Contract No:

This document was prepared in conjunction with work accomplished under Contract No. 89303321CEM000080 with the U.S. Department of Energy (DOE) Office of Environmental Management (EM).

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Development of Electrostatic Precipitator (ESP) Technology to Remove Elemental Mercury Vapor, Hg(0)

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June 2022

SRNL-STI-2022-00313, Revision 0

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Prepared for
U.S. Department of Energy

SRNL-STI-2022-00313
Revision 0

Keywords: *Mercury Removal, Electrostatic Precipitator*

Retention: *Varies*

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Savannah River National Laboratory is operated by Battelle Savannah River Alliance for the U.S. Department of Energy under Contract No. 89303321CEM000080.

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PREFACE OR ACKNOWLEDGEMENTS

The senior author would like to thank Dr. Brian B. Looney for his technical and logistic support of this project. In addition, the authors would like to thank Dr. Joseph Manna, Dr. Alex Cozzi, and Dr. John Mayer for their support and coordination during this project. This work was funded by Work Authorization Number EPMTASK1-2021 from the U. S. Department of Energy Oak Ridge Office of Environmental Management to the Savannah River National Laboratory.

EXECUTIVE SUMMARY

The presence of mercury vapor or other forms of mercury presents issues with worker safety, decommissioning facilities, and environmental impacts. As such, it is desired to develop a strategy to either remove or reduce mercury levels in Oak Ridge's Y-12 Complex facilities. A testing methodology was developed to evaluate electrostatic precipitator technology for removal of mercury vapor. This methodology involved supplying mercury vapor-containing air to the ESP device by flowing air through a column containing alternating layers of sand and liquid mercury droplets. Initial attempts at quantifying the efficacy of the ESP device in removing mercury vapor were plagued with difficulties in controlling the flow of mercury into the ESP device due to poor performance of the generator column and the contamination of these experiments with mercury from an unknown source. These issues were resolved by creating a new generator column with slower air velocity and higher surface area of liquid mercury, along with moving the air intake for the ESP device to outside of the chemical hood in which testing took place. This resulted in a steady, quantified flow of mercury vapor from the generator column and no observation of unintended mercury sources. A final test of the ESP device under these controlled conditions showed that for a certain amount of time (on the order of 20 – 30 minutes) mercury concentrations were reduced by approximately 33 – 67% of the inlet concentration. However, episodic releases or pulses of mercury observed only at the outlet indicated that the mercury accumulated in the ESP device is periodically expelled. As a result, it was not deemed to be an efficient strategy for the removal of elemental mercury vapor.

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LIST OF ABBREVIATIONS

cfm	Cubic Feet per Minute
DMA	Direct Mercury Analyzer
ESP	Electrostatic Precipitator
NEPA	National Environmental Policy Act
PSI	Pounds per Square Inch
R&D	Research and Development
SRNL	Savannah River National Laboratory
std L/min	Standard Liters per Minute

1.0 Introduction

Mercury presents many issues to human health including toxicity affecting the respiratory, reproductive, and central nervous systems [1]. Additionally, unintended releases of mercury into the environment can be detrimental to many other lifeforms, in particular aquatic species. At Oak Ridge, several buildings at the Y-12 National Security Complex have had significant amounts of elemental mercury spilled during their operational history, including as much as 200,000 kg in Building Alpha 5 alone. In addition to presenting health risks, this contamination impedes transition to decommissioning activities and restricts access for personnel. Within these facilities, elemental mercury is likely present as vapor and in the form of particle-bound mercury in fine particulates. It is necessary to reduce mercury levels to reduce worker risk and allow for effective and efficient remediation of these facilities.

Savannah River National Laboratory (SRNL) has 25 years of experience using electrostatic precipitator (ESP) technology across a wide array of applications. Multiple publications have shown that ESP technology can be used to collect mercury vapor under certain conditions, and the conditions in the ESP can modify the chemical speciation and redox state of mercury [2,3]. ESP technology has also been shown to be effective in removing particle-bound mercury as well [4]. Electrostatic precipitators have also been employed to remove mercury-containing particulates from industrial smokestack emissions.

Considering these applications of ESP technology utilized to remove various forms of mercury, SRNL sought to evaluate the use of their ESP device for the removal of mercury vapor. Air containing mercury vapor from a mercury generator column was flowed through the ESP device while air sampling was conducted at the inlet (prior to treatment) and outlet (after treatment) ports. Efficacy of the ESP device for the removal of mercury vapor was based on the reduction in mercury concentration of the air stream as sampled before and after treatment by the ESP device.

2.0 Experimental Procedure

2.1 Experimental Design

Evaluation of the efficacy of using ESP technology for the removal of mercury vapor was conducted by flowing air containing mercury (Hg^0) vapor through the ESP device and using sampling ports installed at the inlet (prior to entering the ESP device) and outlet (after treatment by the ESP device) to obtain representative air samples. A schematic of the ESP test setup and an image of the actual test setup are presented in Figures 2-1 and 2-2, respectively.

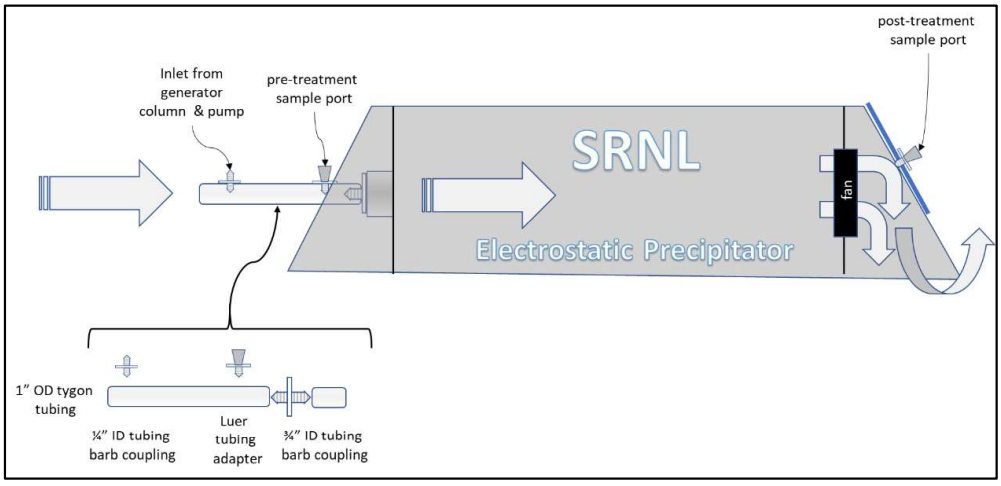

Figure 2-1. Schematic of ESP Test Setup Including Sampling Locations

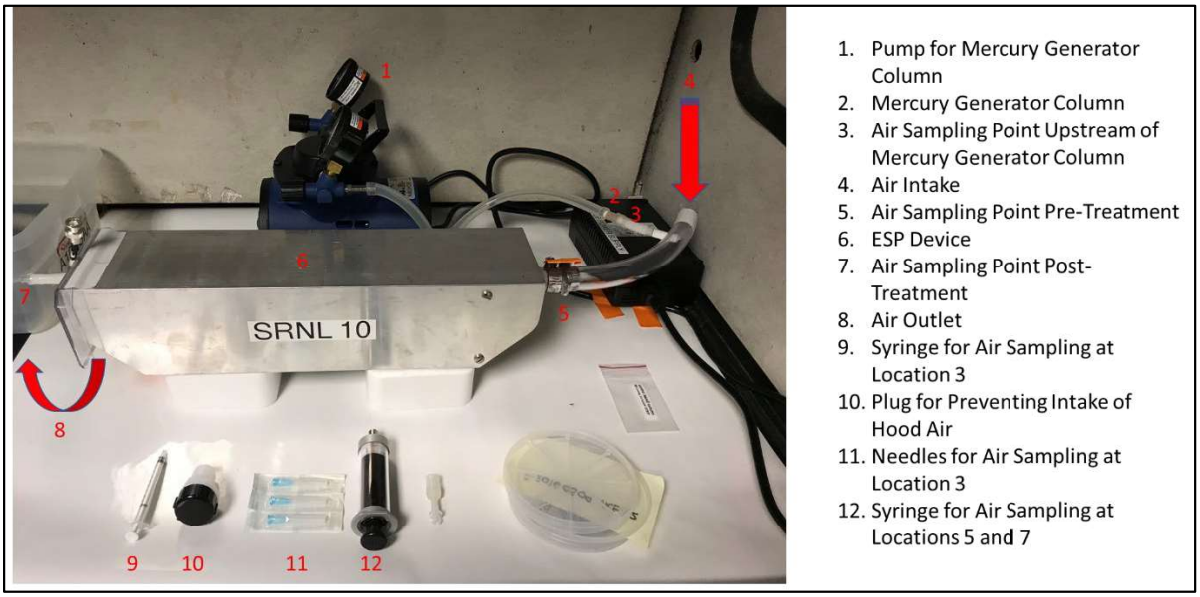

Figure 2-2. Image of ESP Test Setup with Labelling of Equipment, Sampling Locations, and Air Flow

Mercury vapor was generated by flowing air through a column containing sand and liquid mercury droplets. To create these columns, two ceramic felt disks were inserted into an 8 mm quartz column into the downstream, tapered end of the column. Clean sand was then added to the column to fill approximately 15% of the volume and packed tightly into the column using a packing tool. Two to three droplets of mercury were then added to the column, taking care to not deposit the droplets against the side of the column. This process was repeated until three layers of mercury were obtained. Sand was then added and packed into the column until 75% of the column volume had been filled. Two additional ceramic felt disks were then added on top of the sand to complete construction of the mercury generator column. In addition, a blank sand column was constructed in a similar manner, with the exception that no liquid mercury was added to this column. In subsequent experiments, a larger generator column was used. This column was produced in a similar manner to the smaller column, but used a quartz tube of approximately 2 cm in diameter and a length of 25 cm. This new column had approximated 6 cm of clean, packed sand on the outlet end, 5 layers of mercury (totaling between 0.1 and 0.2 mL of mercury) 1-2 cm of between layers, and approximately 4 cm of clean, packed sand on the inlet end. An image of this generator column is presented in Figure 2-3.

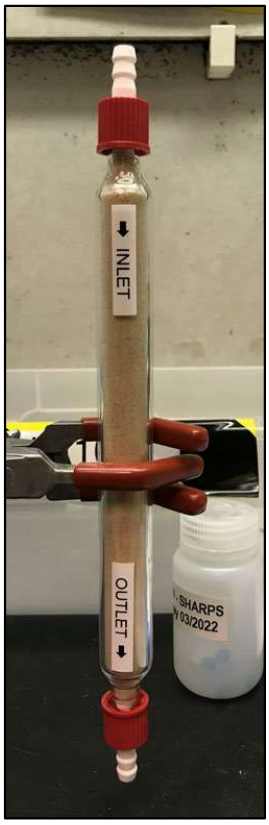

Figure 2-3. Image of Larger Diameter Mercury Generator Column

Air was pumped through the mercury generator columns at a nominal rate of 21.87 std L/min. This flow rate was confirmed for the larger diameter generator column using a flow meter – the measured flow was 20.02 L/min at a back pressure of 6 PSI. The mercury vapor-containing air from the generator column was then mixed with air from an air intake hose driven by a fan that was a part of the construction of the ESP device. This fan had a maximum air flow rate of 12.7 cfm or 360 L/min. This mixture of air from the air intake and generator column was then passed through the ESP device.

Air sampling was conducted at a number of locations to quantify the amount of mercury present in various air streams. These locations included the lab in which the experiments were conducted, the hood in which the setup was placed, directly downstream of the mercury generator column (prior to mixing with air from the air intake hose), the inlet of the ESP device (prior to treatment), and the outlet of the ESP device (following treatment). In all cases except sampling at the mercury generator column, a 30 mL syringe was used to collect air samples. In the case of the ESP inlet and outlet samples, a Luer adapter was used to interface the syringe with the tube containing the air stream, as shown in Figures 2-1 and 2-2. After collection of the air sample, the air was passed through columns containing high surface area activated carbon produced specifically for mercury sampling (Adsoquick™, Milestone Scientific, Sheldon CT) for analysis by EPA Method 7473 using a Milestone DMA80 direct mercury analyzer (DMA). To sample air from the generator columns, a smaller syringe (10 mL) with a needle was used to obtain air samples through the silicone tubing connecting the generator column to the air intake hose. Similar to the other air samples, these samples were then passed through columns containing activated carbon for analysis of their mercury concentration. The sampling and testing strategies for each test run are explained in Section 3.0.

2.2 Quality Assurance

Requirements for performing reviews of technical reports and the extent of review are established in manual E7 2.60. SRNL documents the extent and type of review using the SRNL Technical Report Design Checklist contained in WSRC-IM-2002-00011, Rev. 2.

2.3 Environmental, Safety, and Health Documentation

Pursuant to compliance with Environmental Compliance Manual 3Q, Procedure 5.1 National Environmental Policy Act (NEPA) Implementation and the Environmental Evaluation Checklist, an Environmental Evaluation Checklist was prepared and approved for this project. As required in SRNL Procedure Manual L1, Procedure 7.02 SRNL Research and Development (R&D) Hazard Analysis, a hazard analysis was also prepared and approved for the ESP project.

3.0 Results and Discussion

The first step in evaluating the efficacy of the ESP device in removing mercury vapor was to quantify the output of the smaller diameter mercury generator column. To achieve this task, air samples were taken just upstream of the generator column with a blank sand column (control) and with the mercury generator column at 5, 10, and 15 minutes of run time, labelled samples A, B, and C, respectively. The results of this assessment are shown in Table 3-1.

Table 3-1. Evaluation of Small Diameter Mercury Generator Column

Sample Name	Amount [mL]	Height	Hg [ng]	Hg [µg/L]
ESP Blank Sand Column	0.790	0.1653	1.6997	2.1515
ESP Generator Column A	0.785	0.2836	3.1046	3.9549
ESP Generator Column B	0.800	0.4047	4.7995	5.9993
ESP Generator Column C	0.800	0.4058	4.8163	6.0204

The results of this assessment indicated that some mercury (approximately 2.15 µg/L) was present in the hood environment even without introduction of mercury to the system. However, this was not deemed to be of concern considering that mercury concentration would be measured at the inlet of the ESP device, as well as the outlet, and a mass balance would then be calculated. The results with the mercury generator column in place indicated two main points. First, the initial output of the mercury generator column was not at a steady state, meaning, the generator column should be operated for at least ten minutes prior to conducting tests of the ESP device to ensure a steady concentration of mercury vapor was supplied. The second point was that it was anticipated that a steady supply of air containing approximately 6 µg/L of mercury vapor would be supplied to the air stream entering the ESP device prior to dilution of that air with air from the air intake hose.

Next a test run of the ESP device was planned to evaluate the amount of reduction in mercury concentration could be attributed to treatment of the air stream with ESP technology. The testing methodology and results are presented in Table 3-2.

Table 3-2. First Test Run of ESP Device

Sample Name	Amount [mL]	Height	Hg [ng]	Hg [µg/L]
ESP Blank Sand Column	20	0.0978	0.974	0.0487
5 minutes to equilibrate				
ESP Generator Column A	20	0.8405	24.061	1.203
ESP Generator Column B	20	Overload - In excess of 1000 ng		
10 minutes to equilibrate				
ESP Device Off Inlet A	60	0.0334	41.3587	0.6893
ESP Device Off Outlet A	60	0.3966	9.6955	0.1616
ESP Device Off Inlet B	60	0.0321	39.7495	0.6625
ESP Device Off Outlet B	60	0.1172	145.0906	2.4182
10 minutes to equilibrate				
ESP Device On Inlet A	60	0.6392	16.8273	0.2805
ESP Device On Outlet A	60	Overload - In excess of 1000 ng		
ESP Device On Outlet A-cleanout	60	1.0825	1339.987	22.3331
ESP Device On Inlet B	60	0.5015	12.6228	0.2104
ESP Device On Outlet B	60	0.7118	19.2554	0.3209
10 minutes with sand column to purge system				

In this test run, it was observed that the mercury concentration with the control sand column in place was significantly lower, indicating that that amount of background mercury concentration was somewhat transient. In addition, the output from the mercury generator column did not appear to be steady as was observed from the previous analysis. Sample A contained approximately one fifth of the mercury vapor measured previously, and Sample B overloaded the DMA, indicating in excess of 1000 ng or mercury present. Because all samples were analyzed after conclusion of the experiment, the test was not terminated on this basis. After samples were taken from the mercury generator column, this part of the apparatus was connected to the rest of the testing system and samples were taken at the ESP device inlet and outlet. A and B Samples were taken 5 minutes apart. The first set of samples were taken with the ESP device off, meaning that the fan from the ESP device was not diluting the flow from the generator column and no electrostatic discharge was taking place. This was conducted in an attempt to quantify the amount of mercury concentration reduction that occurred due to amalgamation of mercury within the system. The results indicated that initially mercury concentration was reduced by amalgamation of mercury within the device by 76.6%, but after 5 minutes, the outlet concentration far exceeded that of the inlet concentration. While the inlet and outlet samples were collected consecutively, it cannot be ruled out that a pulse of mercury vapor, as was observed during evaluation of generator column output, during sample collection resulted in the discrepancy.

After conducting sampling with the ESP device turned off, the device was turned on, meaning both the electrostatic discharge and fan were now running, and allowed ten minutes to equilibrate. Following equilibration, inlet and outlet samples were taken 5 minutes apart. In both cases, the inlet concentration was appreciably lower that the outlet concentration. In the case of Sample A for the inlet and outlet, the outlet concentration of mercury was 2 orders of magnitude higher than the inlet concentration, indicating another pulse of mercury vapor through the system. Sample B for the inlet and outlet of the ESP device appeared to represent more stable conditions; however, the outlet mercury concentration was still on the order of 150% higher than the inlet concentration.

As a result of this test run, it was observed that no reduction attributable to operation of the ESP device was present; however, this result could likely have been impacted by the large pulses of mercury vapor that

were observed, inundating the system with unanticipated levels of mercury. In an attempt to mitigate the technical issues experienced in the first test run, several changes were made to the experimental design. First, the mercury generator column was to be run for 20 minutes without being connected to the rest of the system to mitigate any effects of mercury pulses that may occur when air begins to flow through the generator column. Second, more time was placed between samples to increase the time of the run and determine whether the behavior observed in the first run was more that short-lived at start up. In addition, sampling with the ESP device on was to precede any testing with the ESP off, meaning that the system would not be introduced to mercury vapor prior to beginning the sampling protocol with the device on. The testing methodology and sampling results are displayed in Table 3-3.

Table 3-3. Second Test Run of ESP Device

Sample Name	Amount [mL]	Height	Hg [ng]	Hg [µg/L]
Run ESP with no mercury for 20 minutes				
ESP On No Hg Inlet	90	0.0119	14.745	0.1638
ESP On No Hg Outlet	90	0.1056	130.7315	1.4526
Attach GC to pump, but not ESP setup. Wait 15 minutes				
ESP Generator Column A	10	0.0392	48.5383	4.8538
Wait 10 minutes				
ESP Generator Column B	10	0.2413	5.6939	0.5694
Attach GC to ESP setup. Wait 15 minutes				
ESP On Inlet A	60	0.1739	1.7956	0.0299
ESP On Outlet A	60	0.0683	84.5597	1.4093
Wait 10 minutes				
ESP On Inlet B	60	0.4074	9.9872	0.1665
ESP On Outlet B	60	0.7243	19.6902	0.3282
Turn off ESP device. Insert plug into air intake. Wait 30 minutes				
ESP Off Inlet A	10	0.1383	1.4038	0.1404
ESP Off Outlet A	10	0.0989	0.9850	0.0985
ESP Off Outlet B	10	0.4377	5.3284	0.5382
Remove GC and turn off ESP device. Allow to run for 4 hours to purge device of excess mercury				

First, inlet and outlet samples were taken with the ESP device on prior to any intentional introduction of mercury vapor to the system. These results indicated that the concentration of mercury was low at the inlet but considerably high at the outlet. This result indicated one of two possibilities, or perhaps a combination of the two. The first possibility is that mercury pulses may be resulting from some process occurring inside the hood. However, high mercury concentrations have typically only been measured at the outlet; but there remains a possibility that mercury is collected within the device before it is intentionally introduced to the system. This leads to the second possibility, that mercury retained in the system either through amalgamation or otherwise is being expelled from the ESP device as a result or the electrostatic discharge or airflow through the system. In other words, mercury may have been accumulating in the system, whether that mercury is accrued when it was intended or unintended, and then episodically released from the system, where it is measured at the outlet. This is a potential explanation for measuring low levels of mercury at the inlet while measuring levels well beyond that of the inlet concentration at the outlet.

The results from samples taken at the mercury generator column again indicated that a steady state flow of mercury vapor from the column was not achieved. After samples were taken from the mercury generator column, the column was attached to the rest of the system and allowed 15 minutes to equilibrate. After

equilibration, Sample A from the inlet and outlet were taken, followed by Sample B from the inlet and outlet ten minutes later. These results again indicated an increase of mercury concentration after treatment through the ESP device on the order of approximately double (Sample B) to two orders of magnitude (Sample A). After these samples with the ESP device turned on, the device was turned off and the system was allowed to equilibrate for 30 minutes. After the equilibration, an inlet sample and two outlet samples were collected. These samples again showed a mixture of some mercury accumulating in the system leading to an observed reduction in mercury at the outlet, followed by increased mercury levels at the outlet as mercury was released.

At this point, several opportunities for improvement in the test setup and protocol were identified, despite the ESP device displaying no indications of removing mercury vapor from the incoming air. First, a second mercury generator column was designed and evaluated so that a known amount of mercury introduced to the system could be quantified. The new generator column utilized a larger diameter column to slow air velocity through the column, larger buffer regions of clean sand to prevent liquid mercury from entering the system, and more droplets of mercury to increase the surface area and provide a more predictable supply of mercury vapor to the system. This mercury generator column was then tested to determine the steady state mercury vapor concentration, as well as the amount of time required before that mercury concentration was reached. Table 3-4 contains the testing methodology and results of this analysis. The results are also shown graphically in Figure 3-1.

Table 3-4. Evaluation of New Generator Column Output with Respect to Run Time

Sample Name	Amount [mL]	Height	Hg [ng]	Hg [µg/L]
Generator Column Attached to Pump and Run for 80 Minutes. Samples were taken at 2.5, 5, 10, 20, 40, and 80 minutes. Duplicate samples were obtained at 10 minute sampling period and after.				
Generator 2.5	5	0.4608	4.9983	0.9997
Generator 5	5	0.4344	4.5712	0.9142
Generator 10 A	5	0.3814	3.8124	0.7625
Generator 10 B	5	0.3922	3.9585	0.7917
Generator 20 A	10	0.2952	7.6725	0.7673
Generator 20 B	10	0.3346	8.8009	0.8801
Generator 40 A	10	0.3082	8.0413	0.8041
Generator 40 B	10	0.3074	8.0212	0.8021
Generator 80 A	10	0.2898	7.5215	0.7521
Generator 80 B	10	0.3107	8.1134	0.8113

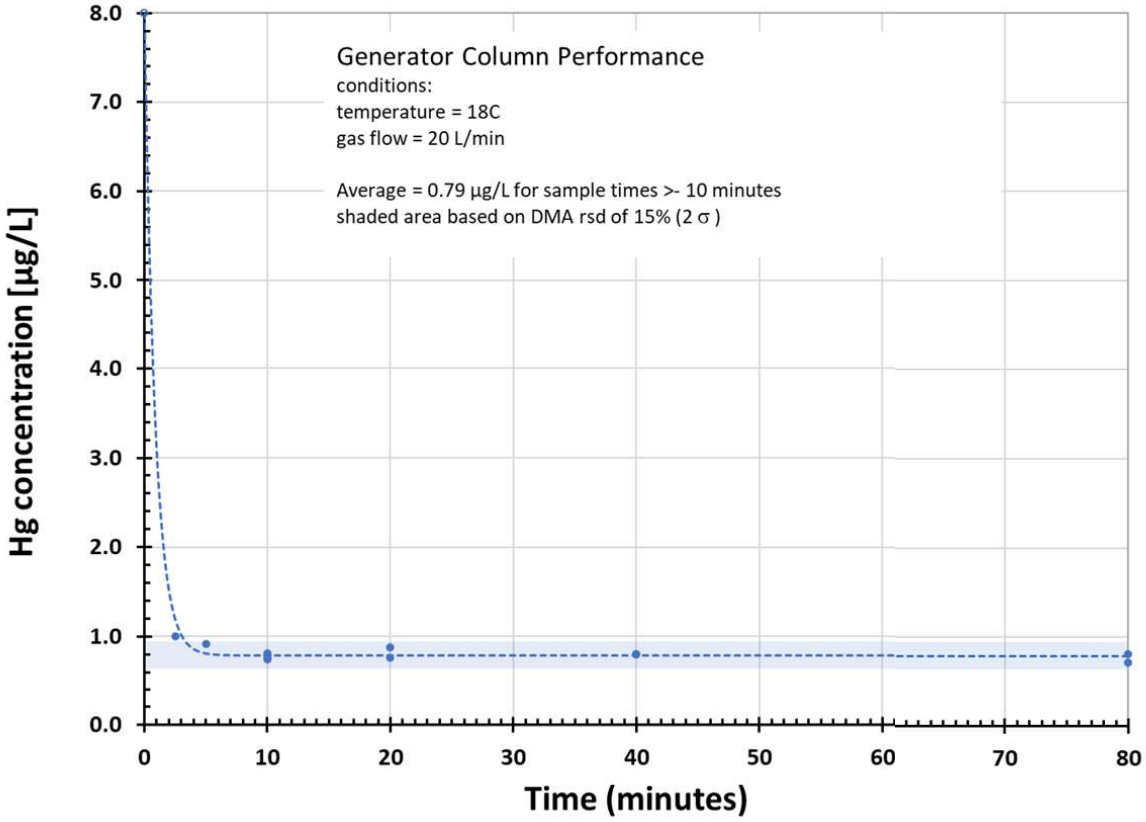

Figure 3-1. Quantification of New Generator Column Output

The new generator column was attached to the pump and run for 80 minutes. Samples were taken at 2.5, 5, 10, 20, 40, and 80 minutes during the run time. Duplicate samples were obtained for all samples taken at 10 minutes and later during the evaluation. As can be seen in Table 3-4 and the associated plot in Figure 3-1, a steady state mercury vapor concentration (0.79 +/- 15% µg/L) was achieved after 10 minutes of run time through the duration of the test. This indicated that the new generator column was stable over the time scale in which tests were being conducted and any pulses in mercury would not be associated with the generator column in future tests.

The other main concern was the unintended introduction of mercury that may be occurring due to unaccounted for processes within the hood. To address this concern, the air intake hose for the test setup was moved to outside of the hood, despite air sampling within the hood that resulted in negligible mercury vapor concentrations (> 0.006 µg/L). It was believed that some sort of episodic release of mercury vapor may have been affecting the ability of the ESP device to be purged of excess mercury. The ESP device was then run for 30 minutes in the absence of mercury vapor from the generator column to determine if the aforementioned changes resolved the episodic high levels of mercury during sampling. The results are presented in Table 3-5.

Table 3-5. Check of Cleaning ESP Device with Air Intake Moved Outside of Hood

Sample Name	Amount [mL]	Height	Hg [ng]	Hg [µg/L]
Obtained ESP Inlet and Outlet Samples with Intake Outside Hood				
ESP Inlet 0	90	0.0288	0.256	0.0028
ESP Outlet 0	90	0.0197	0.1822	0.002
ESP Inlet 10	90	0.08	0.6813	0.0076
ESP Outlet 10	90	0.0139	0.136	0.0015
ESP Inlet 20	90	0.0131	0.1295	0.0014
ESP Outlet 20	90	0.0155	0.149	0.0017
ESP Inlet 30	90	0.0098	0.1028	0.0011
ESP Outlet 30	90	0.0208	0.1914	0.0021
Intake will Remain Outside Hood. Continue to Run ESP to Purge System				

These results confirmed that over the 30 minutes that sampling was conducted, the mercury concentration was low (orders of magnitude lower than new generator column output) and that no pulses of mercury were detected. With the positive indications of these tests, a third tests run of the ESP device was designed. The testing methodology and results are presented in Table 3-6 and Figure 3-2.

Table 3-6. Third Test Run of ESP Device

Sample Name	Amount [mL]	Height	Hg [ng]	Hg [µg/L]
ESP Operated with Air Intake Pulling Clean Air from Outside of Hood.				
Samples Obtained from ESP Inlet and Outlet before Introduction of Mercury to Confirm Low Levels				
ESP Inlet Blank Check	90	0.036	0.3146	0.0035
ESP Outlet Blank Check	90	0.2122	1.8907	0.021
Generator Column Attached to Pump. Run for 10 Minutes then Samples in Duplicate.				
Generator Column Check A	10	0.3114	8.1346	0.8135
Generator Column Check B	10	0.2772	7.1662	0.7166
Generator Column Attached to ESP Setup.				
ESP Inlet and Outlet Samples Taken Every 5 Minutes for 30 Minutes				
ESP Inlet 5	60	0.348	3.384	0.0564
ESP Outlet 5	60	0.8056	24.2786	0.4046
ESP Inlet 10	60	0.3734	3.7074	0.0618
ESP Outlet 10	60	0.1704	1.4885	0.0248
ESP Inlet 15	60	0.3522	3.4366	0.0573
ESP Outlet 15	60	0.2722	2.5101	0.0418
ESP Inlet 20	60	0.3418	3.3078	0.0551
ESP Outlet 20	60	0.2096	1.865	0.0311
ESP Inlet 25	60	0.3429	3.3214	0.0554
ESP Outlet 25	60	0.1209	1.0365	0.0173
ESP Inlet 30	60	0.3526	3.4413	0.0574
ESP Outlet 30	60	0.6066	17.2034	0.2867
Pump Turned off to GC and GC Removed and Placed in Plastic Storage Bag. ESP Continued to Run to Purge System for 40 Minutes. Samples were Taken from ESP Inlet and Outlet to Confirm Purge of System.				
ESP Inlet Post 40	90	0.0115	0.1171	0.0013
ESP Outlet Post 40	90	0.1307	1.124	0.0125

Before introducing mercury vapor, and control sample was taken at both the inlet and outlet, which showed low values of mercury, indicating a clean system to start the test run. Next, two samples were taken upstream of the generator column to ensure that the system had reached its steady state mercury concentration, which was the case. Following this confirmation, a 30 minute test run of the ESP device was carried out with measurements occurring at the inlet and outlet every 5 minutes. In addition, the inlet and outlet concentration were taken 40 minutes after the conclusion of the test to evaluate if the system returned to relatively clean conditions. The results are plotted in Figure 3-2.

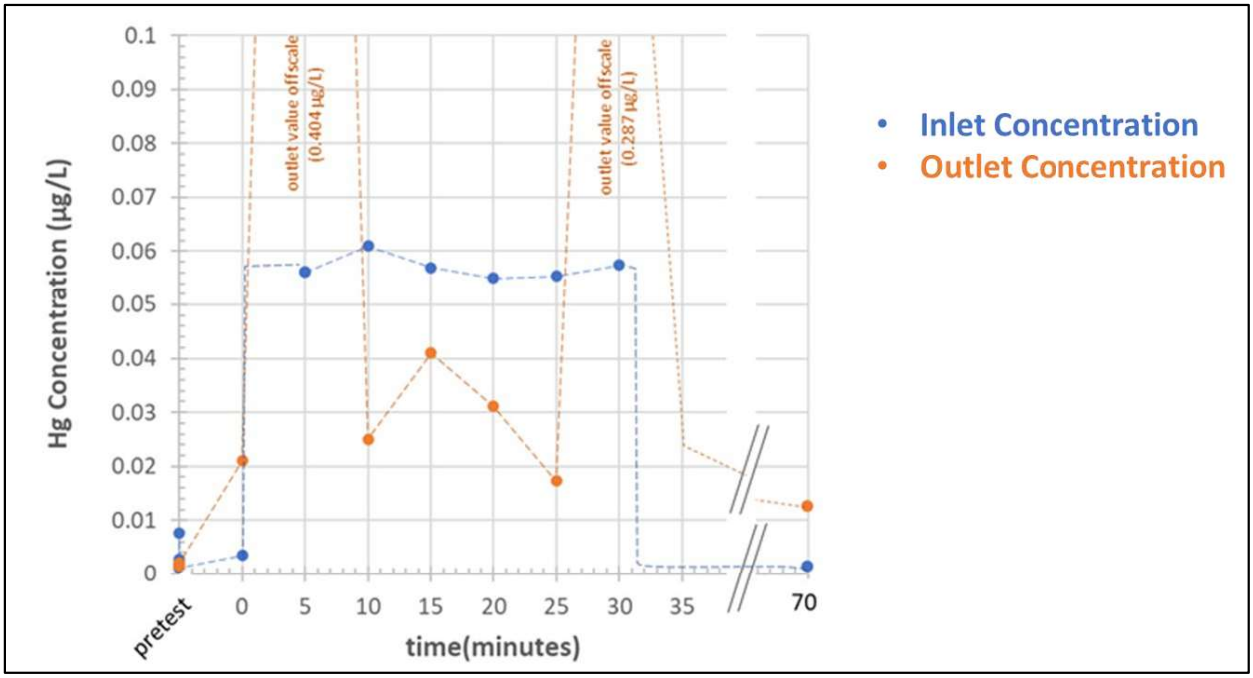

Figure 3-2. Mercury Concentration with Respect to Run Time for Third Test Run of ESP Device

These results showed that the inlet concentration remained steady at an average of 0.057 µg/L for the duration of the 30 minute experiment. This reinforced that the new generator column performed as intended and moving the air intake hose to outside of the hood prevented uptake of mercury from any unintended sources. The outlet concentrations, however, delivered mixed results. During the time span of 10 minutes to 25 minutes, the ESP device showed a reduction in mercury concentration of approximately between 33 – 67% of the steady inlet concentration. However, the samples taken at 5 and 30 minutes indicated outlet concentrations that exceeded an order of magnitude higher than the inlet concentration. It is hypothesized that this behavior typifies the other pulses of mercury exhibited in earlier experiments. This ESP device appeared to collect mercury for a finite period of time, then expel that mercury in episodic pulses, meaning it is not an efficient strategy for removal of mercury vapor.

In an effort to further understand these mercury pulses, an observed fan flow rate was calculated in order to conduct a mass balance during the final test run. Based upon inlet concentration and the steady state concentration of the mercury generator column, an observed fan flow rate of 256 L/min was calculated. Using this flow rate and the inlet concentration average, a total mass of mercury entering the system was calculated to be 474 µg. Using the average of the outlet concentration excluding the spikes in mercury concentration, it was calculated that 236 µg of the 474 were associated with the spikes in mercury concentration. This would make the duration of the mercury pulses approximately 160 seconds assuming they are symmetrical. All of this amounted to releases of mercury that last for approximately 2.7 minutes that occur every 20 – 30 minutes based on the results of the final test run.

4.0 Conclusions

A testing methodology was developed to evaluate electrostatic precipitator technology for removal of mercury vapor. This methodology involved supplying mercury vapor-containing air to the ESP device by flowing air through a column containing alternating layers of sand and liquid mercury droplets. Initial attempts at quantifying the efficacy of the ESP device in removing mercury vapor were plagued with difficulties in controlling the flow of mercury into the ESP device due to poor performance of the generator column and the contamination of experiments with mercury from an unknown source. These issues were resolved by creating a new generator column with slower air velocity and higher surface area of liquid mercury, along with moving the air intake for the ESP device to outside of the chemical hood in which testing took place. This resulted in a steady, quantified flow of mercury vapor from the generator column and no observation of unintended mercury sources. A final test of the ESP device under these controlled conditions showed that for a certain amount of time (on the order of 20 – 30 minutes) mercury concentrations were reduced by approximately 33 – 67% of the inlet concentration. However, episodic releases or pulses of mercury observed only at the outlet indicated that the mercury accumulated in the device is periodically expelled. As a result, it was not deemed to be an efficient strategy for the removal of elemental mercury vapor.

5.0 Recommendations, Path Forward or Future Work

While the ESP device tested did not appear to efficiently remove mercury vapor from an air stream, the device may have applicability to other remediation applications. Previous research documents that mercury speciation may be impacted in an ESP, suggesting possible ESP treatment train options such as converting elemental mercury to ionic forms and then using an ionic mercury removal unit operation. Additional research on the impacts of ESP on mercury speciation would support advancing such systems. If the mercury present in the ESP effluent is no longer elemental mercury, a subsequent filter or removal strategy may prove efficient for removal of mercury from a facility. However, such a hybrid treatment train would be more complex than available standard commercial air treatment processes such as sorption onto activated carbon or sulfur impregnated activated carbon specially formulated for mercury treatment (such as Mersorb™). A few passive methods and active building controls (such as maintaining differential pressure and building ventilation) may also prove effective as primary or adjunct technologies for mitigating exposures.

Though the removal of elemental mercury has not been shown to be efficacious, removal of particle-bound mercury remains viable for facilities and conditions where particulate mercury is a dominant form of the contamination. Similarly, abatement of other species of interest in remediation of facilities that is particle bound may benefit from ESP technology.

6.0 References

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