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May 13, 2003

Ms. Florence Kapoor
Air Technology
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P.O. Box 159
Willingboro, New Jersey 08046-3518

Reference: ***AirMATION Unit Evaluation***
Union Fire Company Firehouse
Medford, New Jersey
TTI Project No. 03-246, Revised

Dear Ms. Kapoor:

TTI Environmental, Inc. (TTI) was contracted to develop and implement an indoor air quality study to determine the effectiveness of the AirMATION unit in reducing concentrations of specific contaminants in air associated with diesel engine combustion. The Union Fire Company Firehouse in Medford, New Jersey was chosen for the study due to its relatively low ceiling at 13.5 feet, representing a positive bias or worst case scenario for the study area. There are also no other air handling units in the apparatus area that would influence the study area. The area is heated by a radiant floor system. There is no air conditioning provided to the apparatus area for cooling. There are two louvered exhaust fans, 3 by 3 feet in size, located at the top of the eastern wall of the apparatus area, now out of service, that were previously used to exhaust combustion fumes. These fans were switched on automatically upon opening of the bay doors. The Union Fire Company was experiencing the presence of black soot/film on surface areas within the apparatus area, office and lounge areas that was suspected to be associated with the ineffective removal of diesel fumes within the apparatus area.

The Union Fire Company installed a total of six AirMATION units approximately one year ago to eliminate the diesel fume problem and improve on overall air quality. According to Mr. Wayne Rockhill, Firehouse Trustee, the walls and other surfaces were cleaned immediately following the installation of the units. Since that time there has been no evidence of any black soot film on any surfaces in the apparatus area, office or lounge areas. TTI confirmed this during the study. A 6 inch by 6 inch white oil absorbent pad was used to wipe the wall of the building in the test area. No evidence of any black soot was identified on the wall surface in this area. A similar procedure was employed on surfaces in the office area where a black soot film was always present on various surfaces. The outcome indicated no evidence of any black soot film present. Another benefit indicated by Mr. Rockhill was the removal of smoke odor from the fireman's gear stored in the rear of the test area.

The study designed by TTI focused on normal operating procedures performed at the firehouse. These activities included the operation of a fire truck in the building during a typical response to a fire call and exercising of the vehicle engine in accordance with standard operating procedures for the fire company. Another test run was performed on the AirMATION unit itself to evaluate the direct effectiveness (inflow/outflow characteristics) of the filtration unit. Specific air contaminants included in the study were Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), Sulfur Dioxide (SO_2), Volatile Organics (VO), Particulates and Elemental Carbon as measured with an Aethalometer.

Ambient air temperature and relative humidity readings could not be obtained on site due to an operational problem with the instrument (Alnor APM360). Data for air temperature, relative humidity and other weather conditions was obtained from the National Weather Service (NWS) as recorded at the South Jersey Regional Airport located approximately 2 miles north of the test area. Physical measurements of the firehouse and test area were recorded along with a determination of all building air handling equipment and air exchange pathways.

Technical Information/Testing Procedures

The study was performed on April 17, 2003. The TTI study team included Richard Schneidereit, Chris Macri and Ian Lambert. Mr. Wayne Rockhill and Mr. Thomas Thorn, Medford Fire Marshall provided procedural information and equipment operation. The following monitoring instruments were used to obtain air quality data:

- T-80 Single Gas Monitor, manufactured by Industrial Scientific Corporation, was used to measure Nitrogen Dioxide and Sulfur Dioxide. Operating range is 0.1 to 1999 parts per million (ppm).
- MiniRae Photoionization Detector (PID), manufactured by RAE Systems, Inc., was used to measure Volatile Organics. Operating range is 0.1 to 10,000 ppm.
- PDR 1000 personal DataRam aerosol monitor, manufactured by MIE, was used to measure particulates (0.1 to 10 microns). Operating range is 0.001 to 400 milligrams per cubic meter (mg/m^3).
- Passport Personal Alarm Multi-Gas Monitor, manufactured by Mine Safety Appliances Company, was used to measure Carbon Monoxide (CO). Operating range is 1 to 1,000 ppm.
- Aethalometer 19 inch rack mount version, manufactured by Magee Scientific, was used to measure aerosol black carbon in units of nanograms per cubic meter (ng/m^3)
- Air temperature, relative humidity readings and other weather conditions were obtained from the NWS Mount Holly Office. The readings were taken at the South Jersey Regional Airport in Lumberton, New Jersey. The airport is located approximately 2 miles north of the Union Fire Company building.

TTI measured the dimensions of the firehouse and selected the test area based on its location within the apparatus area. A scaled diagram of the firehouse, bay doors, AirMATION unit locations and test area is provided as Figure 1.0. The test area was in a section of the apparatus bay area side by side with the wall and door to the lounge area and the wall of the office/meeting room area directly to the rear of the AirMATION unit used for the test. Firemen's gear is also stored and donned along the rear wall of the test area. Being in a corner with an AirMATION unit overhead, this area appeared to provide for more controlled testing conditions. The total volume of the firehouse apparatus area was calculated at approximately 52,000 cubic feet. The test area was calculated to be approximately 7,938 cubic feet or 15 % of the total firehouse apparatus area. There are eight bay doors in the firehouse. The bay doors each measure approximately 12 by 12 feet in size. Three of the six bay areas are drive through. The AirMATION units begin operating automatically when any bay door is opened. They are set to run for 15 minutes before shutting down. There is also a manual override switch that can be used to operate the units.

TTI installed new filters in the AirMATION test unit (Model AMB302D, serial number AM30205200517B) prior to initiating any testing procedures. The units are suspended by chains directly beneath the drop ceiling in the firehouse. The drop ceiling is positioned approximately 2 feet below the roof of the firehouse.

Technical Information/Testing Procedures (Continued)

The fire truck using the test bay area is a 1998 KME 300 horsepower Cummings Diesel Rescue Truck with an electric generator. The truck measured approximately 25 feet in length.

According to Fire Marshall Thorn, when a call comes in to respond to a fire, the bay door for the truck in the test area is opened and the truck is started while waiting for firemen to assemble, don their gear and man the truck. The truck typically would run in the firehouse for approximately 2 to 5 minutes. When the truck pulls out of the firehouse, the bay door is closed usually by a remote control located on the fire truck. Based on this information, the first test run to represent normal operating conditions consisted of opening the bay door, starting the fire truck and allowing it to run for 3.5 minutes in the firehouse and then driving the truck out and closing the bay door. Air monitoring readings were taken in the breathing zone (approximately five (5) feet above the floor) starting with background prior to starting the truck and at approximate 2-minute intervals over the 15 minute period that the AirMATION unit runs. The truck was backed into the firehouse and the bay door closed. This triggered the AirMATION unit to run for another 15-minute period. After shutting down, background readings were taken to demonstrate that air conditions had returned to normal and another test run could be performed.

Another typical standard operating procedure with all fire companies is to exercise (operate) truck engines on a regular basis to ensure that the vehicle is in operating condition. Fire Marshall Thorn indicated that their company typically starts each truck on a daily basis. The frequency of this procedure varies by department and status of the firefighters. For example, in the city of Philadelphia, the engine in each fire truck must be exercised once during each 8-hour work shift period to ensure proper engine operating condition. At the Union Fire Company in Medford, various operating features or units on each truck may be checked during this exercise. The truck typically runs for approximately 2 to 3 minutes inside the firehouse with the door opened. This procedure was simulated for another test run. The bay door was opened and the fire truck was started and allowed to run for 2 minutes. The truck was then turned off and the bay door was closed. Air monitoring readings were taken in the breathing zone starting with background prior to starting the truck and at approximate 2 minute intervals over the 15 minute period that the AirMATION unit runs.

Finally, in order to evaluate unit-filtering effectiveness, the bay door in the test area was opened and the fire truck was allowed to run for 3.5 minutes. Air monitoring readings for all parameters other than elemental carbon were taken at the air intake of the AirMATION unit and exhaust outlet over a 5-minute interval beginning with the truck start up. Two additional test runs were performed on the unit using the Aethalometer. The truck was allowed to run for approximately 2 minutes in the firehouse with the Aethalometer recording readings at the inlet over the 15-minute AirMATION unit run period. Another similar run was performed with the aethalometer recording readings at the unit exhaust.

All firehouse bay doors other than the test area remained closed during the entire testing period.

Monitoring Results

Weather conditions during the testing period included mostly cloudy skies with winds from the east at 10 to 20 miles per hour (MPH) with gusts from 25 to 33 MPH recorded by the NWS during the testing period. Air temperature and relative humidity were stable ranging from 44°F to 45°F and 48% to 56%, respectively. Air pressure ranged from 1,025 to 1,028 millibars.

Table 1.0: Test Run/Standard Operating Procedures
Truck Start: 10:35 AM Truck Run: 3.5 Minutes

Time	VO (PPM)	NO_2 (PPM)	SO_2 (PPM)	Particulates (mg/m^3)	CO (PPM)	Carbon (ug/m^3)
10:34	0.0	0.0	0.0	0.000	0	0.455
10:37	0.0	0.6	-0.5	0.0018	7	5.150
10:39	0.0	0.2	-0.1	0.0023	2	9.016
10:41	0.0	0.2	-0.1	0.0010	2	7.752
10:43	0.0	0.1	0.0	0.000	1	5.479
10:45	0.0	0.1	0.0	0.0002	1	3.719
10:47	0.0	0.1	0.0	0.000	1	2.735
10:49	0.0	0.0	0.0	0.0006	1	2.288
10:51	0.0	0.0	0.0	0.000	1	1.547
10:53	0.0	0.0	0.0	0.000	1	1.327

Note: Negative Readings for SO_2 were the result of cross interference caused by the low level presence of NO_2 interacting with the SO_2 detector.

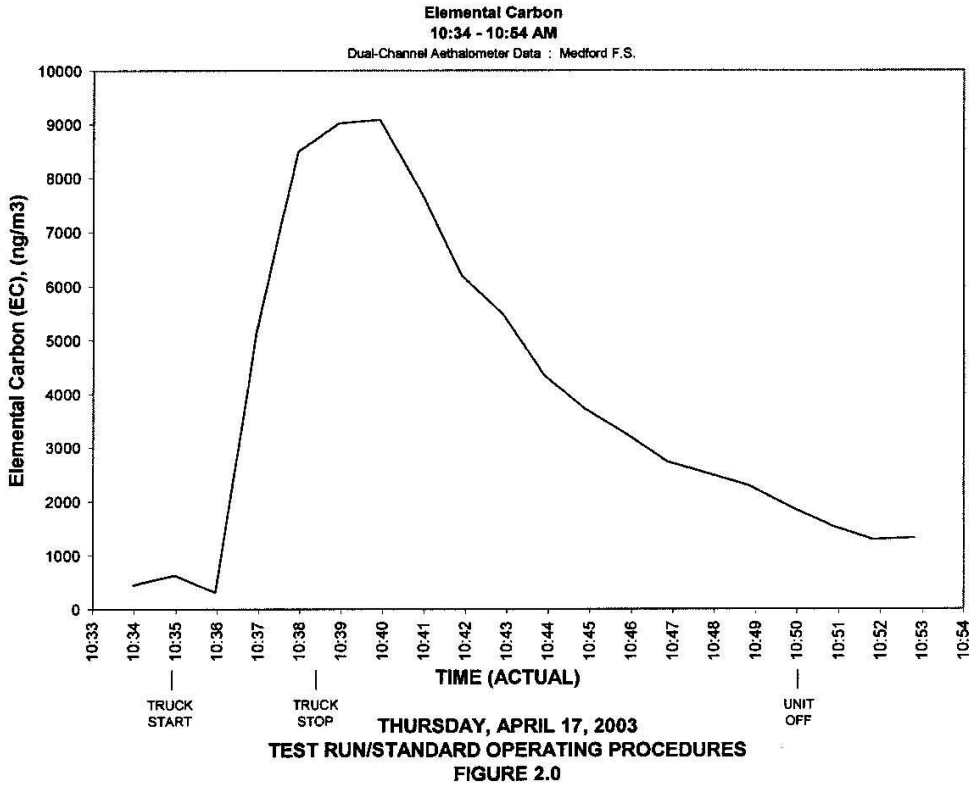
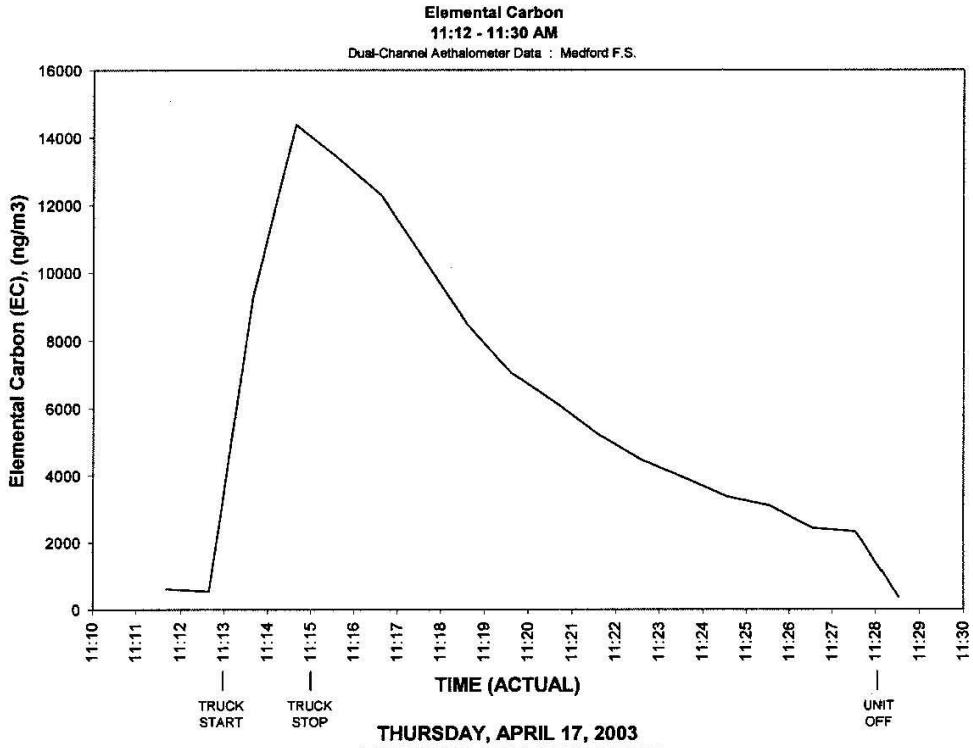


FIGURE 2.0

Monitoring Results (Continued)

Table 2.0: Exercising of Truck Engine Truck Start: 11:13 Truck Run: 2 Minutes						
Time	VO (PPM)	NO_2 (PPM)	SO_2 (PPM)	Particulates (mg/m^3)	CO (PPM)	Carbon (ug/m^3)
11:12	0.0	0.0	0.0	0.000	0	0.619
11:14	0.0	1.0	-1.5	0.048	4	9.246
11:16	0.0	0.3	-0.3	0.026	4	13.381
11:18	0.0	0.3	-0.3	0.014	3	10.365
11:20	0.0	0.1	-0.1	0.007	2	7.406
11:22	0.0	0.2	-0.2	0.001	2	5.235
11:24	0.0	0.1	-0.1	0.000	1	3.937
11:26	0.0	0.1	0.0	0.001	1	3.108
11:28	0.0	0.1	0.0	0.000	1	2.327
Note: Negative Readings for SO_2 were the result of gross interference caused by the presence of NO_2 interacting with the SO_2 detector under the low level presence SO_2.						

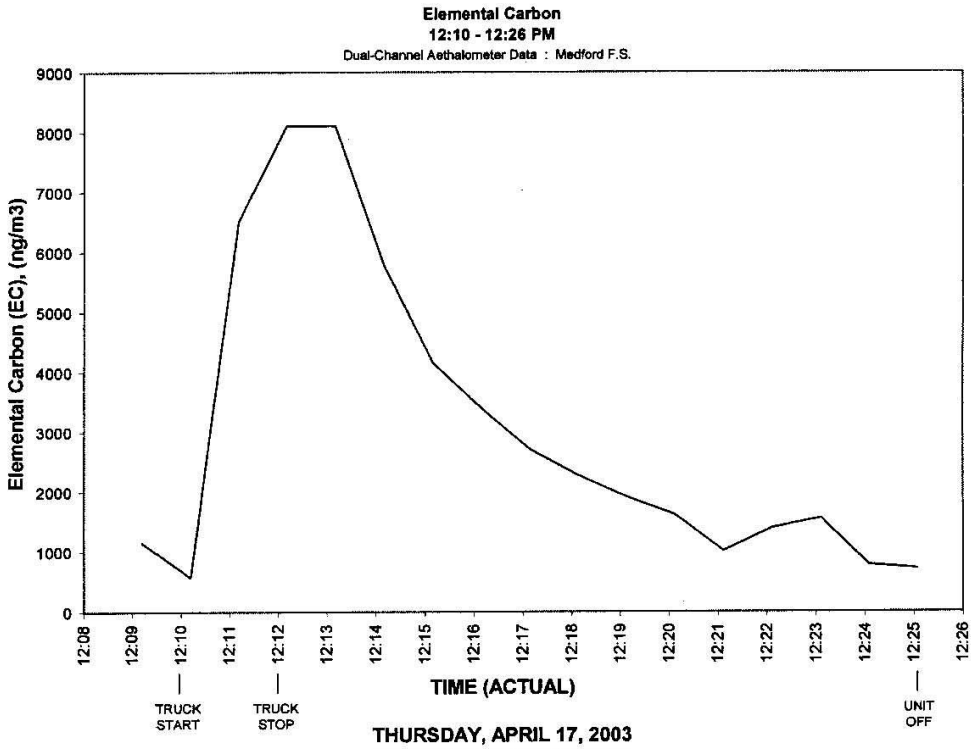


THURSDAY, APRIL 17, 2003
EXERCISING OF TRUCK ENGINE
FIGURE 3.0

Monitoring Results (Continued)

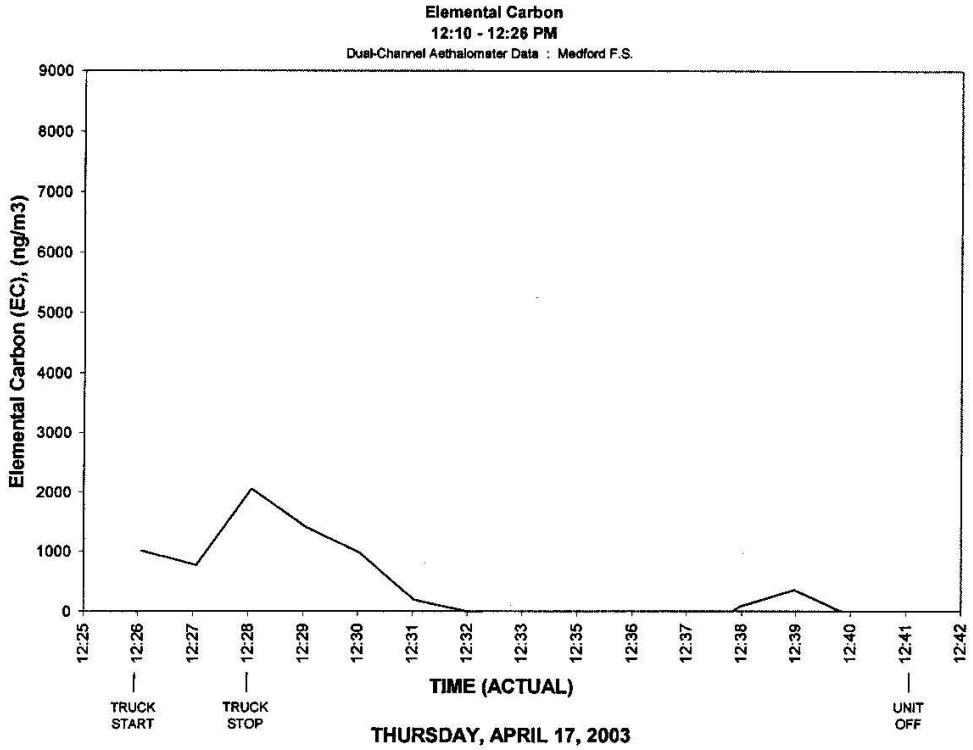
Table 3.0: AirMATION Unit Evaluation.
Truck Start: 11:48 Truck Run: 3.5 Minutes

Time	VO (PPM)		NO_2 (PPM)		SO_2 (PPM)		Particulates (mg/m^3)		CO (PPM)	
	Intake	Exhaust	Intake	Exhaust	Intake	Exhaust	Intake	Exhaust	Intake	Exhaust
11:52	0.0	0.0	0.3	0.1	0.1	0.1	0.009	0.000	8.0	6.0
11:57	0.0	0.0	0.2	0.1	0.1	0.1	0.000	0.000	2.0	2.0



THURSDAY, APRIL 17, 2003
UNIT EVALUATION/INTAKE
FIGURE 4.0

Monitoring Results (Continued)



THURSDAY, APRIL 17, 2003
UNIT EVALUATION/EXHAUST
FIGURE 5.0

Regulatory Guidelines

Table 4.0: Air Quality Regulatory Guidelines

	NIOSH[1]	OSHA[2] PEL*	ACGIH[4] TLV/STEL	(Short Term) ASHRAE[3]/BOCA[5]	Highest Reading on April 17, 2003
VO	*	*	---	---	0.0
NO_2	1 ppm	5 ppm	3.0/5.0 ppm	---	1.0 ppm
SO_2	2 ppm	5 ppm	2.0/5.0 ppm	0.14 ppm (24 Hour Average)	0.1 ppm
CO[6]	35 ppm	50 ppm	25 ppm	9 ppm (8 Hour Average) 35 ppm (1 Hour Average)	8.0 ppm
Particulates	---	5 mg/m^3	3.0 mg/m^3	150 mg/m^3 (24 Hour Average)	0.048 mg/m^3
Diesel Exhaust Particulates	---	---	0.02[7] mg/m^3	---	0.0144 mg/m^3

* Establishes exposure limits for individual Volatile Organic Compounds

[1] National Institute for Occupational Safety & Health REL (Recommended Exposure Limit/10 Hour Time Weighed Average)

[2] Occupation Safety & Health Administration PELS (Permissible Exposure Limit/8 Hour Time Weighed Average)

[3] American Society of Heating, Refrigerating and Air Conditioning Engineers

[4] American Conference of Governmental Industrial Hygienists; Threshold Limit Value (Average Over 8 Hour Workshift)/Short Term Exposure Limit (Over 15 Minute Period).

[5] Building Officials and Code Administrators International, Inc.

[6] Section M-1605.6 Public Garages, BOCA stipulates that mechanical ventilation systems for public garages are not required to operate continuously where the system is arranged to operate automatically upon detection of a concentration of carbon monoxide of 25 ppm by approved automatic detection devices.

[7] Proposed TLV for Diesel Exhaust Particulates measured as Elemental Carbon.

Study Report Findings

"The purpose of this evaluation was to determine the effectiveness of the AirMATION® unit in reducing concentrations of specific contaminants in air associated with diesel engine combustion fumes emitted within a firehouse. The AirMATION unit has a multiple stage filter capacity that removes particulates and…contaminants associated with vehicle exhaust smoke, soot and fumes…The results of TTI's evaluation have confirmed the operating characteristics and effectiveness of the AirMATION unit…In summary, the results of this evaluation indicate that the AirMATION unit rapidly reduces air contaminant concentrations associated with diesel combustion under these test conditions…Generally, none of the air contaminants evaluated in this study were measured at concentrations above any regulatory limits/standards."

AirMATION® is a registered trademark of Biological Controls.

Discussion of Findings

The purpose of this evaluation was to determine the effectiveness of the AirMATION unit in reducing concentrations of specific contaminants in air associated with diesel engine combustion fumes emitted within a firehouse. The AirMATION unit has a multiple stage filter capacity that removes particulates and a large variety of contaminants associated with vehicle exhaust smoke, soot and fumes. Airborne contaminants that are not effectively removed by the unit are rapidly diluted due to its high volume air handling capacity.

The results of TTI's evaluation have confirmed the operating characteristics and effectiveness of the AirMATION unit. Airborne contaminants for which the unit has a high capacity for removal including total particulates (0.1 to 10 microns) and elemental carbon aerosol particles were rapidly reduced in concentration during the initial 10 minute operating period of the AirMATION unit. Reduction of total particulates was between 85% and 100% in the first six (6) minutes for the breathing zone test runs and 100% in the first five (5) minutes for the unit evaluation test run. Elemental carbon aerosol particle concentrations were reduced by 59% and 60% during the initial peak six (6) minute period. A further reduction of 85% and 83% was documented over the full 15 minute period of AirMATION unit operation. The unit evaluation test run for elemental carbon illustrated by Figure 4.0 (Intake) demonstrates a reduction of 90% during the 15 minute period of operation. The test run for the exhaust (Figure 5.0) compared to the intake test run illustrates a relatively flat line indicating the effective removal of carbon aerosol particles.

The contaminants NO_2 and CO were also rapidly reduced in concentration during the initial 10 minute operating period of the Air MATION unit. The unit has a lower capacity for removal of these contaminants. Reduction of NO_2 was 83% and 90% in the first six (6) minutes for the breathing zone test runs. A further reduction of 90% and 100%, respectively, was documented over the full 15 minute period. Similar reductions were noted for CO in the breathing zone test runs where concentrations decreased by 86% and 50% in the initial peak six (6) minute period and by 86% and 75%, respectively, over the full 15 minute operating period. The unit evaluation test run for NO_2 showed an instantaneous reduction of 67% initially. The instantaneous reduction in CO concentration was 25%, this being the result of dilution caused by high volume air handling capacity. Volatile Organic compounds and SO_2 were not a factor in the study since these compounds were generally not present at detectable concentrations throughout the testing period.

In summary, the results of this evaluation indicate that the AirMATION unit rapidly reduces air contaminant concentrations associated with diesel combustion under these test conditions. Air contaminant concentrations are reduced to background or near background levels within 15 minutes of initial start up of the fire truck under normal operating conditions in the firehouse. Since the Medford Union Fire Company firehouse has a low ceiling, it can be assumed that the AirMATION unit will be more effective in reducing airborne contaminant concentrations in firehouses with a more typical, higher ceiling. Generally, none of the air contaminants evaluated in this study were measured at concentrations above any regulatory limits/standards. The highest instantaneous concentration for elemental carbon at 0.0144 mg/m^3 was below the ACGIH Proposed TLV of 0.02 mg/m^3 for diesel exhaust particulates measured as elemental carbon.

Thank you for allowing TTI the opportunity to assist you with this project. If you have any questions or require additional information, feel free to contact the undersigned at any time at (856) 985-8800 extension 15.

Respectfully Submitted,

TTI ENVIRONMENTAL, INC.

Richard Schneidereit
Vice President/Sr. Project Manager

RJS;ddc

c: Mr. Barry Scott, C.I.H.
Director of Safety & Loss Prevention
City of Philadelphia

Results of the test may differ in other fire stations

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