# Effect of ERLAB HALO Filter Units on Chemical Concentrations in a Laboratory Over a Range of Air Change Rates (ACH)


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# INTRODUCTION AND SUMMARY

Exposure Control Technologies, Inc., (ECT, Inc.) was contracted by Erlab to perform a series of tests to challenge a set of prototype HALO re-circulating filter units. The filter units are designed to be installed in the ceiling of a laboratory to clean and re-circulate the air within the space. They operate by the use of a built in fan that pulls air through the filters to remove contaminants. The test challenge involved generating concentrations of three different solvents in the test lab at ECT, Inc. and evaluating the accumulation and decay of concentrations in the laboratory with and without the use of 4 HALO filter units installed in the ceiling.

The primary objectives of this project were:

1. *To evaluate the ability of the re-circulating filters to reduce concentrations and increase decay rates of solvents generated within the lab space.*

2. *To evaluate the potential of the re-circulating filters to reduce exhaust and lower room ACH and achieve equivalent or better dilution.*

The tests began on Monday, February 3, 2014 and were observed by Erlab representative Kenneth Crooks. Tests were performed in the laboratory under three flow conditions including 10 ACH, 4 ACH and 4 ACH with the units in operation. The test lab was measured and determined to be 29 feet long by 27 feet wide with a 10.5 feet ceiling (See Figure 1). Three solvents were chosen including isopropyl alcohol (IPA), toluene and acetone. The first test was conducted by setting the exhaust flow through the fume hoods and general exhaust to achieve 10 ACH with the filters turned off, the second test was conducted at 4 ACH with the units turned off and the third test was performed at 4 ACH with the 4 units in operation. The 4 units operating simultaneously provide a flow equivalent to approximately 2.3 ACH of re-circulating air.

The results of the three tests indicate the concentrations and the rate of decay for 2 of the solvents (IPA and Toluene) were lower when operating at 4 ACH when the HALO units than operating the lab at 4 ACH or even 10 ACH without operation of the units. The acetone concentrations and decay rates were lower at 10 ACH than 4 ACH with use of the HALO filters. As a result of the tests, operation of the HALO units at 4 ACH provided equivalent or better dilution of solvent concentrations in the room and enabled a significant flow reduction of 842 cfm in the test lab. The flow reduction equates to an annual savings of approximately $4,000 based on reducing flow from 10 ACH to 4 ACH minus the cost of operating the HALO units. The savings estimated from flow reduction is based on a cost of ventilation of $5 per cubic feet per minute (cfm) per year.

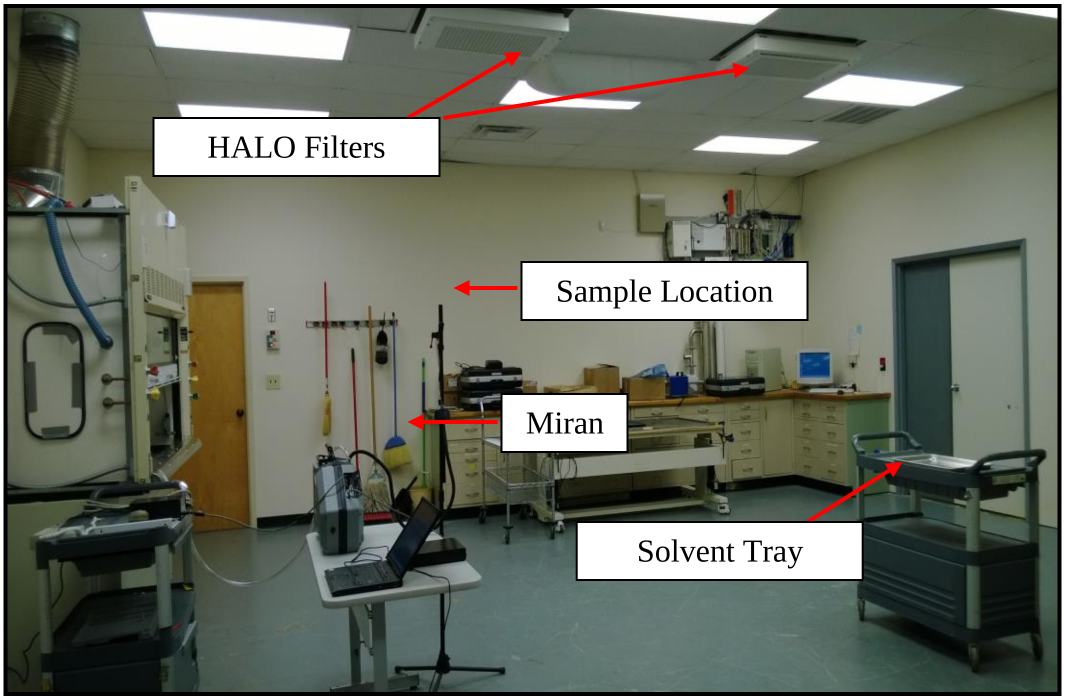



**Figure 1: ECT Test Lab showing solvent generation location, sample location and Miran.**

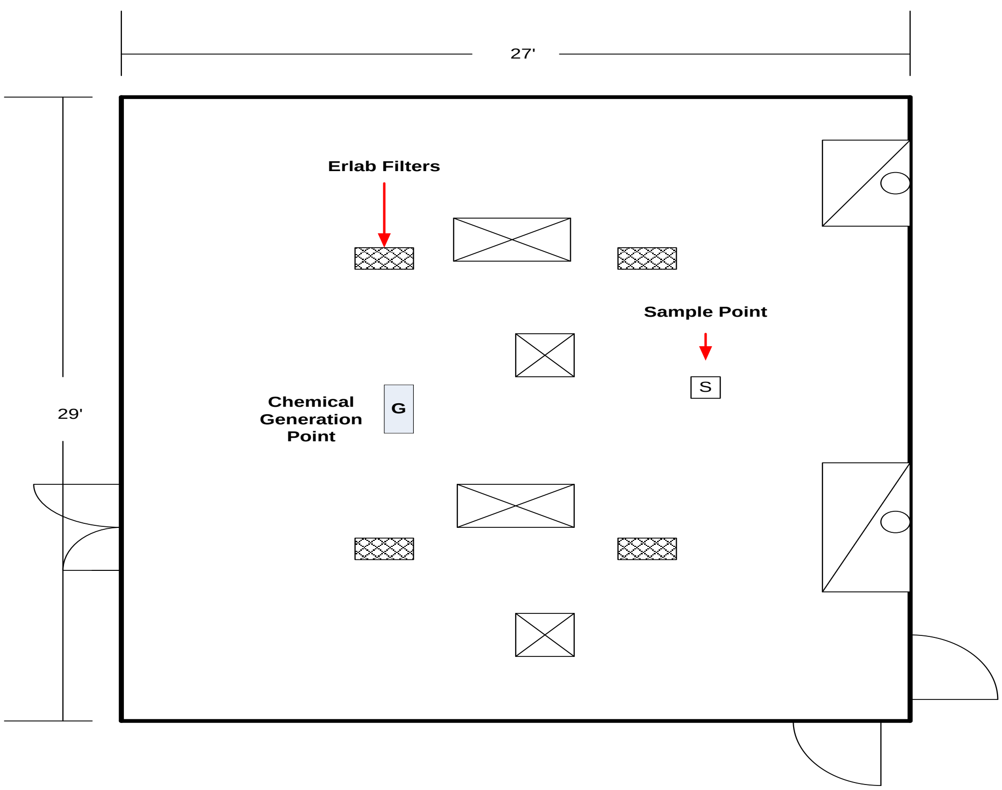



**Figure 2: Plan diagram of ECT Test Lab showing chemical generation location, sample location, exhaust and supply.**

# METHODS

The test methods consisted of three chemical challenges which included IPA, acetone and toluene. The flow in the test lab was set to achieve the ACH appropriate to the challenge. The first series of tests were conducted at 10 ACH with the filtration turned off; the second series were conducted at 4 ACH with the filtration turned off; and the last series of tests were conducted at 4 ACH with the filtration turned on. The flow and resulting ACH was confirmed by measuring the exhaust flow using a Pitot tube traverse (see Table 1). The filter units have an inlet area of 2.08 $ft^2$ and an inlet flow of approximately 80 cfm each. All 4 units operating simultaneously re-circulated approximately 320 cfm or the equivalent of 2.3 ACH during the tests at 4 ACH of outside air. The temperature and relative humidity was measured with a factory calibrated Vaisala measurement device and recorded in table 2.

**Table 1: Room Exhaust Measurements at ACH**

| ACH | Room Volume ($Ft^3$) | Exhaust (cfm) |
|---|---|---|
| 10 | 8,222 | 1370 |
| 4 | 8,222 | 528 |

**Table 2 Temperature and Relative Humidity**

| Test Lab Conditions | |
|---|---|
| Temperature ° F | Relative Humidity % |
| 69 | 38 |

For each test, air concentration samples were collected from one location in the lab using a factory-calibrated Miran Sapphire portable ambient analyzer. The measurement location was approximately 5'-5" above the floor to approximate the breathing zone of a person (see figures 1 and 2). The chemicals were dispensed into a rectangular tray measuring 12 ¼ inches by 17 inches by ½ inch deep located in the approximate center of the lab and allowed to evaporate. The room airflow was set to the specified ACH with the doors to the labs closed. Concentrations were measured continuously at approximately one reading per second for one hour. The liquid volume of the chemicals dispensed into the tray was selected to achieve sufficient concentration for detection by the Miran. The limits of detection and maximum concentration measured for each material are shown in table 6.

**Table 3: Test Chemicals for 10 ACH.**

| 10 ACH Test Challenge | |
|---|---|
| **Chemical** | **Amount Dispensed (mls)** |
| Isopropyl Alcohol (IPA) | 25 |
| Toluene | 25 |
| Acetone | 25 |

**Table 4 Test Chemicals for 4 ACH**

| 4 ACH Test Challenge | |
|---|---|
| **Chemical** | **Amount Dispensed (mls)** |
| Isopropyl Alcohol (IPA) | 25 |
| Toluene | 25 |
| Acetone | 25 |

**Table 5 Test Chemicals for 4 ACH with HALO Filters**

| 4 ACH Test Challenge with HALO Filters | |
|---|---|
| **Chemical** | **Amount Dispensed (mls)** |
| Isopropyl Alcohol (IPA) | 25 |
| Toluene | 25 |
| Acetone | 25 |

**Table 6: Measurement Range of Miran for Test Chemicals**

| Chemical | Minimum Concentration (ppm) | Maximum Concentration (ppm) | Accuracy % (+/- of reading) |
|---|---|---|---|
| Isopropyl Alcohol | 0.3 | 100 | 10 |
| Toluene | 1 | 200 | 10 |
| Acetone | 5 | 2000 | 5 |

# RESULTS

With exception of Acetone, the results indicate that the maximum concentrations were equivalent or less when operating the HALO units at 4 ACH of outside air than operating at 10 ACH or 4 ACH under similar solvent emission scenarios. There may have been some issues with the lower limit of detection for the Miran that may have biased the results when measuring concentrations of acetone. The results during the tests with Acetone indicated that maximum concentration at 10 ACH was 18% less than the maximum concentration detected when operating the HALO unit at 4 ACH, but the maximum concentration was 5% less than when operating the room at 4 ACH without filtration. As noted above, the 4 HALO units provide an equivalent flow of only 2.3 ACH. Table 7 shows the maximum concentration detected at each operating condition for each chemical and Figures 3-5 show the accumulation and decay in the lab for each chemical and operating scenario.

From the data, the decay times were determined by the time required to dilute the maximum concentration by 50%. The shortest decay time was found at 10 ACH for all chemicals, but the Halo Units resulted in significantly shorter decay times than operating at 4 ACH without filtration. The residence time of the materials in the lab may also have been a function of the room airflow patterns that were not investigated during the tests. Lower airflow rates may have reduced the mixing and decreased equivalent airflow rates. Refer to Table 7 for Decay Time for each chemical and operating scenario. The dilution and rates of decay can be observed in Figures 3-5.

**Table 7: Chemical Concentrations and Decay Time to 50% of Max. Concentration**

| | Max. Concentration - ppm | | | Decay Time - minutes | | |
|---|---|---|---|---|---|---|
| **Chemical** | 10 ACH | 4 ACH with filters off | 4 ACH with filters on | 10 ACH | 4 ACH with filters off | 4 ACH with filters on |
| **Isopropyl Alcohol** | 7.6 | 10.4 | **6.6** | 4.3 | 12 | **9** |
| **Toluene** | 6.6 | 7.6 | **6.6** | 9 | 24 | **16** |
| **Acetone** | 26 | 35 | **32** | 4 | 7 | **5** |

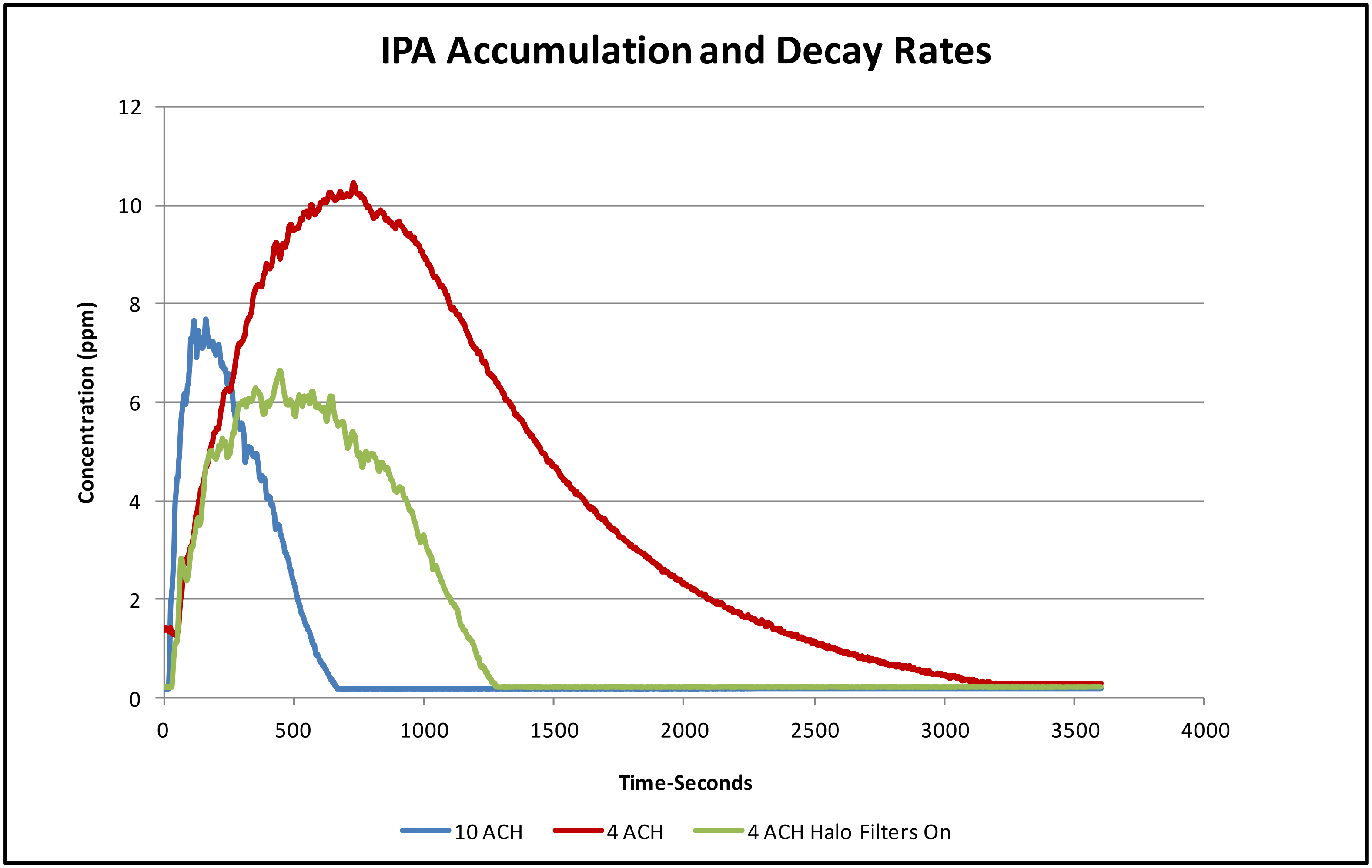



**Figure 3 IPA Accumulation and Decay Plot**

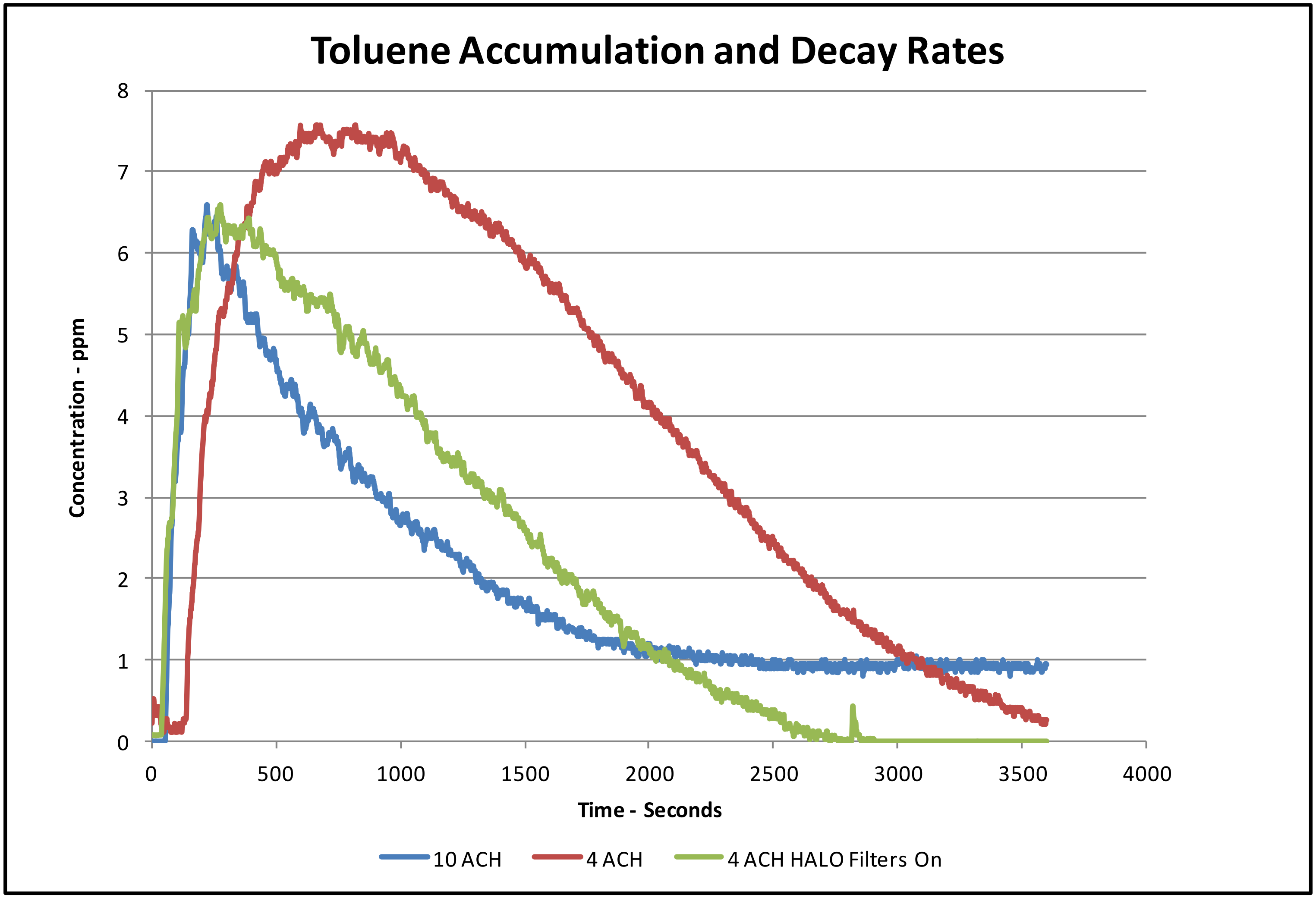



**Figure 4 Toluene Accumulation and Decay Plot**

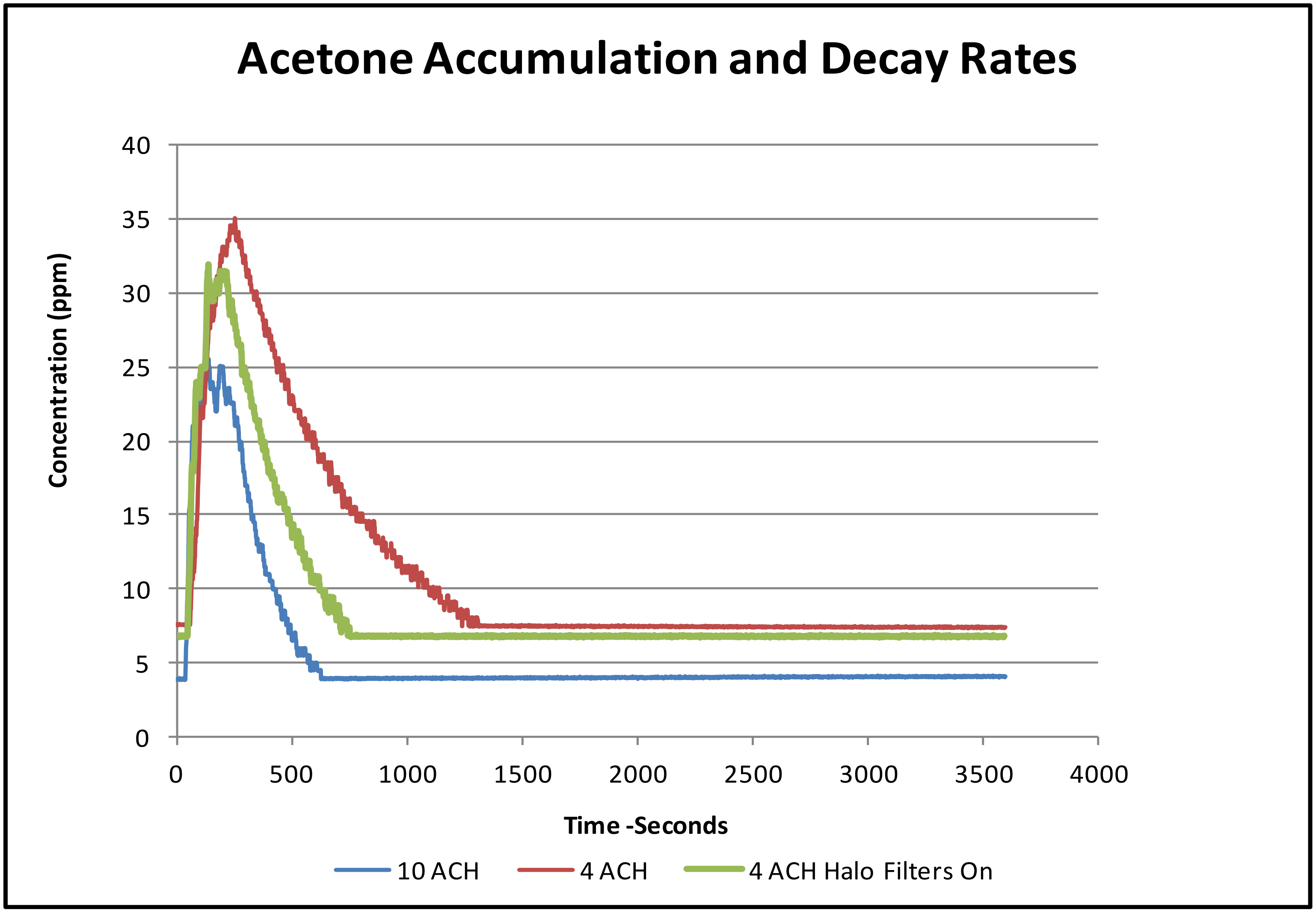


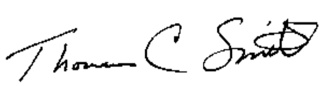

**Figure 5 Acetone Accumulation and Decay Plot**

## Conclusions and Recommendations

The results indicate that the HALO Filter Units help reduce the accumulation of concentrations of chemicals that might be generated in laboratories outside approved exposure control devices. With the exception of Acetone, the maximum concentrations detected in the lab were equivalent or lower when operating at 4 ACH with the units operating than when the units were not operating at an airflow rate equivalent to 10 ACH. As such, the HALO units could be considered for use instead of operating at higher ACH to reduce concentrations improperly generated outside approved ventilated devices. Due to the high cost of providing 100% outside air for dilution, filtration may be an attractive option to reduce concentrations rather than the use of a higher air change rates. The issue of decay time should be further investigated to evaluate the impact of room airflow patterns on dilution and residence time in the space. Despite the benefits of the filters operating in a lab to reduce ambient concentrations, generation of all chemicals should be done in approved ventilated devices.

As noted in the introduction, a decrease of airflow from 10 ACH to 4 ACH in the ECT Lab resulted in a flow reduction of 842 cfm. Given that ventilation is a significant contributor to the overall energy costs for a lab, the reduction in airflow could offer savings of as much as $4,000 annually (based on a cost of approximately $5 per cfm per year) minus the cost of operating the filters. The savings results from a reduction in exhaust and the need for conditioned makeup air. Implementation of filtration units should follow a laboratory hazard and ventilation assessment that would include evaluation of the type of chemicals used in the lab, the potential for generation of chemicals outside of the laboratory hoods, the effectiveness of the filtration units, the impact on airflow patterns in the lab and the resultant indoor environmental air quality.

Please note that the test results are subject to the materials used in the investigation and the operating conditions prevailing in the lab at the time and date of the investigation. ECT, Inc. makes no warranties or guarantees implied or otherwise regarding the effectiveness of HALO filtration units outside the conditions prevailing during the investigation described herein. Any questions concerning information or conclusions contained within this report can be referred to Exposure Control Technologies, Inc. We welcome your questions, comments and suggestions and we thank Erlab for the opportunity to participate in this project.



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