Contract No:

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Disclaimer:

SR19007 – Future TCAP Implementation Issues

Facility Need

Thermal Cycling Absorption Process (TCAP) is the cornerstone of tritium processing at Savannah River Site. The prototype Plant-Configured Mini-TCAP developed at SRNL would reduce footprint and increase energy efficiency significantly compared to the currently used systems. However, questions remained regarding the use of zeolites in tritium processing and their ability to irreversibly adsorb ammonia impurities present in tritium processing lines. This project aimed to resolve the issue by investigating a guard bed for ammonia capture and investigating the fate of ammonia if/when it enters the TCAP system. Further questions regarding opportunities for improvement in inventory control and cycle time were also addressed by this project, along with added scope related to TCAP operation and ion chamber integration. The outcome of this project will drive insertion of Mini-TCAP technology in TEF and potentially future TCAP column replacements in the facility while maintaining SRNL/SRTE as a world leader in hydrogen isotope separations.

Potential Benefits

- ☑ Cost Reduction
- ☑ Defect Reduction
- ☑ Error Reduction
- ☑ Mission Diversification
- ☑ Mission Viability
- ☑ Obsolescence Solution
- ☑ Process Optimization
- ☑ Safety

Project Summary

This project demonstrates the success of the PDRD program in bringing a concept from the R&D phase to direct plant funding. Although Mini-TCAP technology is overall at a TRL of ~6.5, the specific questions addressed in this project were brought from a low (2-3 TRL) to a TRL 5 over the course of the project. This project successfully completed all initial goals ahead of schedule (inventory control, guard bed, ammonia impact, and cycle time) and furthermore addressed additional scope (continued TCAP evaluation, ion chamber) in FY20.

SR19007

Status

Started in FY19, Move to direct funding in FY20

Technology Readiness Level

Start of FY19:	3
End-of-FY20 Forecast:	5
End-of-FY20 Actual:	5

Financial

FY20 Project Cost:	$357,059
Cumulative Total Project Cost:	$574,312
FY20 Authorized Amount:	$357,059

Credits

Principal Investigator:	Thompson
Facility Engineering Co-Lead:	Foster, Trotter
Contributor:	Randall, Xiao

First, this project resolved minor inventory control issues by introducing a new parameter tracking and correcting for inventory changes over multiple cycles. This project also involved modification of the previously constructed plant-configured Mini-TCAP in order to allow ammonia impurity studies. TCAP was tested with ammonia in the feed stream both with and without a guard bed present to determine guard bed efficacy and the effect of ammonia if it enters TCAP. The TCAP columns were then replaced with brazed columns, where the LN_2 cooling coil is brazed to the column and the column is self-brazed along the coils. This drastically improved heat transfer and consequently reduced cycle time compared to the previous columns, in which the coils were mechanically held in place. Finally, additional scopes were taken on in FY20, including evaluation of TCAP with faster cycle time and procurement of ion chambers for future TCAP integration.

Milestones/Findings/Accomplishments

Project Milestone	Expected End	Actual End
Resolve inventory control issue	12/31/19	12/31/19
Ammonia guard bed testing	7/31/20	7/31/20
Cycle time reduction with brazed columns	7/31/20	7/31/20
Submit year-end report/project summary	8/31/20	8/31/20
Continue TCAP evaluation throughout the year	9/30/20	7/30/20
Acquire Ion chambers for TCAP integration	9/30/20	9/10/20

Inventory control issues were resolved this year by monitoring the performance of TCAP with a modified code that was introduced in FY19. The modified code contains a parameter, Accumulated Inventory Change (AIC), which tracks inventory changes over multiple cycles and corrects for a minor pressure overshoot issue. The pressure overshoot is a limitation of the control system due to a time lag between the command to actuate a valve and the valve physically actuating. The AIC tracks small inventory "errors" introduced from this limitation and adds them to the next cycle to correct for the inventory change. As shown in Figure 1, the improved TCAP inventory control system holds inventory constant over many cycles.

For ammonia testing, a small bed of 4A molecular sieves was tested for ammonia capture and the functionality of TCAP was confirmed with the guard bed present. Even with the amount of ammonia tested here, which was likely in excess of the amount of ammonia present in the tritium facility lines, the guard bed captured all incoming ammonia and, as expected, had no impact on TCAP operation. Breakthrough experiments were performed in order to determine ammonia capacity, but the capacity was higher than expected and ammonia was never observed in the guard bed effluent. Based on these results, a small 1-L guard bed at ambient temperature would protect a TCAP column from ammonia contamination for at least 100 years, given current throughput rates and estimates of ammonia concentration.

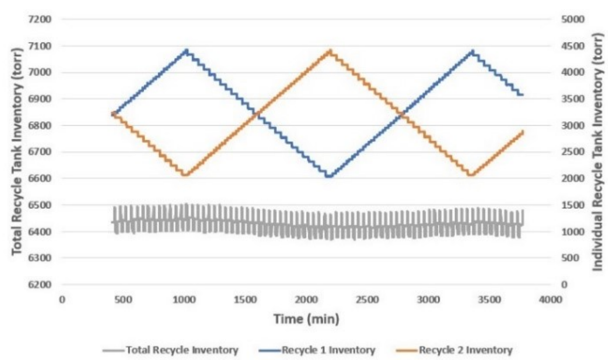

Figure 1. Pressure plot of recycle tanks showing cycling stability and constant inventory

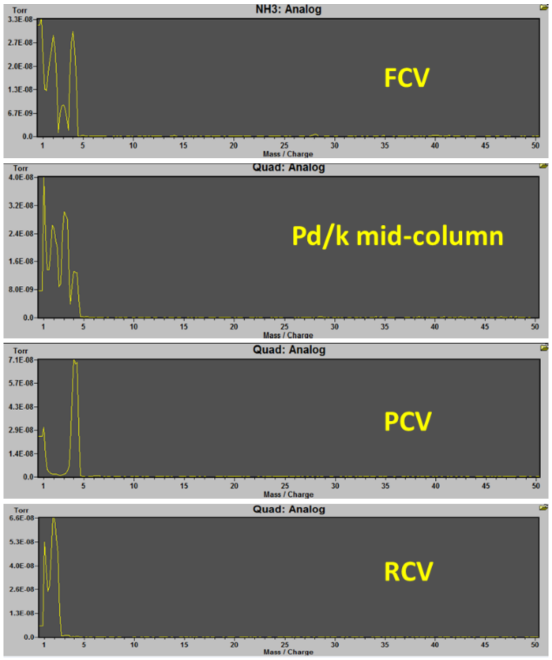

Figure 2. Residual gas analysis of the FCV, PCV, RCV, and Pd/k mid-column showed no ammonia present during guard bed testing

To determine the performance of TCAP in the presence of ammonia, experiments were performed without the guard bed. After injection of ammonia into the Pd/k mid-column, it was initially liquefied due to the low temperature in the column. In the follow sequence of the cycle, a small amount of ammonia was observed in both the mid column and the product side. After several cycles, however, ammonia accumulated on the product side. Based on these results, ammonia is not expected to travel to the molecular sieve column during normal operation. Even if ammonia diffused to the MS column, it would most likely condense in the cooled column fittings. TCAP performance was not significantly affected by the presence of ammonia, except that it accumulated on the product side and may need to be removed periodically. Isotopic purity was maintained during ammonia testing and no changes to column capacities were observed.

The use of column brazing for enhanced heat transfer was evaluated in this project. New columns contained inter-column brazing between the TCAP coil and the LN_2 coil, as well as intra-column brazing of each coil to itself along the curved interface. This resulted in drastically enhanced heat transfer, reducing the cycle time by 45 min and potentially improving throughput by as much as a factor of 2.

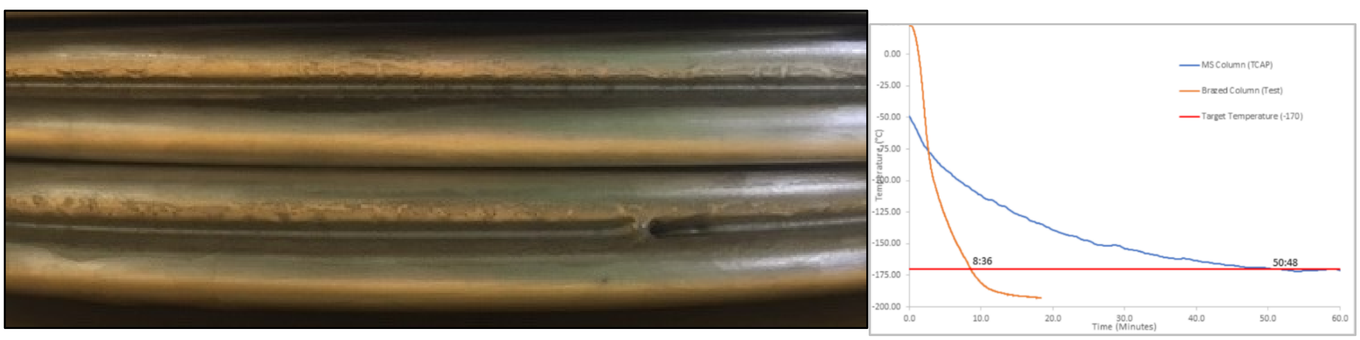

Figure 3. New brazed TCAP columns (left) vastly improved heat transfer (right), reducing total online cycle time from 90 minutes to 45 minutes

Finally, TCAP was successfully operated throughout the year to demonstrate stability after integration of the new inventory control system and the new brazed columns, and ion chambers were procured for future evaluation and integration to TCAP.

Future Work

- Parameter study to optimize cycle time
- Install ion chambers in plant-configured mini-TCAP
- Verify long-term stability of TCAP components with rapid cycle time
- Verify the performance of new thermocouple type on TCAP operation