RESEARCH & DEVELOPMENT

Electrostatic Precipitation System for Radionuclide Particle Collection

DOE DNN R&D SBIR

June 15, 2019

Michael Swanwick (swanwick@creare.com) Patrick Magari

SBIR/STTR Rights Notice (JAN 2015)

These SBIR/STTR data are furnished with SBIR/STTR rights under Award No. DE-SC0015731. Unless the Government obtains permission from the Recipient otherwise, the Government will protect SBIR/STTR data from non-governmental use and from disclosure outside the Government, except for purposes of review, for a period starting at the receipt of the SBIR/STTR data and ending after 4 years, unless extended in accordance with 48 CFR 27.409(h), from the delivery of the last technical deliverable under this award. In order for SBIR/STTR data to be extended by an SBIR/STTR Phase III award, the Recipient must properly notify DOE's Office of Scientific and Technical Information (OSTI) before the end of the previous protection period. After the protection period, the Government has a paid-up license to use, and to authorize others to use on its behalf, these data for Government purposes, but is relieved of all disclosure prohibitions and assumes no liability for unauthorized use of these data by third parties. This notice shall be affixed to any reproductions of these data, in whole or in part.

DISCLAIMER

This report was prepared by Creare LLC for the Department of Energy. Neither Creare, nor any person acting on its behalf, makes any warranty or representation, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of the information, apparatus, method or process disclosed in this report. Nor is any representation made that the use of the information, apparatus, method or process disclosed in this report may not infringe privately-owned rights.

Creare assumes no liability with respect to the use of, or for damages resulting from the use of, any information, apparatus, method or process disclosed in this report.

Acknowledgment

This material is based upon work supported by the U.S. Department of Energy, Office of Science, under Award Number DE-SC0015731.

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof."



About Creare

Creare's Mission

- Creare means "to create"
- Creare engineers create value by:
 - Helping our clients solve their most difficult problems
 - Developing innovative new technologies
 - Applying new technologies to clients' products, systems, and processes
 - Commercializing new technologies and developing new products

Core Expertise

- Thermal & Fluid Engineering
- Technology Innovation
- Cryogenics and Power Systems
- Innovative Fabrication and Manufacturing





Our People

- Diverse technical expertise
- Over 70 engineers including mechanical, electrical, materials, aerospace, and software
- Highly skilled technicians, machinists, and designers

Customers

- Federal: DOE, Navy, Air Force, Army, DTRA, NASA, and NIH
- Commercial: Large and small businesses, both domestic and international



Creare Capabilities

Our Facilities

- 60,000 sq. ft. office/laboratory/shop, plus 20,000 sq. ft. shared with affiliate
- Capabilities range from micromachining to running large outdoor experiments
- Wide range of in-house fabrication facilities include precision machining, laser welding, vacuum brazing, EDM, and thin-film deposition
- Electronics lab, clean room, environmental chambers, inspection lab, thermal vacuum systems
- Established Record of Technology Transition
 - Hubble Space Telescope Cryocooler
 - Mars Curiosity Rover Miniature Vacuum Pumps
 - Compact Swaging Machine for Aircraft Carriers
 - Multiple Spin-off Companies and Technology Licenses





Miniature Vacuum Pumps on Mars Curiosity Rover



NICMOS Cryocooler System on Hubble Space Telescope



Cryogenic Machining



Compact Swaging Machine



Technology Licensing



AEROVECTR

Part of Over \$1B in Commercialization Revenue From Creare SBIR Projects







- Anti-Corrosion Coverings
 - Shield Technologies Corporation
- Machine Tool Cooling Systems
 - MAG Industrial Automation
- Aerosol Drug Delivery Devices
 - AerovectRx Corporation
 - NASA/NIH funding
- MorTorq[®] Threaded Fasteners
 - Phillips Screw Company
 - Used for Space Shuttle viewports, advanced gas turbine engines



Proprietary Information September 2017 MTG-18-12-6789A/1008113-5

International Monitoring System Radionuclide Stations

- Each station includes Radionuclide Particulate Monitoring
- Existing system is the Radionuclide Aerosol Sampler/Analyzer (RASA)
- Samples captured in a filter-paper collector over 24-hour sample period (batch process)
- Decay of fission isotopes are measured with gamma-ray spectrometry: provides positive proof of nuclear detonation
- Samples are archived for physical analysis if desired

Challenges for Current Systems

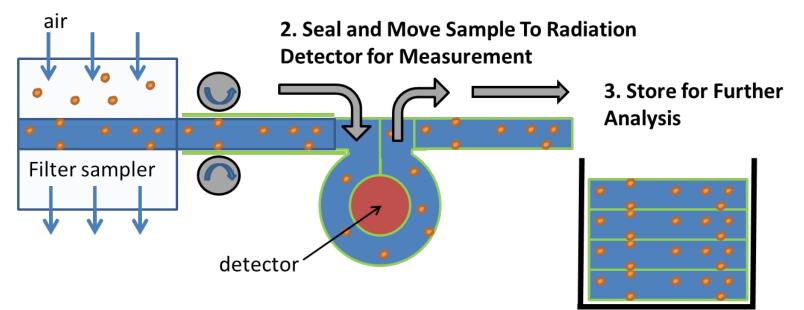
- Power Consumption
 - Some sites are limited in power access
 - Filter based approach requires high blower power due to large ΔP across filter
- Sensitivity
 - Blower power limits air flow rate and total sample quantity
 - Creating more compact samples will increase detection sensitivity
 - Environments with high background radiation limit detection
 – some locations operate barely above minimum detection sensitivity due to limited sample collection



Radionuclide Monitoring Station Locations- 63/80 certified. https://www.ctbto.org/map/

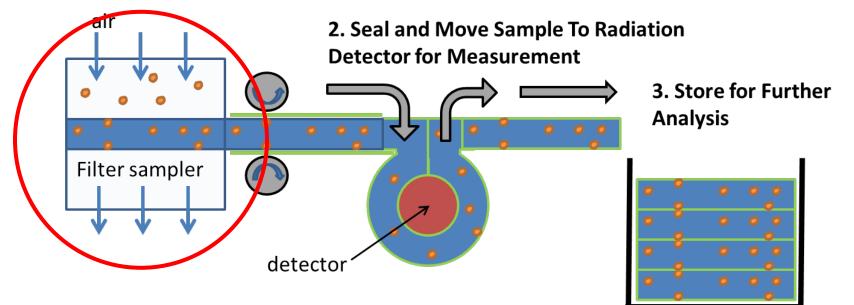


- Improvements Needed to Existing System:
 - Reduce Power (Existing System Uses 3 hp Blower)
 - Capture More Particles (Increase Detection Sensitivity)
 - Reduce Sample Size (Increase Detection Sensitivity)
 - Minimize Sample Cross-Contamination
 - **1. Capture Airborne Particles**



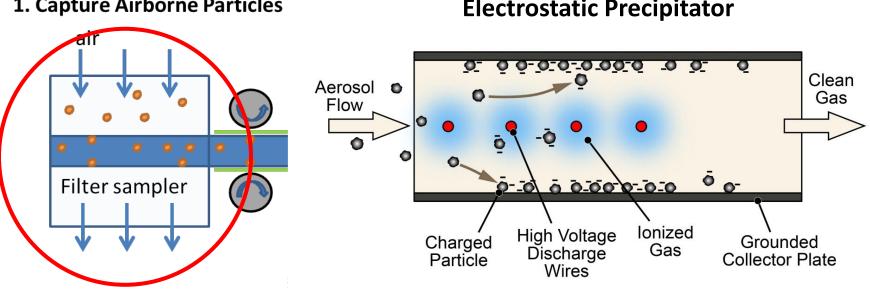


- Improvements Needed to Existing System:
 - Reduce Power (Existing System Uses 3 hp Blower)
 - Capture More Particles (Increase Detection Sensitivity)
 - Reduce Sample Size (Increase Detection Sensitivity)
 - Minimize Sample Cross-Contamination
 - **1. Capture Airborne Particles**





- Improvements Needed to Existing System:
 - Reduce Power (Existing System Uses 3 hp Blower)
 - **Capture More Particles (Increase Detection Sensitivity)**
 - **Reduce Sample Size (Increase Detection Sensitivity)**
 - **Minimize Sample Cross-Contamination**

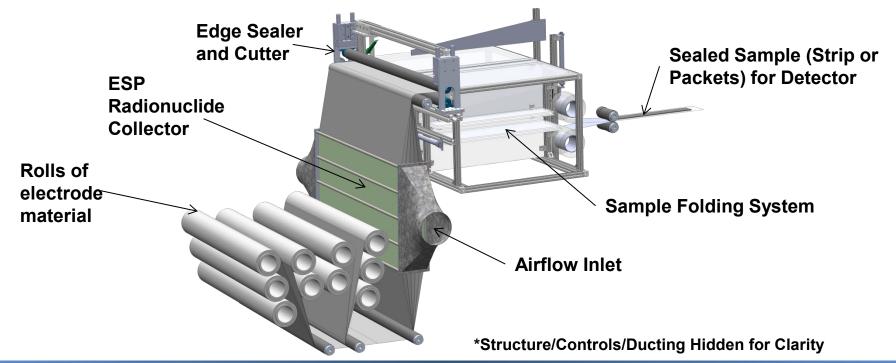


1. Capture Airborne Particles

Electrostatic Precipitator

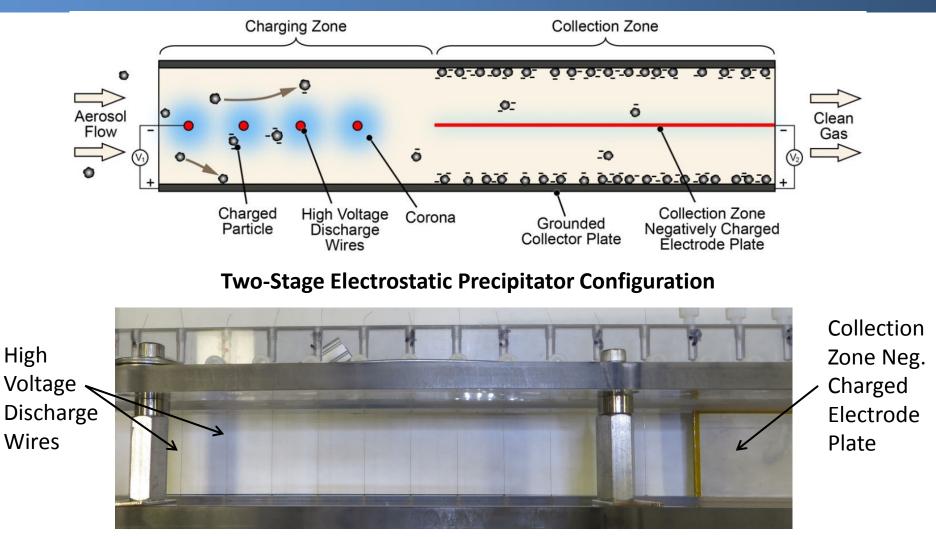


- Creare's Radionuclide Sampling System*:
 - Flexible Electrode Sheets Collect Particles in ESP
 - Roll-to-Roll Process Seals and Folds Sheets and Presents to Detector
 - Enables up to 10x Power Reduction
 - Increase in Instrument Sensitivity through 2x–3x More Sample Mass Collection and Smaller Sample Sizes
 - Flexible Design Configuration Allows Modification for Different Mission Requirements





Electrostatic Precipitation



ESP systems can achieve very high collection efficiencies (>99.5%) across a wide range of particle sizes: 30 nm to >100 μ m



MTG-18-12-6789A/1008113-11

Phase II Progress: Subscale Testing

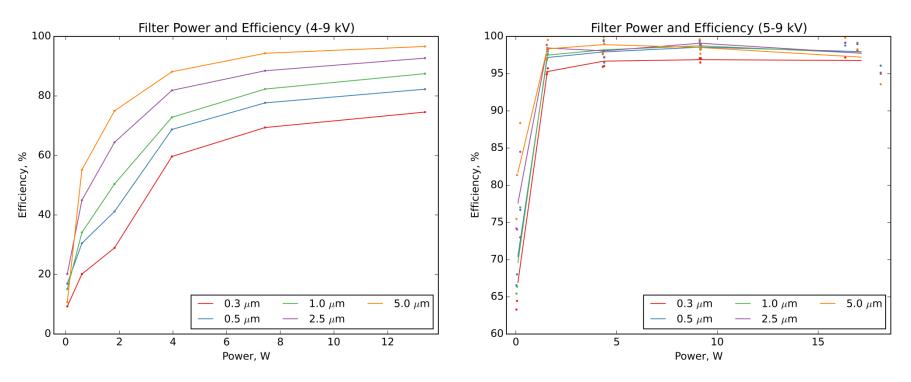
- Goals:
 - Obtain additional data for optimization of ESP performance
 - Determine long-term stability of ESP operation and sampling medium (ensure 24-hour sample time)
- Recent Work:
 - Finalized the charging wire configuration
 - Implemented two-stage configuration to increase particle collection efficiency while reducing ESP power
 - Finalized ESP channel geometry for full-scale prototype



Phase II Progress: Subscale Testing

4-Wire Configuration

12-Wire, Two-Stage Configuration

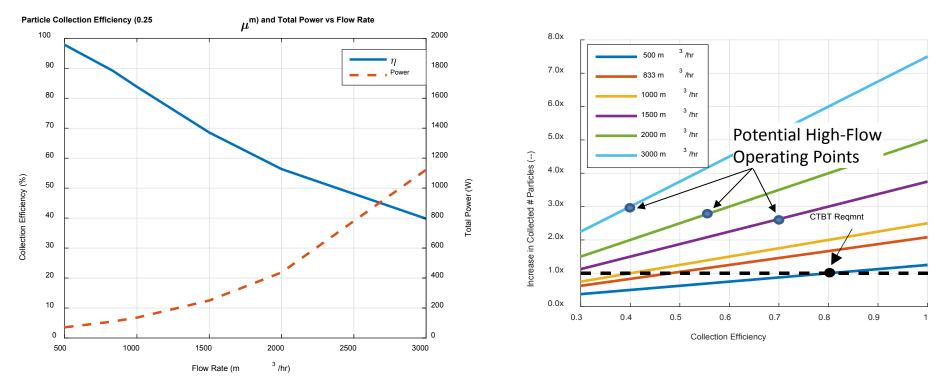


- Significant improvement in particle collection efficiency for a given power
- Results have informed the full-scale sizing and operating parameters
- Subscale experimental results showing better collection performance than model predictions



Phase II Progress: Full-Scale Performance Prediction

- Updated design model to include two-stage ESP configuration
- General trends useful for full-scale design:
 - Can achieve high collection efficiency at lower voltages on charging wires
 - Low overall predicted system power consumption (5x–10x less power than RASA system)

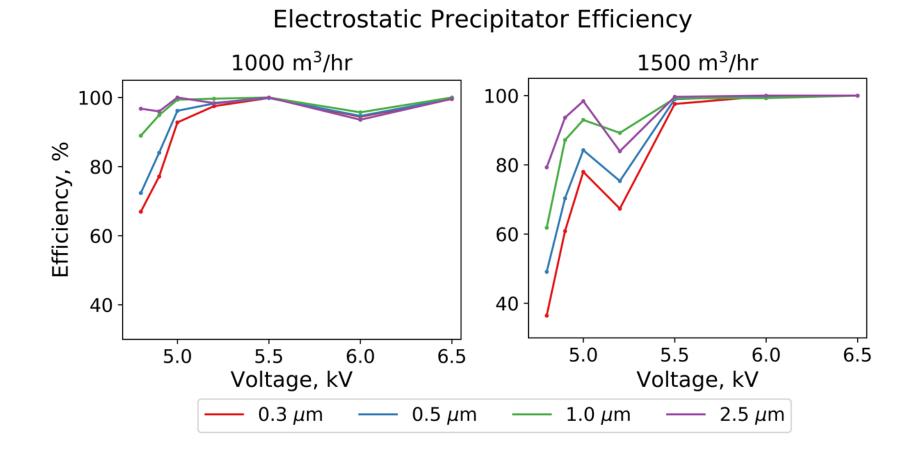


 At higher flow rates, even if η drops to 50%–60%, still achieves significant gains in overall collected sample quantity: increase in sensitivity



Phase II Progress: Full-Scale Experimental Results

Initial Results from Full-Scale Prototype System



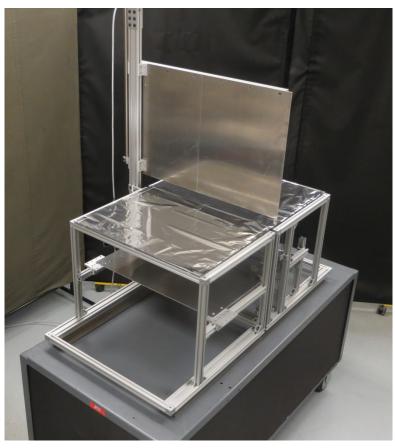


Copyright © 2019 Creare LLC An unpublished work. All rights reserved.

Phase II Progress: Sample Handling System

• Goals:

- To seal and fold sample, integrate with detector, and spool to storage
- Folding system must reduce sheets to strip <10 cm wide x 40 cm long (RASA Sample Size)
- Recent Progress: Discrete Folding
 - Cutting into discrete sample sections
 - Successive multiple folds of the sheet length to achieve <u>~5.6 cm x 40 cm strip</u>
 - Adhesive seal samples to produce continuous web to wrap around the detector
 - Option to add additional folds to make a ~<u>5.6 cm x 5 cm x 2 cm puck</u> for alternative detector interface





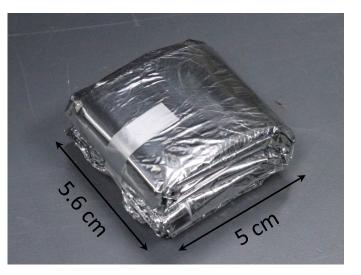
Phase II Progress: Sample Handling System





Multiple Fold System Produces 5.6 cm x 40 cm Strip

Extra Folds Produce 5.6 cm x 5 cm x ~2cm tall puck





Copyright © 2019 Creare LLC An unpublished work. All rights reserved.

Status Summary

- Subscale Test Results Demonstrating High ESP Performance
 - Performed Sweeps of Critical Operating Parameters
 - Answered Key Questions for Full-Scale Design
 - Demonstrated Two-Stage Configuration Maximizes Performance
 - Expect to exceed RASA particle collection for less power
- Discrete-Sample Folding System
 - Working Full-Scale Prototype
 - Flexible design offers options for final sample (strip or packet)
 - Enables smaller samples than existing RASA, leading to gains in instrument sensitivity
- Full-Scale Prototype Design Almost Complete
 - System can be optimized in future effort to minimize footprint
 - Key Mechanical, Electrical, and Flow Control Design Elements are Complete
 - Fabrication of Full-Scale Prototype Beginning in Feb



System Benefits

- Increased Sensitivity compared to the RASA system
 - Smaller sample presented to the detector including sample height and thickness (potential ~1.3x improvement in detector efficiency)
 - Option for a puck design to be place on top of detector (~2x improvement)
- Options for Interfacing with next generation detectors
- Flexible design for changing particle collection based on conditions
 - Reduce the particle collection efficiency and increase the flow rate to collect more overall particles
 - Change collection efficiency if an 'event' occurs
 - Increase ESP power or flow rate to shorten sample times during events
- More Power Efficient for a given particle collection efficiency
 - Advantageous for remote locations



Phase II Plan: Next Steps/Schedule

- Complete sample handling (Jan 2019)
 - Demonstrate integrated sample handling system (sealing, cutting, folding)
 - Pneumatic operation for each fold
 - Drive roller/conveyor integration of folder with ESP particle collector
- Complete Full-Scale Integrated Prototype Design (Jan 2019)
 - Detailed design of ESP assembly currently in-progress and near completion
- Build and Test (Feb–June 2019)
 - Demonstrate full-scale ESP performance for varying flow rates, particles, conditions (i.e., humidity)
 - Demonstrate collection efficiency
 - Demonstrate sample handling
 - Goal to collect 24-hour atmospheric sample to send to PNNL for analysis with detector



Post Phase II

- Phase II will end with end-to-end prototype and performance demonstration
 - 80/20 Aluminum Frames, Non-Optimized System Packaging for Low Footprint
 - Uses Laboratory-Level Power Supplies, Data Acquisition, and Control, etc.
- Future Next Steps:
 - Fieldable Version:
 - Increase robustness of mechanical system
 - Optimize footprint/configuration
 - Incorporate controls and remote operation features
 - Longer Term Testing
 - Integration with a Detector



Questions/Discussion



MTG-18-12-6789A/1008113-22