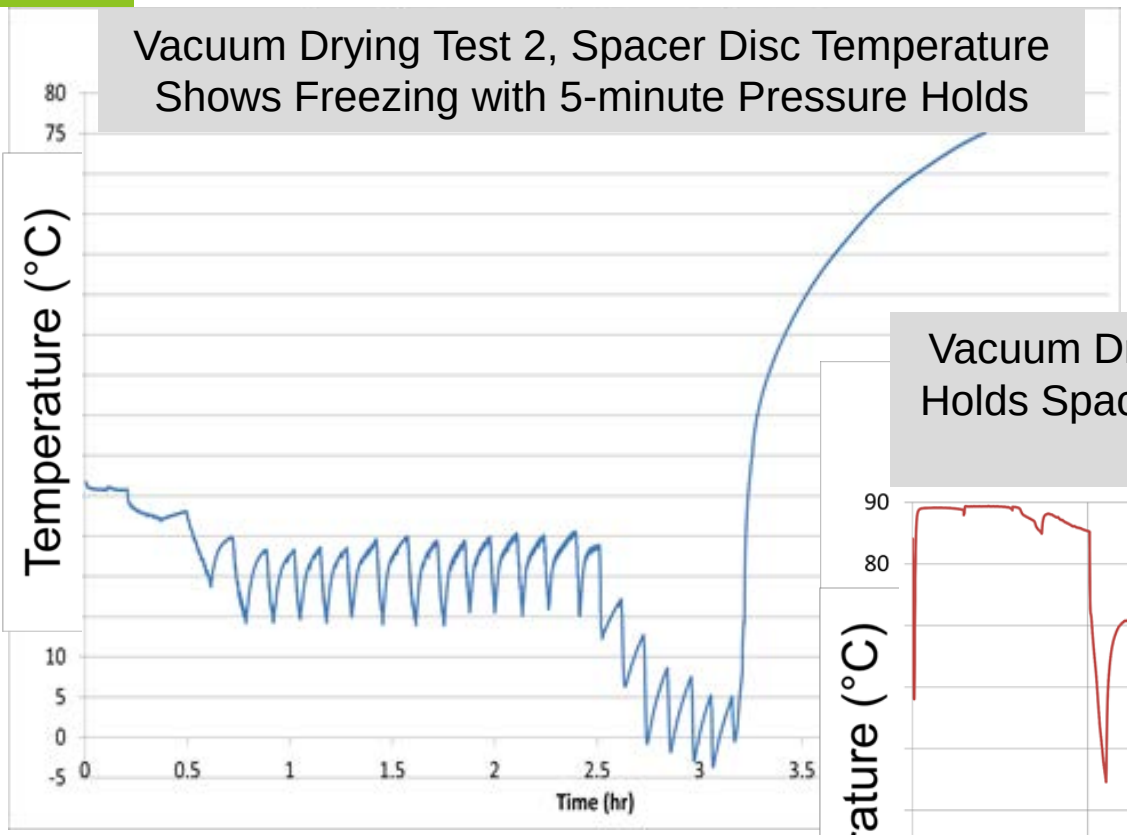
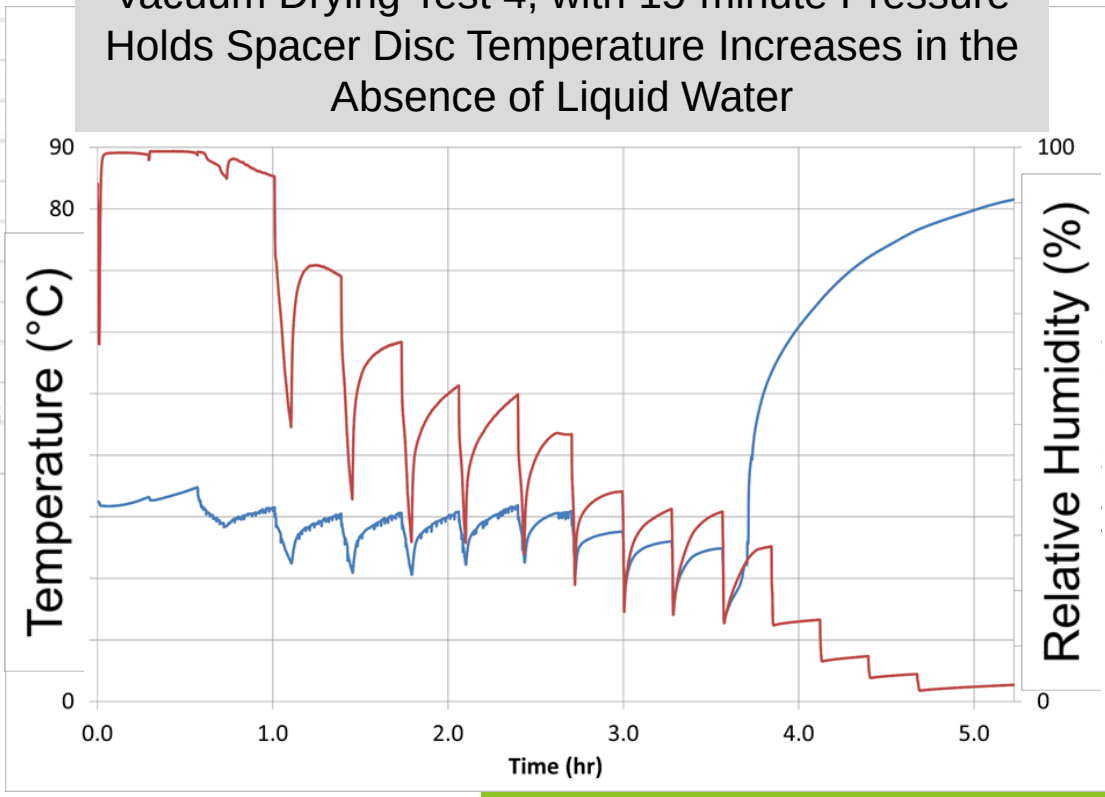


Vacuum Drying Behavior

Vacuum Drying Test 2, Spacer Disc Temperature Shows Freezing with 5-minute Pressure Holds



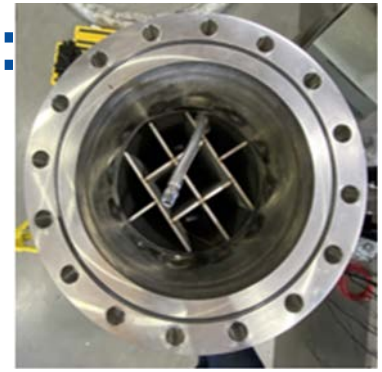
Vacuum Drying Test 4, with 15-minute Pressure Holds Spacer Disc Temperature Increases in the Absence of Liquid Water



—Spacer Disc Temperature

—Relative Humidity Inside Vessel

Engineering Scale Drying Experiment: Drying Vessel and Type 1a Basket



- Ports for instrumentation, viewing
- Basket false bottom to promote mass transfer