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U.S. ARMY SOLDIER AND BIOLOGICAL CHEMICAL COMMAND

ECBC-TR-065

USE OF POSITIVE PRESSURE VENTILATION (PPV) FANS TO REDUCE THE HAZARDS OF ENTERING CHEMICALLY CONTAMINATED BUILDINGS

PPV Guidelines

- The use of PPV fans dramatically decrease the interior chemical agent vapor concentration of structures. For example, PPV fans can reduce the vapor concentration by 50% - 70% within the first 10 minutes of use.
- PPV significantly increases the first responders' protection above and beyond the adequate protection provided by standard turnout gear with SCBA when rescuing known live victims.
- Before using PPV, consider the downwind hazard for unprotected people.
- Bigger fans are better. Two fans are better than one. Tilting the fan improves performance.
- Negative Pressure Ventilation (NPV) should be used at buildings where people are present in closed rooms at other locations within the building.

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July 2000

Aberdeen Proving Ground, MD 21010-5424

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13. ABSTRACT *(Maximum 200 words)* Fire fighters have used Positive Pressure Ventilation (PPV) fans to remove smoke from buildings before entry for rescue operations. A study was conducted to determine their effectiveness in removing chemical vapors from a building to afford quick rescue in the event that a terrorist bomb used chemical warfare agents. The testing was conducted in two phases. The first phase examined the ventilation rate of the building when PPV fans were used to determine the improvement in ventilation, and to determine how much vapor can be purged from a building within the first 10 minutes of PPV fan use. The second phase examined a mock rescue scenario in the same building by filling it with methyl salicylate and measuring the protection factor (PF) that fire fighters received while performing the rescue mission. This testing was performed according to standard Man in Simulant Test (MIST) procedures. Previous MIST testing of fire-fighter gear was used to compare the increased protection obtained through use of the PPV fans. The results show that the PPV fans were able to purge 47-72% of the vapors from the building within the first 10 min. The Ventilation rate was improved from 22 to 43% (over the natural rate), depending upon the fan combination used. Protection of fire fighters was increased up to 27 times when the PPV fans were used. Bigger, gasoline-driven fans were better, and tilting the fans improved performance.

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EXECUTIVE SUMMARY

ARE YOU PROTECTED?

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PPV Guidelines

- The use of PPV fans dramatically decrease the interior chemical agent vapor concentration of structures. For example, PPV fans can reduce the vapor concentration by 50%-70% within the first 10 minutes of use.
- PPV significantly increases the first responders' protection above and beyond the adequate protection provided by standard turnout gear with SCBA when rescuing known live victims.
- Before using PPV, consider the downwind hazard for unprotected people.
- Bigger fans are better. Two fans are better than one. Tilting the fan improves performance.
- Negative Pressure Ventilation (NPV) should be used at buildings where people are present in closed rooms at other locations within the building.

This report contains information concerning testing of Positive Pressure Ventilation (PPV) fans for use by emergency first responders in the event of a terrorist attack that employs Chemical Warfare Agents (CWA) on a U.S. site. This work has been completed by the Edgewood Chemical and Biological Center (ECBC) as a special task under the Domestic Preparedness (DP) program. The DP program was formed under the 1996 Nunn-Lugar-Domenici law to provide expert help for the first responder community at the state and local level in preparing for a potential chemical or biological terrorist attack. Initial testing at the Edgewood Man In Simulant Test (MIST) Facility examined the protection provided to fire-fighters against CWA by their

protective clothing, the Firefighter Protective Ensemble (FFPE – Bunker Gear) with Self-Contained Breathing Apparatus (SCBA). This testing (known as Man In Simulant Testing, or MIST) determined the Overall Protection Factor (PF) of the bunker gear with SCBA suit ensemble. The Overall PF is determined by wearing the suit inside a chemical vapor environment and measuring the ratio of vapor concentration outside the suit to the concentration on the inside of the suit (at several different skin locations). The ratios from the different skin areas are then weighted according to the sensitivity of the skin at each region and summarized to determine the Overall PF. This initial testing showed that the Bunker Gear with SCBA provided just enough protection for quick rescue missions in areas where CWA is present; however, it was desired to further increase the protection offered to the fire-fighters in these situations.

As a follow-on complementary effort, the use of Bunker Gear with SCBA, combined with the use of PPV fans to reduce exposure concentrations during quick rescue responses was tested. Employment of PPV fans to clear CWA from buildings was investigated because they have been used very effectively for clearing out smoke from burning buildings, and most fire-fighters across the country have them already as part of their normal duty equipment. This PPV testing determined the "Combined PPV and Bunker Gear Protection Factor (PF)" to evaluate the increased protection offered to the fire-fighters who are responding to a CWA incident by simultaneously using PPV fans (to reduce the concentration of CWA vapors in a contaminated building) and wearing Bunker Gear with SCBA (and a Quick-Fix of Self-Taping). The "Combined PPV and Bunker Gear PFs" were then compared to the Overall PFs from the initial MIST tests where only the FFPE w/SCBA ensemble was evaluated without using PPV. This evaluation determined the additional protection provided to the firefighter when using PPV to reduce vapor concentrations in a building compared to not using PPV.

It is imperative, however, that the firefighter must assess the scene of the CWA incident, prior to the use of PPV, to ensure that there are no downwind hazards (unprotected people) from the building's door, windows, or other opening that is selected as the PPV exit point. If there are unprotected people downwind they must be evacuated immediately, or PPV should not be employed unless a different opening can be used as the exit point and poses no downwind hazard.

The first portion of this project examined the use of PPV fans through scientific testing to remove chemical contamination from a typical building structure. Different sizes and configurations of fans were used in this testing to include the most commonly used PPV fans (16-inch electric and 20-inch gas) along with some larger fans and series combinations with multiple

fans. The results of this testing showed that the use of PPV fans can reduce the concentration significantly in building areas that have been contaminated with CWA. The use of these fans resulted in the following average drop in concentration for the various PPV fans tested (see Table 1). These concentration reductions occurred during the first ten minutes of use (this is a key concept in that it only takes 5 to 10 minutes for a PPV fan to purge the majority of the vapor contamination from a building).

Table 1. Concentration Reductions and Rate of Ventilation Improvement (RVI)

Concentration Reduction after 10 min. of Use	Phase 1 Average Rate of Ventilation Improvement (RVI)	PPV Fan Configuration (distance measurements identify the location of the fan from the entrance door)
72%	43	One 30-inch Gas Fan at 9' from door, PPV Mode
71%	42	Two 20-inch Gas Fans in Series, 1st tilted 20° at 5' from door, 2nd straight at 9', PPV Mode
65%	37	Two 20-inch Gas Fans in Series (no tilting) at 3'6" and 9' from door, PPV Mode
64%	35	One 20-inch Gas Fan, tilted 20°, at 4' from door, NPV* Mode
63%	32	One 20-inch Gas Fan, tilted 20° at 5' from door, PPV Mode
57%	26	One 20-inch Gas Fan at 9' from door, PPV Mode
55%	26	One 24-inch Electric Fan at 9', PPV
50%	24	One 24-inch Electric Fan at 4', NPV
47%	22	Two 16-inch Electric Fans stacked at 10' 4", PPV

* NPV is Negative Pressure Ventilation where the fan is placed inside the building approximately 4 feet from an open doorway. Also the fan faces the doorway to blow air out the doorway (i.e., the doorway is the exit point for ventilation). Fans used in the Negative Pressure Ventilation (NPV) mode draw air out of the building instead of pushing it in, as is done in the PPV mode.

The improvement in the ventilation rate of the building (over the natural rate) followed similar patterns, and ranged from around 42 times (30-inch gas fan and two 20-inch gas fans in series) to 22 times (16" electric fans) the natural ventilation rate. An evaluation of the effects on interior rooms closed off to the rest of the building (interior doors closed) showed that the use of PPV fans drove the tracer gas into the rooms. Fans used in the Negative Pressure Ventilation (NPV) mode (drawing air out of the building instead of pushing it in) were evaluated and determined to be the preferred method for quick concentration reduction of CWA (when interior rooms with closed doors exist in the building) because they did not cause the gas to be driven into the rooms.

Additional protective clothing MIST testing was performed during the second portion of this study to examine the improvement provided through the use of the PPV fans during several live rescue mission scenarios. The results of this portion of the testing showed that the "Combined PPV and Bunker Gear Protection Factor (PF)" increased the fire-fighters' protection a tremendous amount when the PPV fans were used. A summary of the average "Combined PPV and Bunker Gear PFs" and the Rate of Improvement (ROI) of protection provided to the fire-fighter when using PPV fans (while responding in Bunker Gear) as compared to responding without the use of PPV fans is shown below. This ROI determines how much the use of PPV fans improves the fire-fighters' protection compared to not using PPV.

Table 2. Summary of Phase 2 PF Testing and Rates of Improvement

Test	PPV Fan Configuration Used	Combined PPV & Bunker Gear PF	Phase 2 Rate Of Improvement (ROI)
3	No PPV Fans (baseline)	21.3	1
1	One 20-inch Gas Fan at 10' 4", fan straight	73.1	3.4
4	Two 16-inch Electric Fans at 10' 4", fan straight	138.8	6.5
2	Two 16-inch Electric Fans at 10' 4", fan straight	203.3	9.6
6	One 20-inch Gasoline Fan at 12' 6", fan tilted 20°	255.3	12.0
5	One 20-inch Gasoline Fan at 5', fan tilted 20°	564.3	26.5

The Combined PPV and Bunker Gear PF values improved from an average value of around 21 (value measured with no PPV fan) to 73 with one 20-inch gas fan; to 139 and 203 with two 16-inch electric fans; and to 255 and 564 with one 20-inch gas fan (tilted). The best results were obtained during test 5 (average PF of 564) when one 20-inch gas fan was used in the tilted mode at a predetermined position that yielded the best pressurization of the building. Test 6 was conducted with the same fan, but was positioned by the firefighter visually with streamers taped on the doorway. This resulted in about half the protection as the optimal fan location provided. Also, during test 4 the electric fans were inadvertently not started 5 minutes prior to the fire-fighters entry, as was done in all the other tests. Comparing to test 2 where the electric fans were started prior to the fire-fighters entry demonstrates how starting the PPV fans for just 5 minutes in advance can improve protection significantly. In summary, **all of these test measurements show that the use of PPV fans will improve the protection of fire-fighters to a great degree if they must perform rescue missions in buildings that have been contaminated with CWA.**

PREFACE

The work described in this report was funded by the Domestic Preparedness Program. The work was started in May 1998 and completed in December 1998.

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The author also acknowledges the contributions of Steve Marshall (Engineering Directorate), and William Ahearn, Brenda Cannon, and Dennis Reeves (Research and Technology Directorate) who assisted in conducting the tests.

It is written "*Greater love hath no man than this, that he lay down his life for his friends.*" This report is dedicated to all those who have done this, and to those fire fighters who put their lives at risk everyday to save people they do not know. Thank you all, from the bottom of my heart. I pray that the work performed in this study will help fire fighters throughout the nation and around the world if they have to deal with a situation in which chemical weapons have been used.

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USE OF POSITIVE PRESSURE VENTILATION (PPV) FANS TO REDUCE THE HAZARDS OF ENTERING CHEMICALLY CONTAMINATED BUILDINGS

1. INTRODUCTION AND BACKGROUND

This report contains information concerning testing of Positive Pressure Ventilation (PPV) fans for use by emergency first responders in the event of a terrorist attack that employs Chemical Warfare Agents (CWA) on a U.S. site. PPV fans have been used during fire rescue operations to clear the smoke out of burning buildings so that quick rescue can be made. The practice of using PPV fans in this manner has been widely accepted and clearly documented as an effective method for reducing the hazard of rescue and increasing the safety of fire fighters. Most fire fighters across the country have them already as part of their normal duty equipment. It was decided (through the Domestic Preparedness (DP) Program at Aberdeen Proving Ground) to investigate the effectiveness of using these fans to reduce the concentration of CWA (or any other vapor HazMat material) in buildings that have been contaminated by terrorists (or chemical accidents). A study was undertaken to document the results in a scientifically valid report. If the fans were effective in reducing the concentration in simulated conditions, they could also be used to reduce the hazard of rescue operations at actual chemical terrorist incidents to quickly reduce the concentration of agent in the building before fire and rescue personnel enter. Rescue personnel would wear Self-Contained Breathing Apparatus (SCBA) for respiratory protection and Bunker Gear for skin protection for rescue operations of living victims only. Reducing the vapor concentrations in the building before the rescue operation begins would reduce the potential skin absorption hazard to rescue personnel when they enter ***(note: respiratory protection should always be used at a scene where chemical contamination is suspected)***. The Edgewood Chemical and Biological Center (ECBC) completed this work as a special task under the DP program to evaluate the increased protection provided to fire fighters and emergency rescue personnel when they use PPV fans to reduce the concentration in buildings under these circumstances. This report outlines the testing and shows the benefits of using these fans in this situation and in other instances of chemical contamination of buildings.

The DP program was formed under the 1996 Nunn-Lugar-Domenici law to provide expert help for the first responder community at the state and local level in preparing for a potential chemical or biological terrorist attack. Initial testing at the Edgewood Man In Simulant Test (MIST) Facility examined the protection provided to fire fighters against CWA by their protective clothing, the Fire-Fighter Protective Ensemble (FFPE – Bunker Gear) with Self-Contained Breathing Apparatus (SCBA). This testing (known as Man In Simulant Testing, or MIST) determined the Overall Protection Factor (PF) of the Bunker Gear suit ensemble with SCBA. The Overall PF is determined by wearing the suit inside a chemical vapor environment and measuring the ratio of vapor dosage outside the suit to the dosage on the inside of the suit (at several different skin locations). The ratios from the different skin areas are then weighted according to the sensitivity of the skin at each region and summarized to determine the Overall PF. This initial testing showed that the Bunker Gear with SCBA provided enough protection for quick rescue missions in areas where CWA is present; however, it was desired to further increase the protection offered to the fire fighters in these situations.

Results of the initial MIST testing of Bunker Gear with SCBA are documented in a report[1] prepared by the U.S. Army Soldier Biological and Chemical Command (SBCCOM). This report is entitled "Guidelines for Incident Commanders Use of Firefighter Protective Ensemble (FFPE) with Self-Contained Breathing Apparatus (SCBA) for Rescue Operations During a Terrorist Chemical Agent Incident". This referenced report is not only a companion report to this PPV report, but also provides rescue stay times for standard turnout gear and for several Quick-Fixes (i.e., duct taping openings such as wrists, ankles, etc.) applied to standard turnout gear. The PPV fan would be set in place while other rescue personnel are suiting up and applying Quick-Fixes (i.e., duct-taping openings at wrists, ankles, fly, and waist). Standard Bunker Gear and SCBA should be worn while setting the PPV in place.

This testing was a follow-on effort to evaluate the increased protection fire fighters received from both the use of the Bunker Gear (with SCBA) and the use of PPV fans to lower the chemical exposure during quick rescue operations. Therefore, this testing determined the "Combined PPV and Bunker Gear Protection Factor (PF)" that the fire fighters received when they used the PPV fans in addition to wearing the Bunker Gear during rescue operations in buildings where terrorists use nerve agent or mustard gas. This is the scientific measurement of the increased protection the fire fighters who are responding to a CWA incident receive by simultaneously using PPV fans (to reduce the concentration of CWA vapors in a contaminated building) and wearing Bunker Gear with SCBA (and a Quick-Fix of Self-Taping). The Combined PPV/Bunker Gear PFs were then compared to the Overall PFs from a test where only the FFPE w/SCBA ensemble was evaluated without using PPV.

The PPV use procedures (for smoke) are explained briefly here. Upon arrival at a burning building, fire-fighters get out and start up the PPV fan. They open the main door leading into the building and direct the flow of air into that door. Fans are generally placed in front of the door at a distance of between six and nine feet. Streamers are taped around the edge of the door and the flow from the fan is directed in so that all streamers will be caught in the wind and their motion is directed into the building. If streamers are directed out of the building (indicating some backward flow out of the building at the top of the door), the fan may be moved or tilted back in order to fully cover the door opening with air. A window or door is then opened (or window broken/door knocked down) at the opposite end of the building to allow for an exit point of the smoke.

WARNING

It is imperative, however, that the fire fighter must assess the scene of the CWA incident, prior to the use of PPV, to ensure there are no downwind hazards (unprotected people) from the building's door, windows, or other opening that is selected as the PPV exit point. If there are unprotected people downwind they must be evacuated immediately, or PPV should not be employed unless a different opening can be used as the exit point and poses no downwind hazard.

NOTE: RESPIRATORY PROTECTION (SCBA) SHOULD ALWAYS BE USED AT A SCENE WHERE CHEMICAL CONTAMINATION IS SUSPECTED.

Using PPV fans for purging vapors from buildings has certain limitations for its safe and effective use. The use of PPV fans can force the agent to spread to other zones of a building (for example, when the agent has been released in the lobby of a multi-story building and

occupants have not been evacuated from upper floors). In such cases, negative pressure ventilation would be preferable, although the efficiency of PPV fans is generally thought to be less in the depressurization mode than in the pressurization mode. However, during this testing it was found that negative pressure ventilation was just as efficient as positive pressure ventilation and in one case slightly more efficient. Also, driving agent out of the building (whether by positive or negative pressure ventilation) can create a hazard to people downwind of the building. One objective of this study, therefore, was to define parameters and conditions for the safest and most effective employment of PPV fans. A list of the main objectives of this study is given here; these included:

1. To measure the reduction in concentration inside a typical building structure when different PPV fan configurations are used. Measurement of the reduction during the first ten minutes of operation was performed.

2. To determine the increase in the ventilation rate of the building when the different PPV fans are used. Building ventilation rates were measured with no PPV fans and when different PPV fans were used.

3. To determine if agent will be forced into other "closed" rooms in the building during use of the PPV fans and to measure the infiltration rates. Agent concentration was monitored in "closed" rooms within the main building structure.

4. To determine if excessive amounts of carbon monoxide (CO) are produced inside the building when gasoline-powered PPV fans are used. Carbon monoxide levels were monitored inside the building while gasoline-powered PPV fans were being used.

5. To measure increases in firefighter protection produced by using PPV fans at buildings contaminated with chemicals. MIST methods were used to directly measure firefighter protection.

2. SCOPE OF TESTING

This testing was conducted in two main phases. Phase 1 examined the ventilation rates of a building in both the natural (without PPV) and forced air environments with PPV. The difference between the natural and forced ventilation rate was used to determine the improvement to the ventilation rate from using the PPV fans. Phase 2 examined the use of the PPV fans in the same building during a live-rescue mission scenario in which fire fighters used the fans to clear out chemical vapors from the building before entering for a simulated rescue of six 160 pound dummies. Standard MIST testing was used in this phase to determine the increased protection the fire fighters received from using the PPV fans in addition to the protection they received from the Bunker Gear (i.e., the "Combined PPV/Bunker Gear PF"). Additional testing was performed (during the ventilation testing) to evaluate whether contamination was transferred to closed interior rooms when PPV fans were used; this testing was conducted using fans in the positive and negative pressure ventilation modes. One final set of tests was also conducted to determine how much Carbon Monoxide (CO) was produced inside the building during one set of the PPV tests with a gasoline-powered fan operated inside the building in the negative pressure mode.

2.1 Scope of Phase 1 Ventilation Rate Testing.

The first portion of this project examined the use of PPV fans through scientific testing to remove chemical contamination from a typical building structure. Different sizes and configurations of fans were used in this testing to include the most commonly used PPV fans (16-inch electric and 20-inch gas) along with some larger fans and series combinations with multiple fans. The ventilation rates of the building chosen for this study were determined from the data obtained in the chemical removal tests for both the natural (without PPV) and forced air (using PPV fans) environments. Evaluation of the protection offered through use of the different PPV fan combinations in Phase 1 was determined by making a direct comparison of the difference in ventilation rates between the natural and the forced (use of PPV) rates.

In Phase 1, the tracer gas Sulfur HexaFluoride (SF_6) was used at an initial concentration of at least 100 ppm. The concentration of SF_6 during the use of the PPV fans was measured until the level fell below 10 ppm. Eight Miniature InfraRed gas Analysers (MIRANs) were used to monitor the tracer gas at six locations inside the building and in two interior room locations (rooms 1 and 3). The building dimensions are shown in Figure 1. The six locations for monitoring in the building and the location of interior rooms are shown in Figure 2 below.

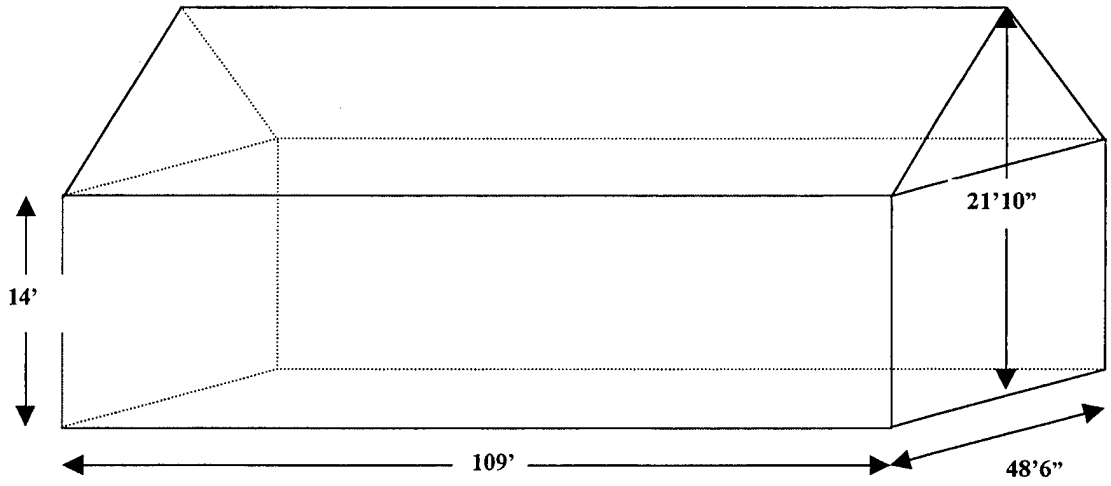

Figure 1. Dimensions of Building E5840.

The fans selected and used in this testing included both gasoline and electrically powered engines. Several different sizes of the PPV fans ranging from 16-inch to 30-inch diameter were also used. A complete list of the fans used during Phase I testing and their specifications is included below.

- 16-inch Electric, SuperVac Model P164S, rated flow 5200 cfm
- 24-inch Electric, SuperVac Model P244S, rated flow: 10800 cfm
- 20-inch Gasoline, SuperVac Model 720G4, rated flow 16895 cfm
- 30-inch Gasoline, SuperVac Model 730G4, rated flow: 26734 cfm

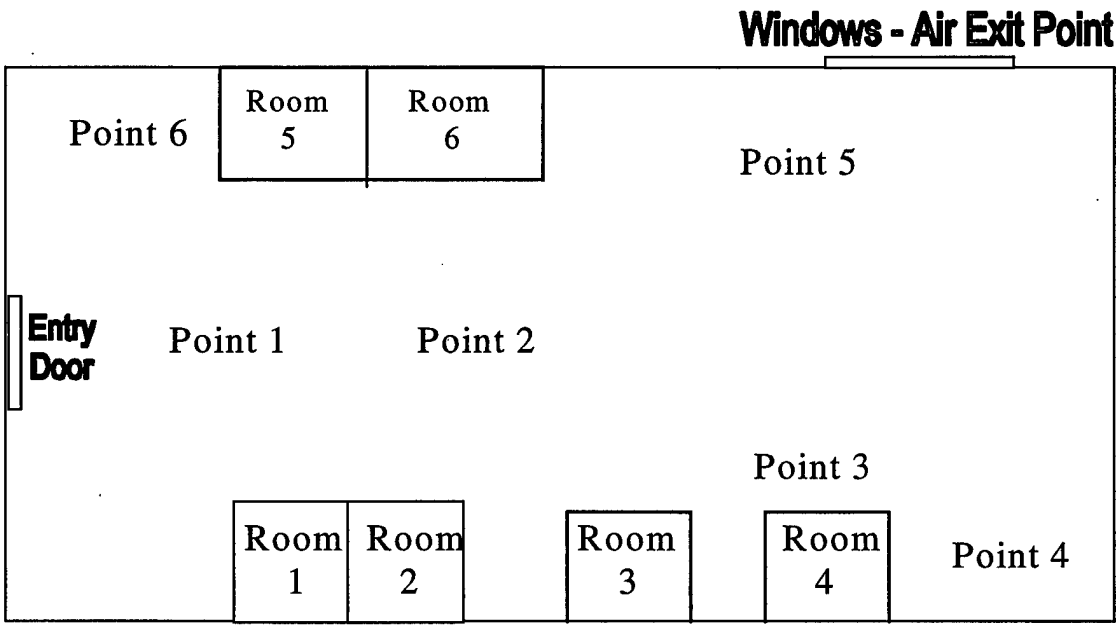

Figure 2. Floor Layout and Monitoring Locations in Building E5840

The different sizes of fans used allowed for a comparison of the range of PPV fans that are most commonly used and/or are available in the fire-fighter industry. A complete list of the fan combinations used in Phase 1 and the number of trials conducted per fan configuration is listed in Table 3.

Table 3. Fan Configurations Used in Ventilation Rate Testing.

Test Series	Fan Configuration Used	Trials Performed
1	Two 16-inch Electric Fans Stacked at 10' 4" from door; positive pressure	3
2	One 20-inch Gasoline Fan at 9' from door; positive pressure	3
3	One 30-inch Gasoline Fan at 9' from door; positive pressure	2
4	Two 20-inch Gasoline Fans in Series, 3' 6" and 9' from door; positive pressure	3
5	One 24-inch Electric Fan at 9' from door; positive pressure	3
6	One 20-inch Gasoline Fan at 5' from door, tilted at 20°; positive pressure	2
7	Two 20-inch Gasoline Fans in Series, first fan tilted at 20°, 5' from door, Second fan (not tilted) at 9' from door; positive pressure	3
8	One 24-inch Electric Fan at 4' from door; negative pressure	3
9	One 20-inch Gasoline Fan at 4' from door, tilted at 20°; negative pressure	3

Photographs of each of the PPV fan configurations listed in Table 3 are shown below in Figures 3 through 11. The Figures are arranged numerically to correspond to the PPV fan configurations listed above (i.e., Figure 3 is Test Series 1, Figure 4 is Test Series 2, Figure 5 is Test Series 3, etc.).

Figure 3. Test Series 1: Two 16" Electric Fans, Stacked

Figure 4. Test Series 2: One 20" Gasoline Fan

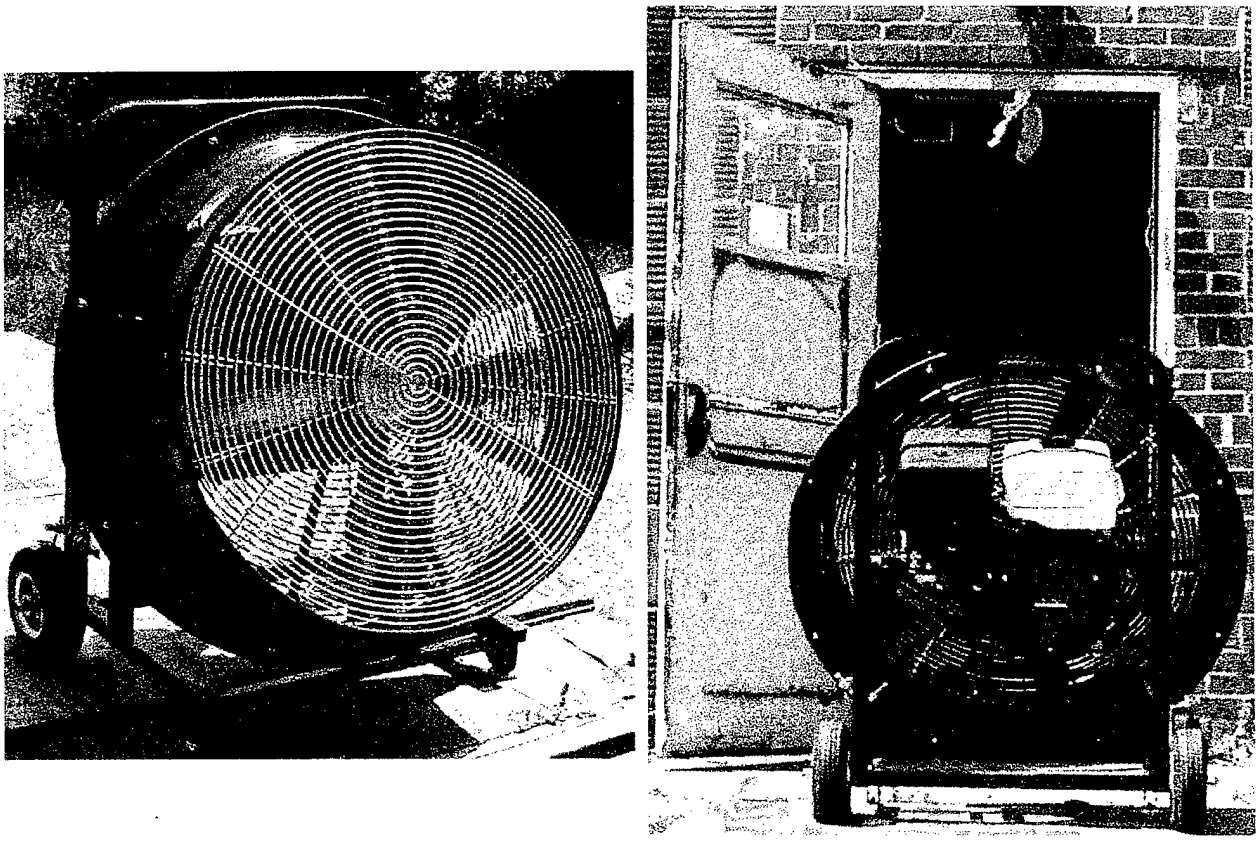

Figure 5. Test Series 3: Single 30" Gasoline Fan; Front View and in Test Position

Figure 6. Test Series 4: Two 20" Gasoline Fans in Series

Figure 7. Test Series 5: One 24" Electric Fan, Positive Pressure Mode

Figure 8. Test Series 6: One 20" Gasoline Fan Tilted, Positive Pressure Mode

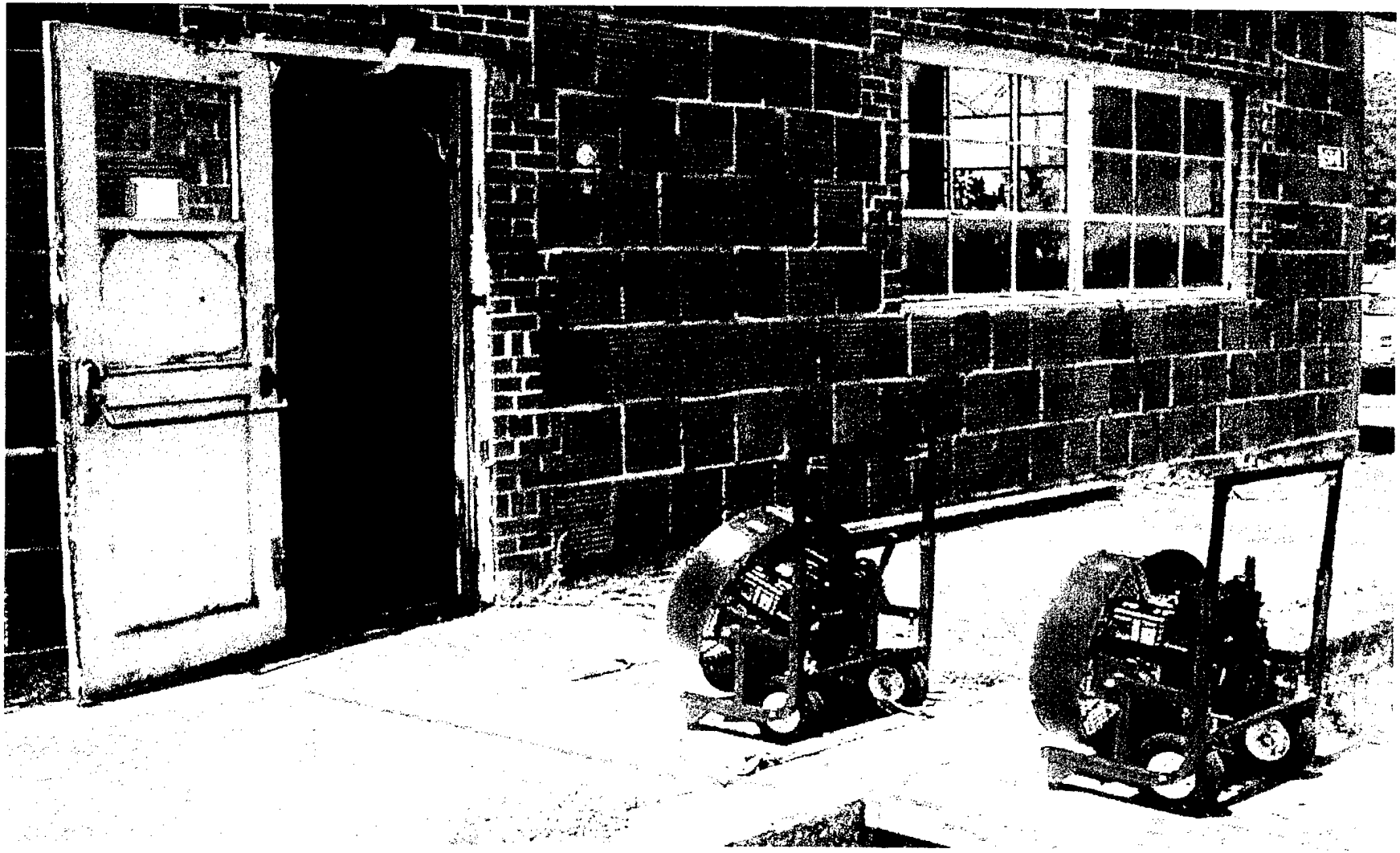

Figure 9. Test Series 7: Two 20"Gas Fans in Series, First Fan Tilted

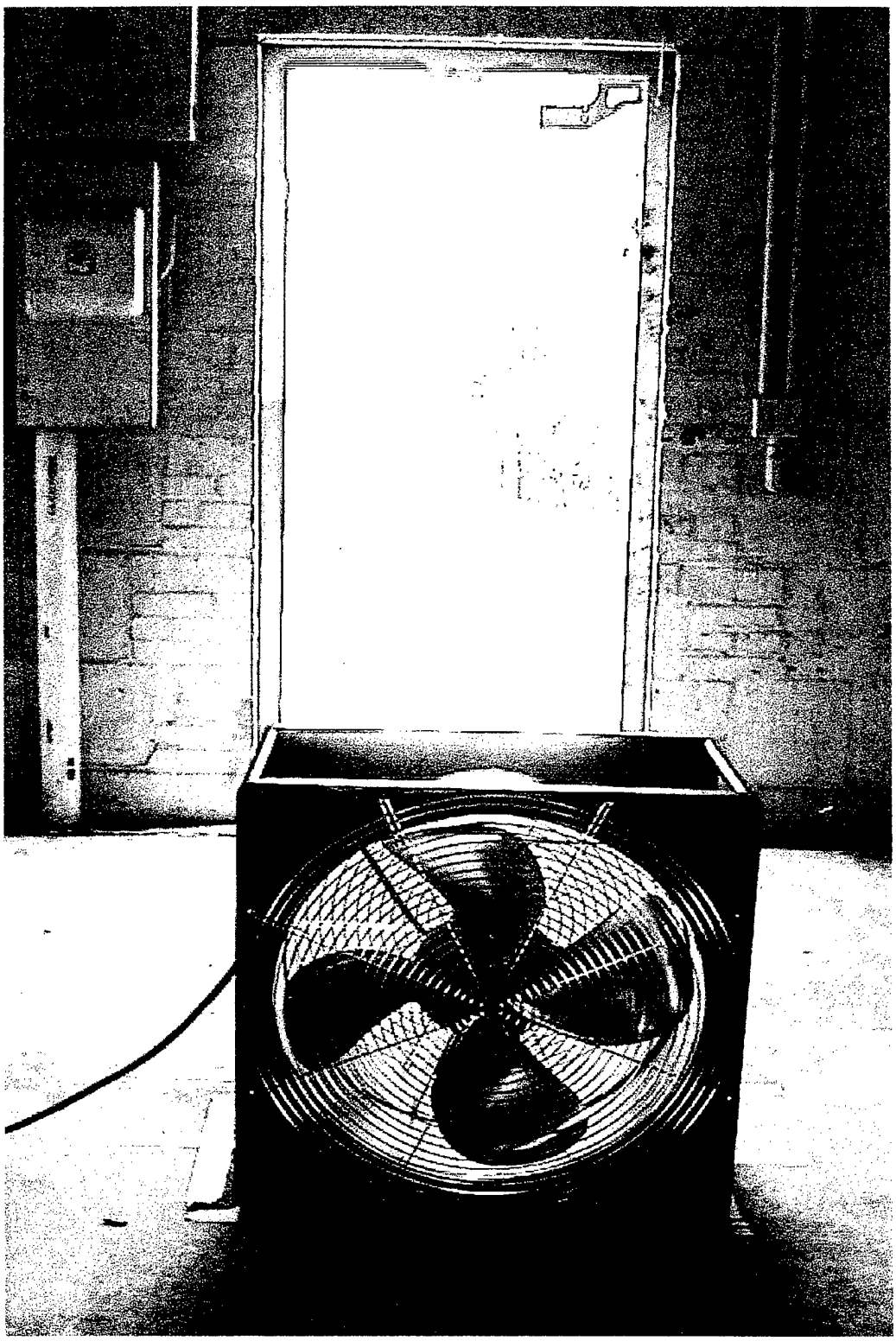

Figure 10. Test Series 8: One 24" Electric Fan, Negative Pressure Mode

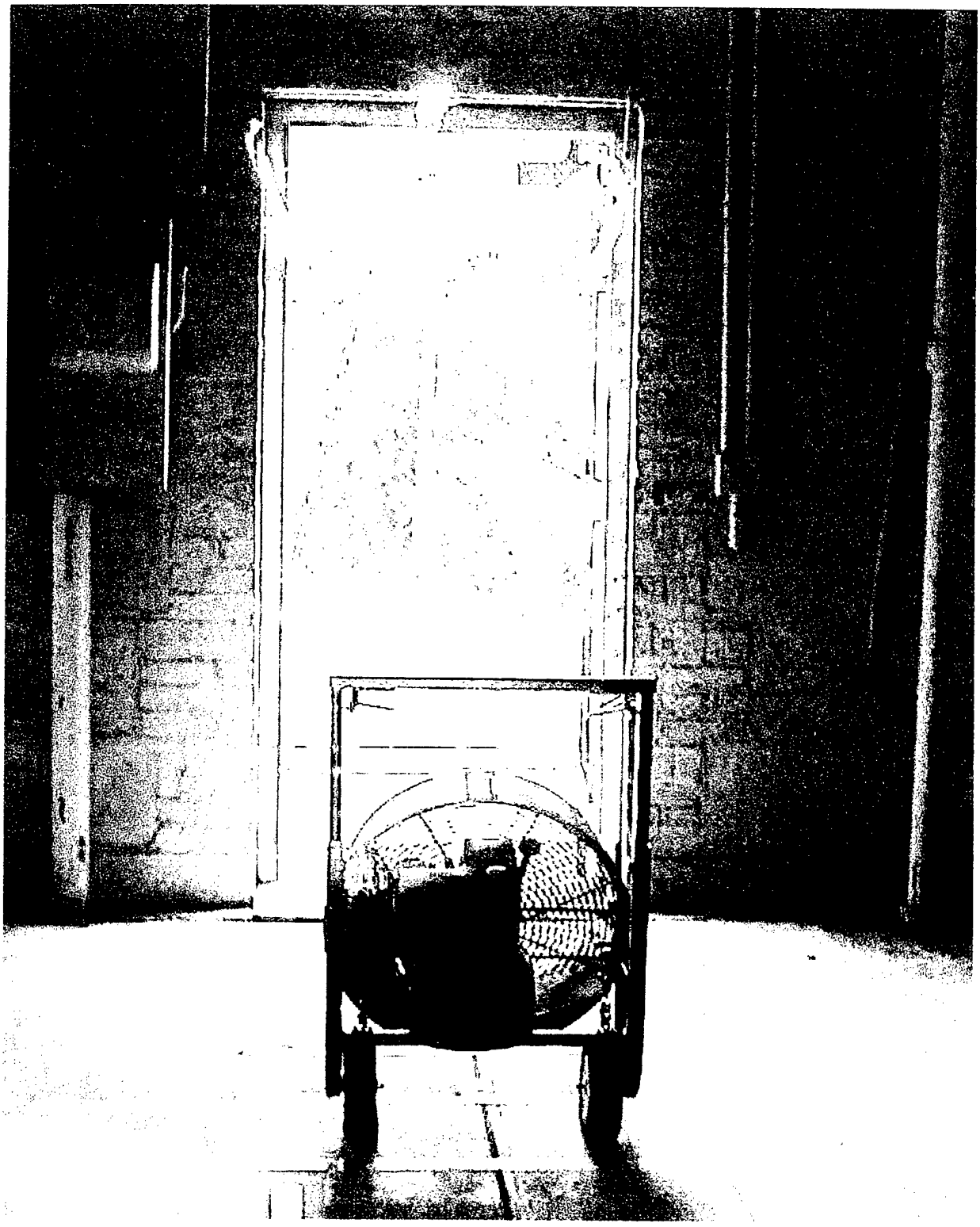

Figure 11. Test Series 9: One 20" Gasoline Fan Tilted, Negative Pressure Mode

2.2 Scope of Phase 2 Live Rescue Mission Test.

The testing conducted in Phase 2 examined the use of the PPV fans in the building during a rescue mission scenario in which fire-fighters (from Montgomery County Maryland) used the fans to clear out chemical simulant vapors before entering the building for rescue. Evaluation of the protection offered the fire fighters in Phase 2 was determined by measurement of the Combined PPV/Bunker Gear Protection Factor (PF) of the taped suit ensemble worn by each fire fighter using standard Man In Simulant Test (MIST) procedures. A single test was also conducted without using the PPV fans, as a baseline, to evaluate the improvement to the Combined PPV/Bunker Gear PFs when the PPV fans were used. All test results were scored according to this baseline test to determine the percentage improvement. *Any difference in PFs from these tests is the direct result of the PPV fans reducing the concentration of vapor inside the building.*

The testing conducted in Phase 2 (the Rescue Mission) consisted of six 30-minute trials with a four-man rescue squad inside a building contaminated with Methyl Salicylate (MeS). The initial concentration of MeS inside the building was set at 50±5 mg/m^3. Only the double 16-inch Electric fan combination and the single 20-inch Gasoline fan were used in Phase 2; *these fans were selected because they are the most commonly used fans across the country by fire-fighters*. It was clear after the Phase 1 testing was completed that the bigger fans would provide even more protection to fire fighters in a live rescue scenario; however, it is unlikely that many fire companies across the country have these larger fans.

Of the six trials conducted in the live rescue mission scenario, two repetitions of the double 16-inch fan were tested, three tests of the single 20-inch Gasoline fan were performed, and one baseline test (where no PPV fan was used) was performed. The double 16-inch fan was positioned at a location that was 10 feet, 4 inches from the door during those tests. The single 20-inch Gasoline fan configuration was varied between the three tests to examine differences in protection during its use. The three configurations used were as described below:

- One test with the fan level (to produce straight flow of air into the building) at 10 feet, 4 inches from the door.
- One test with the fan tilted upward at an angle of 20° (so the airflow adequately covered the entire doorway) at 5 feet from the door. This location was the optimal position (determined through earlier testing) that produced the most pressure inside the building.
- One test with the fan tilted upward at an angle of 20° and set in place by the fire fighters at 12 feet, six inches from the door. This position was determined visually by the fire fighters using streamers taped to the door entrance to indicate adequate coverage of airflow through the doorway.

Real-time concentrations of MeS were monitored in six different locations inside the building, along with one additional interior room location (Room 1) during the Phase 2 testing (the MIRAN in Room 3 was not working during the Phase 2 testing, or this room would have been monitored also). One location was also monitored immediately outside the air exit point of the building with a Fourier Transform Infra-Red (FTIR) device to measure the vapor concentration leaving the building. Sampling on each of the firefighter's body was performed at seventeen locations according to the standard Man In Simulant Test (MIST) procedures.

3. TEST EQUIPMENT AND PROCEDURES

3.1 Phase 1, Ventilation Test Equipment and Procedures.

A brief description of the Ventilation test equipment and procedures is included in this section; complete procedures and equipment for this testing are included in Appendix A. Eight Miniature Infra-Red gas Analysers (MIRAN) were used to monitor the SF_6 tracer gas concentration at six locations inside the building, and at two interior room locations throughout the ventilation testing. All MIRANs were calibrated with tracer gas standards before the testing. The concentration data and time were continuously recorded on a custom built Data Acquisition System (DAS). Weather data was measured throughout the entire test period to determine wind speed, temperature, and relative humidity at locations inside and outside the building.

The optimum location (distance from the door) for use of the PPV fans during Phase 1 testing was determined experimentally (before the testing began) by measuring the maximum positive (or negative) static pressure that was induced inside the building when each fan combination was placed at various distances from the doorway. An electronic pressure transducer was used to record the pressures inside the building as the fan was moved away from the building's door. The first position measured was at the door; the fan was then moved back (in foot increments) until the maximum pressure was obtained. This fan location was then used for all of the ventilation tests. The best distances for the PPV fans were between 9 feet and 10 feet, four inches from the door with the fans pointed straight in at the door (no tilting). When the fan's airflow direction was tilted, the optimum distance was 5 feet from the door. The optimum distance for the NPV mode (fans inside the building blowing air out) was 4 feet from the door.

Basic procedures of the Ventilation test were to fill the building and/or rooms with the SF_6 tracer gas and continuously measure the concentration as it decreased (either naturally or through PPV forced ventilation). The baseline (natural) ventilation rate was measured first by filling the building and rooms with SF_6 gas and measuring the concentration as the building was naturally ventilated (through door/window seal crevices and wall structural leakage areas). The DAS was stopped after enough concentration readings were taken to adequately determine the natural ventilation rate of the building (usually around 2-3 hours).

After the baseline ventilation rate was determined, the building was refilled with SF_6 to determine the ventilation rate while the PPV fans were used. The interior rooms were closed during this part of the testing so no SF_6 would get in. The PPV fans were set in place and started; two windows on the opposite end of the building were opened up and used as the exit point for the fan's airflow. Concentration data was again recorded with the DAS while the building was ventilated by forced air from the PPV fan. After the concentration inside the building was brought down to at least 10% of the initial concentration, the doors for the closed rooms (inside the building) were opened so that improvements to the ventilation rate of these rooms could be measured. This portion of the ventilation testing generally took 30 to 60 minutes to complete one test.

The NPV trials were conducted with the same procedures except that the fans were located inside the building, facing outside to blow the tracer gas from the building. The exit points (opened windows at the opposite end of the building) then became the air entry points

for the building. Internal rooms remained closed and were not opened during the NPV trials because there was no build-up of tracer gas within these rooms.

The CO testing was performed after the last test using a single 20-inch gas fan (tilted upward at 20°) in both the positive pressure ventilation (PPV) mode and the negative pressure ventilation (NPV) mode. A Foxboro SAPPHIRE model MIRAN was used to measure the concentration of CO inside the building at two locations during this testing. The PPV fan was started outside the building and operated for 15 minutes while the CO monitors recorded the concentrations inside the building. After this time, the fan was taken inside and operated in the NPV mode for an additional 20 minutes.

3.2 Phase 2, MIST Test Equipment and Procedures.

The MIST test was conducted according to procedures used at the Edgewood MIST facility. These procedures follow the basic standard test procedures[2] in TOP 10-2-022. A brief outline of the procedures used is presented here; a complete description of the MIST test procedures and equipment is provided in Appendix B.

Sampling and dressing of test subjects was conducted in the MIST test facility's Clean-Room in Building E5354 in the Edgewood Area of Aberdeen Proving Ground, MD. The subjects were outfitted with the Passive Sampling Devices (PSDs) using the Natick patch sampler at seventeen locations on the body (see Figure 12 and Figure 13). These locations were chosen to correspond to locations contained in the Body Region Hazard Analysis[3] (BRHA) model, which is used to evaluate the PF for any protective suit ensemble. After subjects were dressed with the patch samplers and their Fire-Fighter Protective Ensemble (FFPE – PBI Bunker Gear), they were driven to Building E5840 to perform the rescue mission (see Figures 14 and 15).

A challenge concentration of MeS vapor was generated within the building with a hot-plate vapor generator; mixing fans were used to circulate the vapors within the building. The initial concentration was raised to 50±5 mg/m^3 and held there by the data acquisition system until the fire fighters arrived at the building. Six locations inside the building were continuously monitored for MeS (for feedback control through the DAS) by six calibrated Foxboro Miniature InfraRed Gas Analysers (MIRAN©). All MIRAN© readings were recorded by the DAS and the average was used to control the vapor generator.

When the fire fighters arrived at the building for the rescue mission, the PPV fans were set up and started by either the fire fighters or the test technicians (see Figure 16). It should be noted that for test purposes it isn't necessary for fire fighters to set up the PPV fans; the only requirement is that the fans be set up in the proper location. The fire fighters then added a Quick-Fix to their Bunker Gear (see Figure 17) by applying duct tape to their ankle/boot closure, to their glove/wrist closure, and around the waist (in the same fashion as the 'Self-Taped' configuration used in the earlier MIST testing[1]). After the Quick-Fix for the Bunker Gear was in place the fire fighters entered the building and performed the rescue mission (see Figures 18-20). Entry time was generally around 5 minutes after the PPV fans were started. Six 160-lb mannequins were rescued from the building within the 30-minute time set for the rescue mission. Then the fire fighters exited the building and rode back to the clean room area in Building E5354

Figure 12. Subject Having Patch Samplers Applied

Figure 13. All Samplers in Place Before Dressing in Bunker Gear

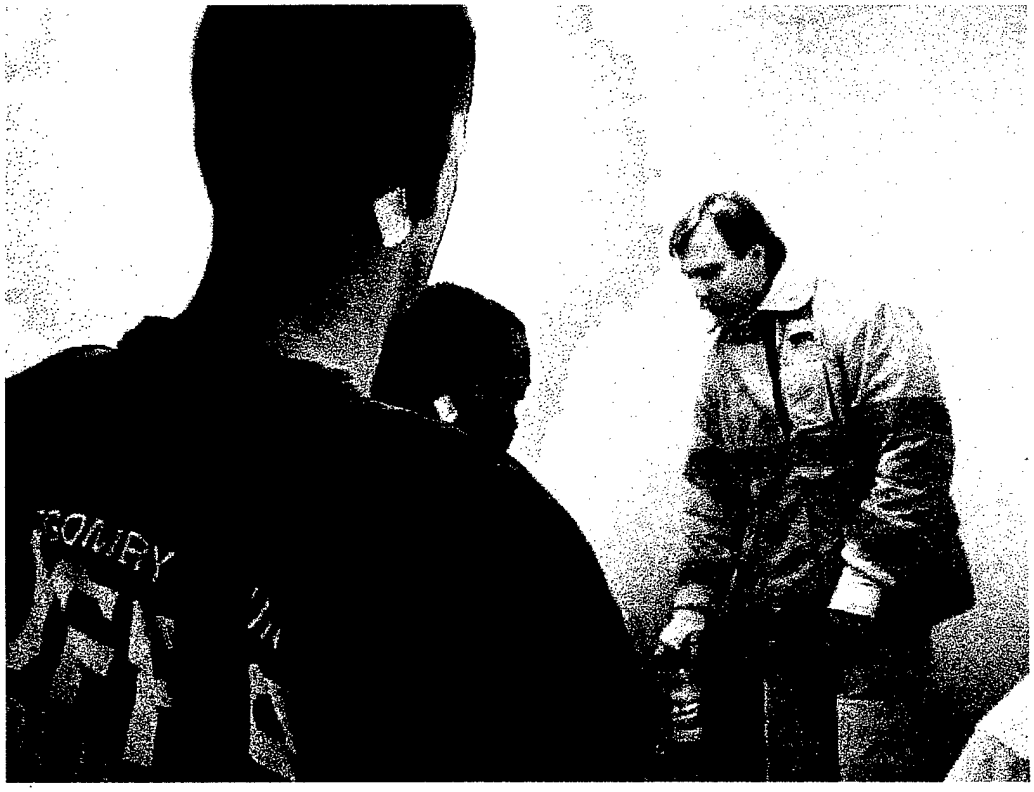

Figure 14. Firemen Finish Dressing Up in Bunker Gear

Figure 15. Transport to Rescue Building

Figure 16. Fireman Setting Up the PPV Fan Upon Arrival at Building Prior to Entry

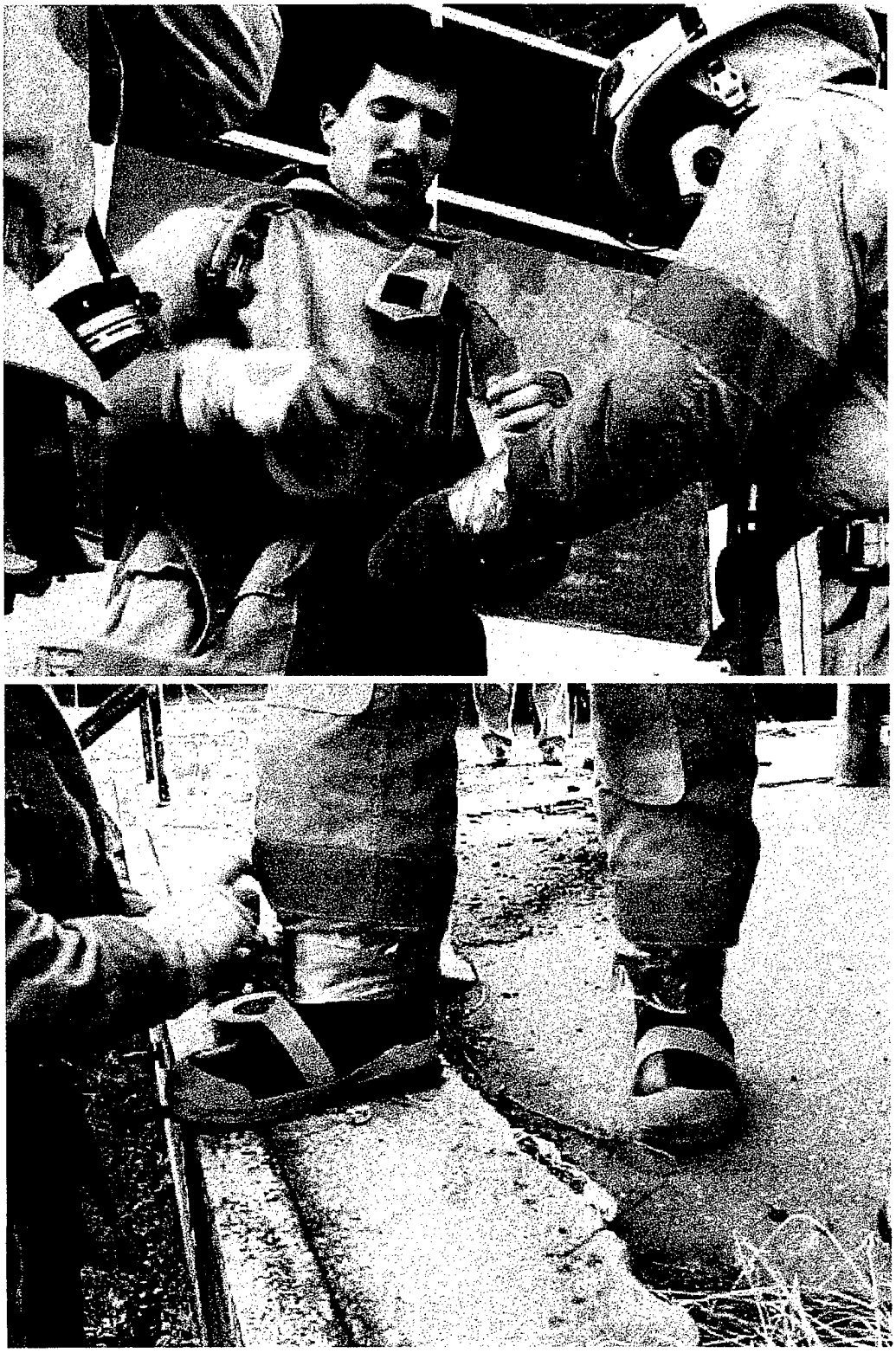

Figure 17. Test Subjects Applying Duct Tape Quick-Fix to Their Bunker Gear

Figure 18. Entry to the Building

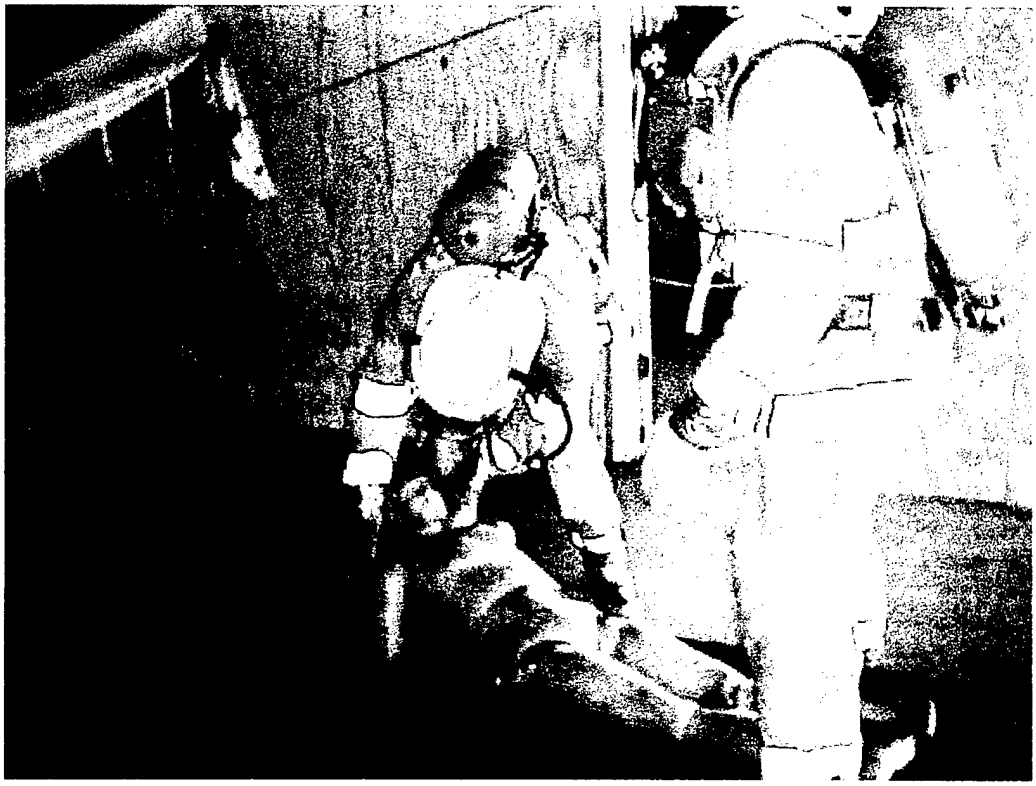

Figure 19. Victim Rescue Operations

Figure 20. Under-Arm Drag Rescue Operation of 160 Pound Mannequin

where the patch samplers were removed and analyzed in the lab. The photographs that are shown in Figures 12-20 show actual footage from one of the tests in the specific order that the procedures were performed.

4. METHOD OF ANALYSIS

4.1 Phase 1, Ventilation Rate Improvement Analysis Methods.

The analysis methods for the ventilation rate improvement portion of the testing are summarized in this section. Complete details on the test and analysis methods are contained in Appendix A. The basic method for determining the ventilation rate of the building is to plot the decay in concentration versus time on a log plot and determine the slope of the linear portion of the curve. The slope is equal to the ventilation rate of the building in air changes/hour. The natural (no PPV fan) ventilation rate was determined first, then the rate when the PPV fan was used was calculated. The difference between the natural and the forced ventilation rates was calculated by dividing the forced rate by the natural rate. The result was the Rate of Ventilation Improvement (RVI). The RVI is simply a multiplying factor of how many times faster the ventilation rate is during PPV fan use compared to not using PPV. All phase 1 series test results were calculated in this fashion. In order to accurately compare the RVIs between the different fan combinations used for ventilating the building, the RVIs were normalized by recalculating with a standard natural ventilation rate. This was performed because the non-normalized RVIs showed significant differences for the same PPV fan between windy days and non-windy days

(since the forced rate is divided by the natural rate, tests on days when the natural ventilation rate was higher decreased the RVI). The ventilation rate used for these calculations was the average rate during test days where the wind speed was at a nominal speed. The 'normalized' RVIs were then calculated by dividing the forced-air ventilation rate by the standard natural ventilation rate. Using this procedure, the RVIs were normalized so that the difference between fans could accurately be determined.

4.2 Phase 2, Rescue Mission Analysis Methods.

The analysis methods used for the Rescue Mission portion of this testing consisted of the standard MIST analysis procedures using the Body Region Hazard Analysis (BRHA) method. Complete details on the use of the BRHA are included in Appendix B. The BRHA model is based upon historical test data of CWA[4] and pesticide[5] adsorption through human skin. The results of the BRHA yield a Combined PPV/Bunker Gear PF for the complete fire-fighter suit ensemble worn during the Rescue Mission. The BRHA is also used to calculate other information on how much dosage of nerve agent or mustard gas a fire fighter can be exposed to (while wearing the protective suit ensemble in these conditions) before he will be affected. These results are called the Minimum Required Exposure Dosages (MREDs). MREDs for both nerve agent effect (Systemic MREDs) and for mustard effects (Localized MREDs) are calculated. The Systemic MREDs predict the dosage (mg-min/m^3) a fire fighter must be exposed to before experiencing the first symptoms of nerve agent poisoning, which is headache. A second-effects MRED is also calculated for the dosage of agent exposure required for more severe effects of nausea and vomiting to occur. The Localized MRED predicts the dosage of mustard a fire fighter must be exposed to while wearing the Bunker gear ensemble to experience the first effects of exposure, which is erythmea, or severe reddening of the skin.

5. RESULTS AND DISCUSSION

5.1 Phase 1 Results, Ventilation Improvement With PPV Fans.

The results of the ventilation improvement tests with the PPV fans are listed below. The natural ventilation rates of the building selected for this study in each of the six locations are listed in Table 4. These are the average values for several days of testing during conditions of nominal wind speeds. These average wind speeds were used to normalize all of the ventilation rate improvement measurements between the trials so that an appropriate comparison could be made between the different models of PPV fans tested.

The optimum location for employment of the PPV fans during this testing (distance from the door) was determined experimentally by measuring the static pressure that was induced inside the building when each fan was placed at various distances from the door. **The best distances for the PPV fans were generally between 9 and 11 feet from the door with the fans pointed straight in at the door (no tilting). When the fans were tilted, the optimum distance was between 3 ½ to 5 feet from the door. The optimum distance for the NPV mode (fans inside the building blowing air out) was 4 feet from the door.**

Table 4. Natural Ventilation Rates of Building E5840

	Air Changes per hour (Conditions at Nominal Wind Speed)	
	Average	Standard Deviation
Building Location 1	0.1990	0.0207
Building Location 2	0.2191	0.0493
Building Location 3	0.1984	0.0428
Building Location 4	0.2061	0.0410
Building Location 5	0.1922	0.0427
Building Location 6	0.1773	0.0228
Average Ventilation Rate:	**0.1987**	
Standard Deviation Ventilation Rate:	**0.0127**	

The results of the ventilation testing of the building using the different PPV fan configurations are summarized in Table 5. The values included in this table are the percentage reduction in concentration inside the building within the first ten minutes, and the Rate of Ventilation Improvement (RVI) of the building while using the fans. The RVI equals the ventilation rate using the PPV system divided by the normal ventilation rate of the building (no PPV fan). The values listed in Table 5 are the average of all six building locations monitored, and are also the average of all the tests performed for each PPV fan configuration used. These results show that the use of PPV fans can significantly reduce the concentration in building areas that have been contaminated with CWA (or other HazMat materials) within just ten minutes. Fan configurations are arranged in this table in order of decreasing performance for reduction of the concentration within the building. Differences between the values in Table 5 illustrate the effectiveness of the different PPV fan configurations. Complete data for every test conducted during the ventilation testing is included in Appendix C (including the actual concentration readings through time during use of the fans).

The best performance was with the 30-inch gas fan, which reduced the buildings' overall vapor concentration by 72% within the first 10 minutes of use. The second best performance was very close to this level (71% reduction); this result was obtained with the two 20-inch gas fans in series, with the first fan tilted upward 20° and the second fan straight. The next three values were the two 20-inch gas fans in series (no tilting) at 65%, and the single 20-inch gas fan that was tilted (both in the NPV and the PPV modes) at 64 and 63%, respectively. These values were so close and are a good example that shows how much improvement is seen just by tilting these fans to redirect the airflow - *one fan was almost as good as two because it was tilted to redirect the airflow*. The next value in the table confirms this conclusion, because the single 20-inch gas fan that wasn't tilted had a much lower value (than the fan that was tilted) of only 57%. Another important observation from these values is that the results from the negative pressure ventilation mode tests were slightly better than the results from the positive pressure tests for the 20-inch gas fan configuration when it was tilted. The electric fan test values for reduction of concentration were the lowest of all the fans tested, coming in at 55% for the 24-inch electric fan in the PPV mode, 50% for the same fan in the NPV mode, and 47% for the double 16-inch electric fans. The NPV mode values were slightly lower than the PPV mode values in this situation. However, even these values showed that the concentration was still

Table 5. Concentration Reductions and Rate of Ventilation Improvement (RVI)

Concentration Reduction after 10 min. of Use		Phase 1 Average Rate of Ventilation Improvement (RVI)		PPV Fan Configuration (distance measurements identify the location of the fan from the entrance door)
72.2%	± 0.2%	42.6	± 11.1	One 30-inch Gas Fan at 9' from door, PPV Mode (see Figure 5)
71.3%	± 3.9%	42.0	± 3.1	Two 20-inch Gas Fans in Series, 1st tilted 20° at 5' from door, 2nd straight at 9', PPV Mode (see Figure 9)
64.9%	± 3.4%	36.8	± 3.2	Two 20-inch Gas Fans in Series (no tilting) at 3'6" and 9' from door, PPV Mode (see Figure 6)
64.4%	± 3.6%	34.6	± 4.0	One 20-inch Gas Fan, tilted 20°, at 4' from door, NPV* Mode (see Figure 11)
62.6%	± 0.9%	31.5	± 5.3	One 20-inch Gas Fan, tilted 20° at 5' from door, PPV Mode (see Figure 8)
56.6%	± 2.9%	26.3	± 3.2	One 20-inch Gas Fan at 9' from door, PPV Mode (see Figure 4)
55.4%	± 3.2%	26.8	± 3.7	One 24-inch Electric Fan at 9', PPV (see Figure 7)
50.4%	± 3.8%	23.6	± 3.2	One 24-inch Electric Fan at 4', NPV (see Figure 10)
47.4%	± 2.6%	21.9	± 1.7	Two 16-inch Electric Fans stacked at 10' 4", PPV (see Figure 3)

* NPV is Negative Pressure Ventilation where the fan is placed inside the building approximately 4 feet from an open doorway. Also the fan faces the doorway to blow air out the doorway (i.e., the doorway is the exit point for ventilation). Fans used in the Negative Pressure Ventilation (NPV) mode draw air out of the building instead of pushing it in, as is done in the PPV mode.

reduced significantly within 10 minutes after putting the fans in operation. All tests using the same fan in both the negative and the positive pressure ventilation modes showed similar results for both modes. **The key concept exhibited by this data is that a PPV fan can purge the majority of chemical vapors from a building after only 10 minutes of use.**

The rate of ventilation improvement (RVI) in the building (over the natural rate) for each PPV fan configuration tested during Phase 1 is also listed in Table 5. The RVI values followed the same general trends seen with the concentration reduction values, with the larger 30-inch gas fan being best and the double 16-inch electric fan having the least effects on changing the natural ventilation rate of the building.

For example, the forced air ventilation rate while using the 30-inch gas fan was 42.6 times faster than the natural ventilation rate. The forced air ventilation rate while using the two 20-inch gas fans in series (with the first fan tilted upward 20° and the second fan straight) was 42.0 times faster than the natural ventilation rate. The rate using the two 20-inch gas fans in series (no tilting), was 36.8 times faster than the natural rate. The rate using the single 20-inch gas fan that was tilted (NPV mode), purged the vapor 34.6 times faster than the natural rate. The rate using the single 20-inch gas fan that was tilted (PPV mode), was 31.5 times faster than the natural rate. The rate using the single 20-inch gas fan that wasn't tilted was 26.3 times faster than

the natural rate. The rate using the 24-inch electric fan in the PPV mode was 26.8 times faster than the natural rate. When the 24-inch electric fan was used in the NPV mode, it provided a ventilation rate that was 23.6 times faster than the natural rate. The rate using the double 16-inch electric fans was 21.9 times faster than the natural rate.

Overall, the concentration reduction and improvement to the ventilation rates were proportional to the airflow rates of the fans, with higher airflow rates performing better than lower rates. It should be noted that there was no discernible rise in concentration in the closed rooms of the building during the negative pressure ventilation tests; however, there were significant rises in concentration in the closed rooms during the positive pressure ventilation tests after the PPV fans were turned on. One other important note was that the negative pressure tests with the 24-inch electric fans showed that the results were similar to the results using the same fan in the positive pressure mode (although NPV was slightly lower than PPV). The results when the 20-inch gas fans were used for both negative and positive ventilation showed that the rate of improvement was actually slightly better with the NPV than with the PPV configuration. ***These results show that it would probably be better to use negative pressure ventilation to remove chemical vapors from a contaminated building that has enclosed rooms in it.*** Finally, the overall results in Table 3 clearly show that ***tilting gas fans produce maximum results***. Only the first fan needs to be tilted when two gas fans are used in series.

The room infiltration rate was evaluated from the data to see how much tracer gas the PPV fans pushed into the interior rooms that were closed off to the rest of the building. The average infiltration rates of the interior closed rooms (rooms 1 and 3) were determined and the average rate from all tests is reported in Table 6. These values are ranked in order of the fan configuration that created the highest room infiltration rate to the lowest. This value is the average ventilation rate of both rooms that was caused by use of the PPV (or NPV) fans. It is clearly seen by all values in this table that the use of the PPV fans drove the tracer gas into the closed rooms. It should also be noted that when the fans were used in the negative pressure ventilation (NPV) mode the infiltration rates were negative; indicating that background levels of the tracer gas were actually removed from the rooms instead of being driven in by the fans (normal purging occurred with NPV). Figures 21 and 22 graphically show the difference in interior room concentrations when PPV versus NPV fans were used. Figure 21 shows how fast the concentrations in the rooms increased when the PPV fans were turned on. Figure 22 however, shows that there was no discernible rise in concentration in the closed rooms of the building during the negative pressure ventilation tests. These results show that when PPV fans are used to clear vapors from a building that has interior closed rooms in it, the fans can drive the vapors into these rooms. Although the 30-inch gas fan did not have the highest rate, the general magnitude of the room infiltration rates was again proportional to the rated airflow of the fans. NVP was determined to be the preferred method for quick concentration reduction of CWA when interior rooms with closed doors exist in the building where people are present.

Carbon Monoxide (CO) monitors were used during the last day of testing to evaluate the amount of CO that accumulated in the building as a result of the use of the gas PPV fans. An additional test was conducted because concern arose that if a gasoline-driven fan was operating inside the building (for NPV), the CO concentration might get too high. The 20-inch gas fan (tilted) was used during this test in both the positive (PPV), and the negative (NPV) pressure ventilation modes. Concentrations were measured in the center of the building and near

Table 6. Closed Room Infiltration Rates Caused by PPV Fans

Average Interior Room Infiltration Rate	PPV Fan Configuration (distance measurements identify the location of the fan from the entrance door)
9.8	Two 20-inch Gas Fans in Series, 1st tilted 20° at 5' from door, 2nd straight at 9', PPV Mode (see Figure 9)
9.5	One 30-inch Gas Fan at 9' from door, PPV Mode (see Figure 5)
8.4	Two 20-inch Gas Fans in Series (no tilting) at 3'6" and 9' from door, PPV Mode (see Figure 6)
6.7	One 20-inch Gas Fan, tilted 20° at 5' from door, PPV Mode (see Figure 8)
5.5	One 24-inch Electric Fan at 9', PPV (see Figure 7)
3.2	Two 16-inch Electric Fans stacked at 10' 4", PPV (see Figure 3)
3.1	One 20-inch Gas Fan at 9' from door, PPV Mode (see Figure 4)
-0.6	One 24-inch Electric Fan at 4', NPV* (see Figure 10)
-1.1	One 20-inch Gas Fan, tilted 20°, at 4' from door, NPV Mode (see Figure 11)

* NPV is Negative Pressure Ventilation mode where the fan is placed inside the building blowing air out.

the door where the NPV fan was operating. The CO concentration during the PPV portion of this test went up immediately after the fan was started and continued to rise throughout the 15-minute period that is was operated (see Table 7 below). The net increase in CO concentration during the PPV portion of the test was approximately 6½ ppm (well below the TWA limit of 35 ppm). The fan was then stopped and brought inside for the negative pressure ventilation (NPV) portion of the test. During this time, the CO concentration actually decreased in the NPV mode. Table 7 shows that the level of CO decreased by a value between 5 and 7 ppm during use of the gas NPV fan inside the building. In general, NVP mode operation of the fans blows CO out of the building, while PPV mode operation of the fans blows CO into the building*. These results show that it would probably be better to use negative pressure ventilation to remove chemical vapors from a contaminated building that has enclosed rooms in it. **General trends for all of this testing showed that:**

- **The larger fans had the best performance;**
- **Gas fans were better than electric fans;**
- **Tilting the fans to redirect their airflow improved the performance a significant amount;**
- **Smaller, non-tilted fans were less effective;**
- **Fans operated in the negative pressure ventilation mode produced results that were similar to fans run in the positive pressure ventilation mode;**
- **Fans operated in the positive pressure ventilation mode pushed vapors into closed rooms elsewhere in the building, while fans operated in the negative pressure ventilation mode did not; and**
- **When gasoline-driven PPV fans were used, CO levels did not build up to hazardous levels inside the building.**

* Gasoline-driven PPV fans should not be started with the fan pointed into the building. Point the fan away from the building and allow a short warm-up period to reduce CO emissions before directing the air-flow into the building.

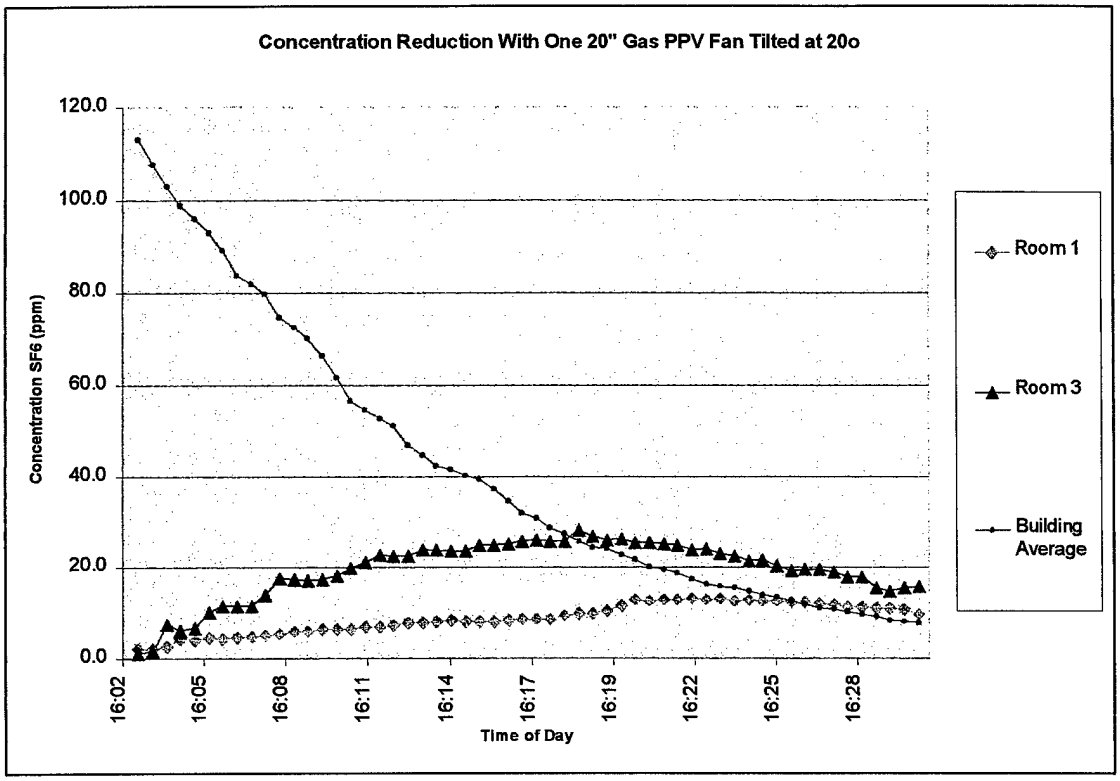

Figure 21. Concentration Profile Using Positive Pressure Ventilation (PPV - Test 4b)

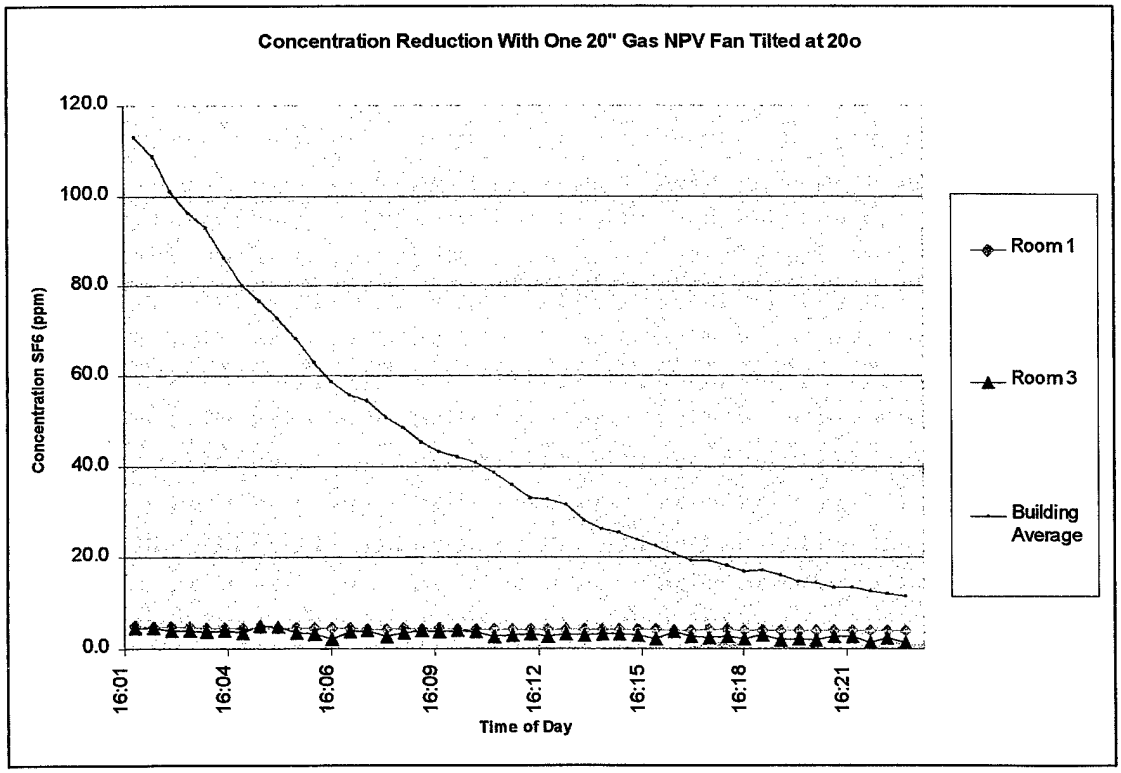

Figure 22. Concentration Profile Using Negative Pressure Ventilation (NPV - Test 7b)

Table 7. CO Concentrations Inside the Building During Use of Gas PPV and NPV Fans

20" Gas Fan Started For Positive Pressure Ventilation of Building			
		CO Concentration (ppm)	
	Time	Middle of Bldg	Near Door (and fan)
Starting Concentration:	16:25	0.000	2.124
Ending Concentration (fan run 15 min):	16:40	6.789	8.634
Net CO Concentration *Increase* for Gas Fan Use in Positive Pressure Ventilation Mode:		**6.789**	**6.510**

20" Gas Fan Brought Into Building and Used In The Negative Pressure Ventilation Mode			
		CO Concentration (ppm)	
	Time	Middle of Bldg	Near Door (and fan)
Starting Concentration:	16:40	5.935	7.998
Ending Concentration (fan run 20 min):	17:00	0.484	1.174
Net CO Concentration *Decrease* for Gas Fan Use in Negative Pressure Ventilation Mode:		**5.451**	**6.824**

5.2 Phase 2 Results, Rescue Scenario Mission.

The results of the Phase 2 testing where the fire-fighters used the PPV fans to reduce the hazard inside the building before performing a live rescue mission showed significant improvement to the safety of the fire-fighters. The 20-inch gas fan and two 16-inch stacked electric fans were selected for Phase 2 testing because they are most commonly available across the Fire Service. The results of the MIST Body Region Hazard Analysis (BRHA) are summarized in Table 8 below. Complete data from all the tests, to include concentration readings at several locations inside the building throughout the rescue time period, and the MIST BRHA and sample tube data are included in Appendix D. Table 8 lists the conditions of each test; the Combined PPV and Bunker Gear PF against nerve agent (VX) that the PPV fans and firefighter's protective ensemble provided; the systemic MREDs for nerve agent; and the localized MREDs (for skin reactions to mustard), along with the skin area corresponding to the lowest localized MRED. The values listed show the increase in protection provided when the PPV fans were used, and are actually the "Combined PPV and Bunker Gear" PF, the "Combined" Systemic MREDs, and the "Combined" Localized MREDs (since a standard exposure dosage was used in the BRHA calculations instead of the actual dosages). The standard Overall PF for FFPE with the Self-Taped Quick-Fix has previously been determined to be a value around 18.

The Systemic MREDs correspond to the systemic dosage the fire-fighters must be exposed to in order to exhibit the first symptoms of agent exposure. The first symptoms are headache or miosis* (pinpointing of the eyes) and are not severe reactions. The second Systemic MRED values listed are the dosages required for more severe reactions of nausea and vomiting to occur (this uses a dosage of 25 mg-min/m^3 instead of 10 in the calculations to determine the Systemic MREDs). The localized MRED data was analyzed to determine the most vulnerable

* Miosis generally occurs only when nerve agent is absorbed through the eyes or the respiratory tract; it is usually not a result of percutaneous skin absorption of agent.

Table 8. Summary of BRHA Data From Rescue Mission Tests Using PPV Fans

	Combined PPV & Bunker Gear PF	Systemic MREDs (mg-min/m^3)		Localized MREDs (mg-min/m^3)	
		Headache	Nausea/Vomiting	Erythmea	Body Region Affected
PPV2 Test 1, 28 Sep 98, 20" Gas at 10' 4" fan straight					
Suit 1	71.46	714.6	1786	1665	Scrotum
Suit 2	83.68	836.8	2092	4769	Chin & Neck
Suit 3	62.67	626.6	1567	2601	Scrotum
Suit 4	74.47	744.7	1861	4974	Scrotum
Average	**73.07**	730.7	1827	3502	
Confidence Interval	**±6.17**	61.7	154.3	1160	
PPV2 Test 2, 1 Oct 98, two 16" Electric Fans at 10' 4" fan straight					
Suit 1	269.0	2690	6726	14139	Chin & Neck
Suit 2	159.2	1592	3981	5328	Chin & Neck
Suit 3	173.3	1733	4333	13443	Chin & Neck
Suit 4	211.8	2118	5294	13663	Scrotum
Average	**203.3**	2033	5083	11640	
Confidence Interval	**±35.0**	349.8	874.4	3006	
PPV2 Test 3, 4 Oct 98, no PPV Fans					
Suit 1	21.91	219.1	547.7	1417	Chin & Neck
Suit 2	20.98	209.8	524.6	932.3	Chin & Neck
Suit 3	20.51	205.1	512.6	1072	Chin & Neck
Suit 4	21.79	217.9	544.6	1182	Chin & Neck
Average	**21.30**	212.9	532.4	1151	
Confidence Interval	**±0.48**	4.8	11.89	145.8	
PPV2 Test 4, 8 Oct 98, two 16" Electric Fans at 10' 4" fan straight					
Suit 1	79.64	796.4	1991	2302	Scrotum
Suit 2	137.2	1372	3431	6629	Chin & Neck
Suit 3	199.6	1996	4991	4185	Ears
Average	**138.8**	1388	3471	4372	
Confidence Interval	**±46.5**	465.4	1163	1682	
PPV2 Test 5, 19 Oct 98, one 20" Gasoline Fan at 5' fan tilted 20°					
Suit 1	410.2	4102	10255	12732	Chin & Neck
Suit 2	555.1	5551	13878	28620	Scrotum
Suit 3	727.6	7276	18191	21323	Chin & Neck
Average	**564.3**	5643	14110	20890	
Confidence Interval	**±123.2**	1232	3080	6167	
PPV2 Test 6, 18 Nov 98, one 20" Gasoline Fan at 12' 6", fan tilted 20°					
Suit 1	343.2	3432	8579	8383	Chin & Neck
Suit 2	221.5	2215	5538	3619	Scrotum
Suit 3	201.2	2012	5031	3636	Chin & Neck
Average	**255.3**	2553	6383	5213	
Confidence Interval	**±59.5**	595.3	1488	2129	

areas in the protective ensemble, that is, the areas in which mustard would redden the skin first (erythmea). All MRED values reported hereinafter have the units of mg-min/m^3; PF values are unitless. It should be noted that these values correspond to the protection afforded against percutaneous adsorption of vapor through the skin only. These values are not indicators of the respiratory protection offered by the SCBA, which is certified by the manufacturer to be at a value equal to, or greater than 10,000.

This data was analyzed to determine the average values of the Combined PPV and Bunker Gear PFs and MREDs of all the test subjects during each test. Other statistical data was also calculated to determine the population standard deviation and the 90% confidence interval of these values for the subjects in each test. The values reported in the text below indicate the average and the confidence interval for each test's data. This data showed that the use of the FFPE ensemble (with a Quick-Fix of Self-Taped use of duct tape) and use of the PPV fans in the different combinations provided the following "Combined PPV and Bunker Gear" protection results:

- The first test used one 20-inch Gas fan positioned at 10 feet, 4 inches from the door, with no tilting. The values from this test showed an average overall PF of 73.07±6.17; a Systemic MRED of 730.7±61.7 (first symptoms of headache), and 1827±154.3 (more severe symptoms of nausea and vomiting); and a Localized MRED of 3502±1160.

- The second test used two stacked 16-inch Electric fans positioned at 10 feet, 4 inches from the door, with no tilting. The values from this test showed an average overall PF of 203.3±35.0; a Systemic MRED of 2033±349.8 (first symptoms of headache), and 5083±874.4 (more severe symptoms of nausea and vomiting); and a Localized MRED of 11640±3006.

- The values for the third test (using no PPV fans) showed an average overall PF of 21.3±0.48; a Systemic MRED of 212.9±4.8 (first symptoms of headache) and 532.4±11.9 (more severe symptoms of nausea and vomiting); and a Localized MRED of 1151±145.8.

- The fourth test used two stacked 16-inch Electric fans positioned at 10 feet, 4 inches from the door, with no tilting. The values from this test showed an average overall PF of 138.8±46.5; a Systemic MRED of 1388±465.4 (first symptoms of headache) and 3471±1163 (more severe symptoms of nausea and vomiting); and a Localized MRED of 4372±1682. It should be noted that a reason for less protection in this test than the previous 16" electric test was that the fans were not started 5 minutes prior to entry for the rescue (while the fire-fighters were taping their gear) as was done in all other tests. This occurred inadvertently due to heavy rains that day.

- The fifth test used one 20-inch Gas fan (tilted at 20°) positioned at 5 feet from the door. The values from this test showed an average overall PF of 564.3±123.2; a Systemic MRED of 5643±1232 (first symptoms of headache), and 14110±3080 (more severe symptoms of nausea and vomiting); and a Localized MRED of 20890±6167.

- The sixth test used one 20-inch Gas fan (tilted at 20°) positioned at 12 feet, 6 inches from the door. The values from this test showed an average overall protection factor of 255.3±59.5; a

Systemic MRED of 2553±595.3 (first symptoms of headache), and 6383±1488 (more severe symptoms of nausea and vomiting); and a Localized MRED of 5213±2129.

In summary, the results of the Phase 2 testing showed that the fire fighters' protection was increased tremendously when the PPV fans were used. The baseline Bunker Gear PF during test 3 (when PPV fans weren't used) was an average of 21. The best results produced an average overall PF of 564 when the single 20-inch gas fan was used in the tilted mode at the predetermined optimal fan location (5 feet) that yielded the best pressurization of the building. Test 6 was conducted with the same fan positioned by the firefighter visually with streamers taped on the doorway. This resulted in about half the protection (PF of 255) as the optimal fan location provided. Also, during test 4 the electric fans were inadvertently not started 5 minutes prior to the fire-fighters' entry, as was done in all the other tests. Comparing to test 2 where the electric fans were started prior to the fire-fighters entry demonstrates how starting the PPV fans for just 5 minutes before entry can improve protection significantly (average overall PF of 203 versus 138). **All of these test measurements show that the use of PPV fans will improve the protection of fire-fighters to a great degree if they must perform rescue missions in buildings that have been exposed to CWA vapor contamination.**

In order to compare the performance of the PPV Fan used in Phase 2, performance improvement factors were calculated. Table 9 lists the Rate Of Improvement (ROI) obtained while using the PPV fans compared to the baseline test where no fan was used. This table lists the conditions of each test, and the Combined PPV/Bunker Gear PF that the PPV fans and fire-fighters' protective ensemble provided (average values of all the test subjects during each test series). These ROIs are different than the Phase I ventilation RVIs defined in paragraph 4.1. The ROIs listed in Table 9 are calculated by dividing the Combined PPV and Bunker Gear PF for each fan configuration by 21.3 (baseline Bunker Gear PF when no PPV fans were used in test 3). This ROI determines how much the use of PPV fans improves the fire-fighters' protection compared to not using PPV – it is simply a multiplying factor of how many times greater the fire-fighters' protection is when PPV fans are used.

These results show that the best improvement was obtained in test 5 when the 20-inch Gas fan (tilted at 20°) was used at the position where the best overpressure in the building was obtained experimentally (5 feet from the door). These results showed an ROI of 26.5 times better than with no PPV fan. This fan position was determined experimentally with pressure gauges before the testing began. The second best ROI was obtained when this same fan configuration was used, but placed at a different distance from the door in test 6. This test obtained an ROI of nearly 12 times better than with no PPV fan. The position of the fan in this test was determined visually by the fire-fighters through use of streamers taped on the door. This demonstrates that additional chemical protection can be gained and shows the importance of positioning PPV fans at the optimal distance from the entrance door (i.e., the protection is doubled by doing so in this case). It also demonstrates that the visual use of streamers (although adequate for on-the-scene use when pressure gauges are not available) is an ineffective means of determining the optimal fan location. If available, hand-held pressure gauges should be used to determine better fan locations than visual streamers; this will provide better protection to the fire fighters. However, even the smallest improvement still provided the fire fighters more than 3 times as much protection as opposed to not using PPV fans.

Table 9. Rate of Improvement (ROI) for Combined PPV/Bunker Gear PFs

Test	PPV Fan Configuration Used	Combined PPV & Bunker Gear PF	Phase 2 Rate Of Improvement (ROI)
3	No PPV Fans (baseline)	21.3	1
1	One 20-inch Gas Fan at 10' 4", fan straight	73.1	3.4
4	Two 16-inch Electric Fans at 10' 4", fan straight	138.8	6.5
2	Two 16-inch Electric Fans at 10' 4", fan straight	203.3	9.6
6	One 20-inch Gasoline Fan at 12' 6", fan tilted 20°	255.3	12.0
5	One 20-inch Gasoline Fan at 5', fan tilted 20°	564.3	26.5

The concentration of MeS outside the building's exit windows as measured by the FTIR equipment during the first five tests is shown graphically in Appendix D. This data showed concentrations that matched the inside concentrations initially, but were reduced later to very low levels. This result was generally expected for use of the PPV fans in this situation. During actual use of a PPV fan to reduce agent concentrations in a building contaminated by terrorist weapons, the concentration would closely match that inside the building, but would be rapidly dispersed outside the building with good winds. General procedures for use of PPV fans at such a site should include clearing of all personnel downwind of the building for a distance of at least one mile (further if possible). Since most terrorist attacks will be in highly populated regions of a city, this may not be possible.

The simulant (MeS) used in this testing has a strong wintergreen smell and was therefore easy to track some relative distances from the building. This scent could be detected easily at distances of 5 to 10 feet from the building, and in most areas within 30 to 50 feet near the exit point of the air from the building. This smell was generally not recognized at distances greater than 100 feet from the building. The odor threshold for MeS is very low (lower than harmful concentration levels for most chemical agents) and therefore, it might be stated that it did not remain in areas further than 100 feet from the building. However, this detection method (sense of smell) is not a quantitative method and therefore, there may have been MeS present at further distances. The evacuation distance must be determined by the Incident Commander (IC) in charge at a site of terrorist activity, and would best be made through use of chemical agent detectors capable of very low level detection of specific chemical agents.

If low level, chemical agent detectors are not available, more specific guidelines for evacuation distances are available in the North American Emergency Response Guidebook[6], NAERG96. Figure 23 shows a diagram of the initial isolation distance and downwind evacuation distances that are recommended for spills. The Initial Isolation Zone distance from the NAERG96 is 700 ft for toxic liquids and 30-80 ft for infectious materials. The Downwind Distances from the NAERG96 are 1.2 miles during the day and 5.5 miles during the night for spills of toxic liquids. Higher ambient winds tend to disperse the agent better as it leaves the building and might facilitate closer evacuation distances; however, this determination is left up to the IC in charge at the scene.

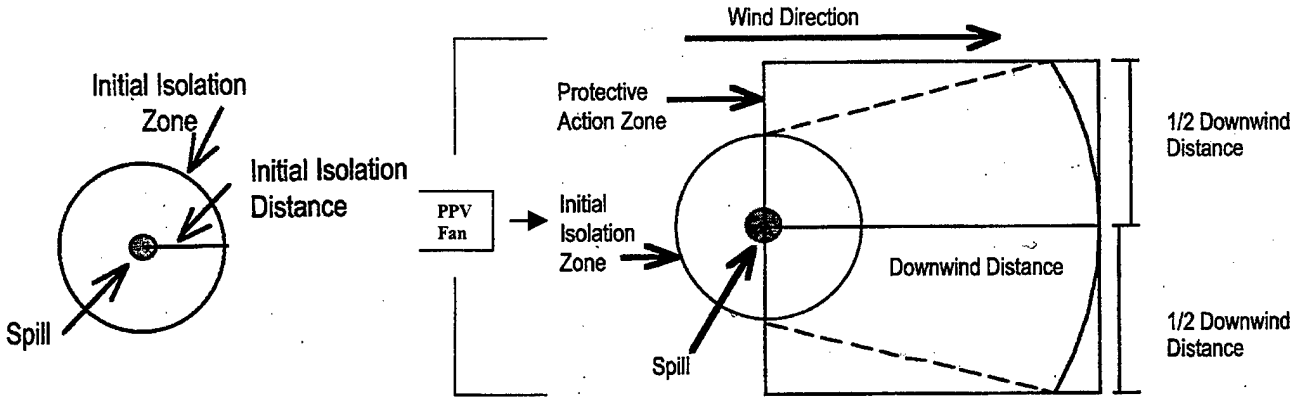

Figure 23. Initial Isolation Zone and Downwind Evacuation Distances for Spills

6. CONCLUSIONS AND RECOMMENDATIONS

The use of PPV fans at a site of terrorist activity where chemicals have been disseminated will significantly reduce the vapor levels inside the building and increase the safety of first responders who must enter the building to effect rescue operations. The most significant conclusions are listed below:

- Rates of Ventilation Improvement (RVIs) ranged between 22 and 43 times the natural ventilation rate. The best improvements were seen when the larger 30-inch gas fan or the two 20-inch gas fans in series (first tilted, second straight) were used.

- The percentage concentration reduction obtained in the building after the PPV fans were put in use for only ten minutes ranged from 47% to 72% of the initial concentration. Best results were again obtained with the 30-inch gasoline fan or the two 20-inch gasoline fans in series (first tilted, second straight) were used.

- Phase 1 testing showed that using fans in the NPV orientation is good because concentrations did not rise inside interior rooms with closed doors as it did in the PPV orientation. Additionally, the fan's performance did not degrade significantly in the NPV orientation compared to the PPV orientation.

- Levels of CO measured inside the building during operation of gasoline-driven PPV fans did not exceed levels generally recognized as safe. Therefore, the use of gasoline-driven PPV fans in either the PPV or the NPV modes does not present a hazard of CO poisoning.

- The overall results of the MIST testing during Phase 2 showed tremendous improvements in the protection afforded to the fire-fighters through use of the PPV fans to clear the vapors from the building. Of the two fans tested during Phase 2 the best results were obtained with the single standard 20-inch gas PPV fan used in the tilted mode.

- Only the 20-inch gas and the double 16-inch electric fans were used during the Phase 2 live rescue mission tests (these are the fans that most fire-fighters have). If more efficient fans are available, such as the 30-inch gas or the double 20-inch gas fans in series (first tilted, second straight), the improvement to the fire-fighters' safety will be increased even more (based upon the concentration reduction test results from Phase 1 of this testing).

- Fan efficiency and chemical protection improved significantly when the optimal fan location (distance from the door) was used. The optimal fan location could only be determined with pressure gauges; using just the visual streamers was not good enough.

It is recommended that a hand-held pressure gauge be used by fire-fighters when determining the optimum distance from entry doors for placing PPV fans in service at a building. Significant improvements in protection are gained when the PPV fan is placed at the optimal distance from the entry door (the distance where the measured pressure inside the building is the greatest). Visual verification with streamers provides a rough indication, but significant improvements were attained when the pre-determined position (based on pressure measurements) was used in the Phase 2 testing. Two sources for portable pressure gauges are Dwyer Instruments, Inc., and Omega Technologies Company. Any source for portable pressure gauges would be sufficient as long as the instrument measures very low-pressure readings; a range of 0 to 1 inches water gauge (iwg) or lower is desired. Meters showing pascals* would be better. However, visual verification with streamers still provides a rough estimate for PPV location if portable pressure gauges are not available.

* Static pressure inside the building in the range from 0 to 1 iwg pressure is equivalent to the metric range of 0 to 25 pascals.

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APPENDIX A

VENTILATION RATE TEST PROCEDURES AND METHODS

1. INTRODUCTION

The methods used in this testing were to fill the building with the tracer gas Sulfur Hexafluoride (SF_6) and measure the rate at which the concentration of the tracer gas decreased (with real-time gas monitors) when PPV fans (pre-positioned at the building doorway) were used to ventilate the building. Concentrations of SF_6 were measured at several locations within the building from an initial concentration of around 100 ppm to a final concentration of around 1 ppm. All tests were conducted in Building E5840 at the Edgewood Area of Aberdeen Proving Ground, MD. These tests determined both the baseline ventilation rate (without PPV fans) of the building and the improved ventilation rates when PPV fans were used.

2. TEST EQUIPMENT AND SETUP

2.1 Building Layout.

The building used for this testing was a rectangular warehouse building that was 109 feet long by 48.5 feet wide (floor surface area of 5238 ft^2); it contained six interior rooms, an exterior room (used as the Instrument Room), and a sealed cable passageway between the exterior room and the main building. Diagrams of Building E5840 showing the floor layout and overall measurements (for volume calculations) are shown in Figures A-1 and A-2. Building and room volume measurements are summarised in Table A-1. The Instrument Room housed all control and monitoring equipment that was used in the tests.

2.2 Test Equipment.

The testing was conducted by dispensing a high concentration of the SF_6 gas into all areas of the building (except the enclosed rooms) and measuring the concentration in real time with gas analyzers. The SF_6 was dispensed directly from a gas cylinder and distributed to each area of the building through a gas manifold, teflon sample lines, and electrical solenoid valves. The solenoid valves were powered by a 24 volt power supply: when power was applied, the valves opened; when the power was removed, the valves closed. Mixing fans were used to circulate the gases inside the building during the time when the gas was released (fans were shut off after mixing was achieved).

The instruments used to monitor the concentrations were the Foxboro Miniature Infra-Red gas Analyzers (MIRAN®). A total of eight MIRAN®s were used, six in the main building and one each in rooms 1 and 3. The locations are shown graphically in Figure A-2 and were as follows: four were in the central area of the building, and two were in the 'dead spaces' (areas where little airflow was expected). The actual locations inside the building are listed in Table A-2. Operating conditions for the MIRAN®s were a pathlength of 0.75 m, a wavelength of 10.7 μm, and a slit width of 1 mm. The MIRAN®s were calibrated with span gas containing known quantities of SF_6.

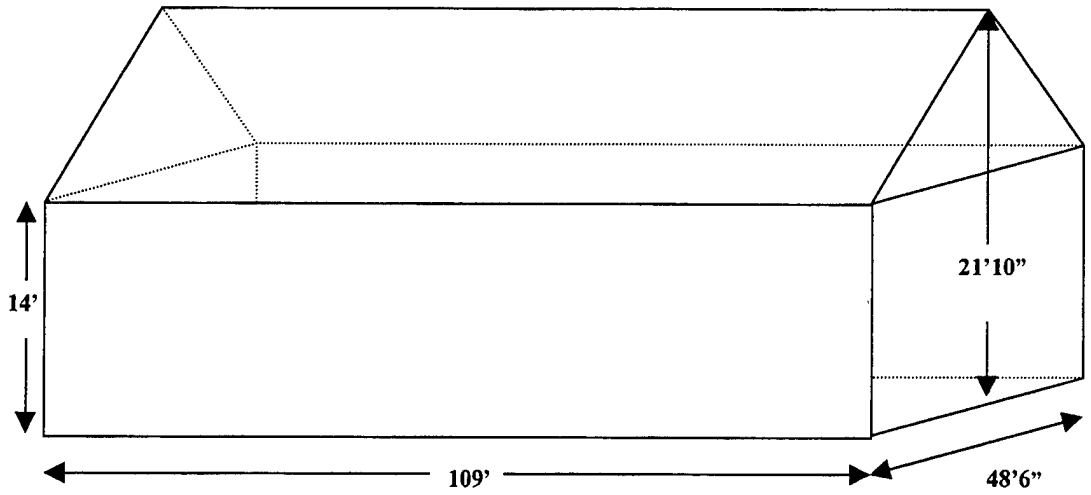

Figure A-1. Volume measurements of Building E5840

Table A-1. Volume Measurements of Building and Rooms

	Length	Width	Area	Height	Volume
Building					
Lower* Area:	109 ft	48.5 ft	5238 ft^2	14 ft	74011 ft^3
Upper **Area:	109 ft	48.5 ft	189.9 ft^2	7.83 ft	20705.5 ft^3
Total Building Volume:					94716.5 ft^3
	Length	Width	Area	Height	Volume
Room 1:	14 ft 10.5 in	12 ft	178.5 ft^2	8 ft	1428 ft^3
Room 2:	14 ft 10.5 in	12 ft	178.5 ft^2	8 ft	1428 ft^3
Room 3:	14 ft 10.5 in	12 ft	178.5 ft^2	8 ft	1428 ft^3
Room 4:	14 ft 10.5 in	12 ft	178.5 ft^2	8 ft	1428 ft^3
Room 5:	14 ft 10.5 in	12 ft	178.5 ft^2	8 ft	1428 ft^3
Room 6:	14 ft 10.5 in	12 ft	178.5 ft^2	8 ft	1428 ft^3

*Lower area volume equals length times width times height

** Upper area volume equals the area of the triangle time the length of the building. Area of the triangle equals one-half the base (width) times the height (figures are not in proper sequence for the area calculation here).

The output data from each MIRAN® (0-1 volt DC) was recorded with a Data Acquisition System (DAS) employing Strawberry Hill data acquisition boards and Work Bench PC™ data acquisition and control software with a desktop computer. Sample lines were installed at the positions listed and connected to the MIRAN® inlet. Data cables were routed from each MIRAN®'s location in the building through an access port in the wall to the Instrument room. The cables were attached to both the DAS terminal panel and the electrical output from the MIRAN® so that all of the data would be recorded during each test. The DAS also displayed a chart that showed a graphical representation of the concentrations inside the building during the tests.

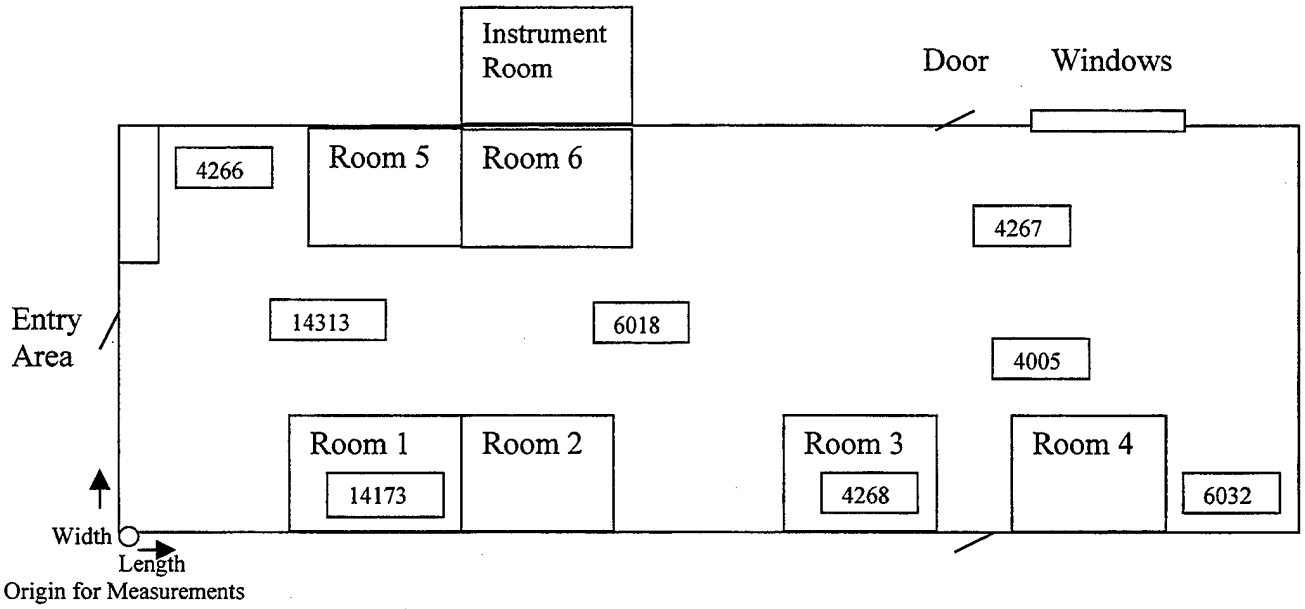

Figure A-2. Floor Layout of Building E5840

Table A-2. Location of MIRAN®s Inside the Building and Rooms

MIRAN® Serial Number	Length	Width	Height
14313	21 ft	23 ft 3 in	5 ft
6018	54 ft 4 in	25 ft	7 ft 8 in
4005	78 ft	17 ft 3 in	5 ft 3 in
6032	102 ft 3 in	11 ft 6 in	5 ft
4267	77 ft	37 ft 6 in	5 ft 3 in
4266	11 ft	42 ft 10 in	5 ft 8 in
4268	65 ft 9 in	6 ft 9 in	5 ft 3 in
(inside room)	7 ft 5 in	6 ft 9 in	5 ft 3 in
14173	23 ft 4 in	5 ft	5 ft 8 in
(inside room)	6 ft 9 in	5 ft	5 ft 8 in

A weather station was used to monitor temperature, relative humidity (both inside and outside the building), wind conditions, rain, and barometric pressure. Omega pressure transducers (model PX163PC01D36) were used to monitor the pressure inside the building throughout the testing. The output from the pressure transducers was connected directly to the DAS and recorded.

2.3 Equipment Setup.

The MIRAN®s were placed in the sample locations and fitted with sample filters (high efficiency particulate). Data cables were installed to the output of the MIRAN®s and to the DAS terminal panel. The MIRAN®s were turned on, warmed up to operating temperature, and zeroed. Calibration constants were entered into the calculation blocks of the DAS for each MIRAN® and the recording of each MIRAN®'s data was verified.

The SF_6 distribution manifold was set up to distribute the gas at three locations in the main building. One of the locations was in the middle of the building (near the door that led to the instrument room), and the others were at opposite ends of the building (in front of Room 1 and in the center at the far end). A cylinder of liquid SF_6 was installed in the instrument room in a cylinder stand and fitted with a standard two-stage regulator. Teflon tubing was connected to the output of the regulator and the tubing was run into the main building to the distribution manifold; tubing was then installed to the manifold and run to each of the three distribution points. Electronic solenoid valves were installed at the end of each gas distribution line to seal off the gas line (and to prevent any SF_6 from leaking into the building during the ventilation tests) when they were shut off. Electrical lines were run to each of the solenoid valves and connected to a 24 Vdc power supply, which was used to open and close the valves when SF_6 was needed.

The building mixing fans were set up at each of the gas distribution points and set to distribute the gas uniformly. Power for the mixing fans was provided by a circuit that was electrically controlled by the DAS so that the fans could be shut off remotely when the test started without entering the building and disturbing the flow patterns.

The pressure transducers were set up with a pressure line located inside the building to measure the building's static pressure while the PPV fans were operated. The output was connected to the DAS.

The PPV fans were set up and maintained according to the manufacturer's instructions. Each fan was operated and a preliminary test was conducted to determine the optimum location for each different type of PPV fan from the door in order to obtain the best pressurization of the building. These locations were then used during the ventilation tests.

3. TEST PROCEDURES

An initial concentration of 100 ppm of SF_6 was generated in the main area of the building (enclosed rooms were shut up during this period). The PPV fans were started, and the concentration was monitored in real-time to determine the purge rate for a 1000 to 1 (3-log) reduction in concentration. After the tests the natural logarithm of the concentration was plotted versus time for each purge test and a linear regression analysis was performed on the linear portion of the curve to determine the ventilation rate of each of the six building locations (and in the two enclosed rooms). All of the data from the complete ventilation test was not used in the regression analysis, only those parts of the curve that were linear were used (data at the very

beginning and at the end were non-linear). Specific procedures followed in the ventilation test were as follows:

3.1 Baseline Ventilation Rate Procedures.

- Each morning the MIRAN®s were checked to ensure they were operating with the correct settings and were zeroed.
- The doors to the interior rooms were opened, all other doors and windows of the building were checked to ensure that they were closed properly.
- A new log file was created on the DAS and the logging process was started.
- The digital output was set on the DAS to turn the mixing fans on.
- The valve on the cylinder of SF_6 was opened and the power supply was activated to release gas through the manifold lines and into the building.
- The chart on the DAS was monitored to see when the building was completely filled with SF_6 gas. When the concentration at all six building locations and in the two rooms was greater than 100 ppm, the cylinder valve was shut and the power supply was turned off (to close the solenoid valves at the end of the manifold lines).
- The interior room doors were closed and the rest of the building doors were also closed.
- The mixing fans remained on for about five minutes after the gas was shut off. The digital output on the DAS was used to turn the mixing fans off after this time.
- The DAS was used to monitor the concentration of SF_6 gas for several hours so that the baseline ventilation rate of the building (without PPV fans) could be determined.

3.2 PPV Fan Ventilation Test Procedures.

The ventilation rate with the PPV fans operating was measured after the baseline ventilation rate was measured in the morning. In the earlier tests, only one PPV fan ventilation test was completed in a day; however, after a few tests were completed, more than one PPV ventilation test were performed each day. Additional tests were repeated by continuing to perform the test procedures after the first test. Procedures for this portion of the test were as follows:

- The building was entered and opened up to clear out the tracer gas. The interior rooms were opened during this portion of the test. The PPV fans for

each test were pre-positioned outside of the building's main entrance door and their operation was verified. Gas tanks were filled if the fan to be used had a gasoline-driven engine.

- The DAS was monitored to see when the building and rooms were cleared of the tracer gas. The doors of the enclosed rooms and building were closed after they were purged adequately.

- The digital output was set on the DAS to turn the mixing fans on.

- The valve on the cylinder of SF_6 was opened and the power supply was activated to release gas through the manifold lines and into the building.

- The chart on the DAS was monitored to see when the building was completely filled with SF_6 gas. When the concentration at all six building locations was greater than 100 ppm, the cylinder valve was shut and the power supply was turned off (to close the solenoid valves at the end of the manifold lines).

- The mixing fans remained on for about five minutes after the gas was shut off. The digital output on the DAS was used to turn the mixing fans off after this time.

- The DAS log file was started.

- The PPV fans were started, the door of the building was opened, and the PPV fan was placed in the pre-determined operating position, and the exit windows were opened.

- The DAS was used to monitor the concentration of SF_6 gas as the PPV fan combination drove it out of the building so that the ventilation rate of the building with the PPV fans could be determined.

- In tests where the concentration in the enclosed rooms rose after the PPV fan was started, the doors of the rooms were opened after the concentration in the main building dropped below 10 ppm The test was continued to measure the ventilation rate of the rooms after this time.

- The DAS log file was stopped and the data was analyzed.

3.3 PPV Fan Position Determination Procedures.

Procedures for determining the optimum location (distance from the door) that the PPV fans should be operated at during Phase 1 testing was as follows. Pressure gauges were installed to monitor the maximum positive (or negative) static pressure that was induced inside the building when each fan combination was placed at various distances from the doorway. An electronic pressure transducer was used to record the pressures inside the building on the data

acquisition system as the fan was moved away from the building's door. The first position measured was at the door; the fan was then moved back (in foot increments) until the maximum pressure was obtained. This fan location was then used for all of the ventilation tests. The best distances for the PPV fans were between 9 feet and 10 feet, four inches from the door with the fans pointed straight in at the door (no tilting). When the fan's airflow direction was tilted, the optimum distance was 5 feet from the door. The optimum distance for the NPV mode (fans inside the building blowing air out) was 4 feet from the door.

4. DATA ANALYSIS PROCEDURES

The DAS data was analyzed to determine the ventilation rate of the building and rooms by performing a linear regression analysis on the plot of the concentration versus time data in each of the building locations. Building pressures and weather conditions were also analyzed for average conditions during each test. The natural logarithms of the concentrations were calculated and plotted versus time (in unit of hours). This produced a curve that depicted the decay rate of concentration over time in the building (or in the rooms). The data from the linear portion of the curve was then chosen and analyzed to determine the slope and intercept of the algebraic function that specified the equation of the line. This equation is presented in equation 1 below:

$$\text{Ln Conc (ppm)} = (\text{Slope of Line}) * \text{Time (hours)} + \text{Intercept} \qquad \text{(equation 1)}$$

The slope of the line is equal to the ventilation rate of the building (or room) in each area. The natural ventilation rate of the building was determined by calculating the ventilation rate of each of the six building locations from the data taken during the morning of each test and averaging the data from these locations. Natural room ventilation rates were also determined.

The data from each PPV ventilation test was then used to determine the forced ventilation rate of the building when the PPV fans were used. The difference between the natural and the forced ventilation rates was calculated by dividing the forced rate by the natural rate. The result was labeled as the Rate of Ventilation Improvement (RVI), which is a factor of how many times faster the ventilation rate is with the PPV fans than without them.

$$\text{RVI} = \frac{\text{Average of Forced Ventilation Rates (6 Building Locations)}}{\text{Average of Natural Ventilation Rates (6 Building Locations)}}$$

All phase 1 series test results were calculated in this fashion. In order to accurately compare the RVIs between the different fan combinations used for ventilating the building, the RVIs were normalized by recalculating with a standard natural ventilation rate. The ventilation rate used for these calculations was the average rate during test days where the wind speed was at a nominal speed. The 'normalized' RVIs were then calculated by dividing the forced-air ventilation rate by the standard natural ventilation rate. Using this procedure, the RVIs were normalized so that the difference between fans could accurately be determined.

The average of each set of tests using the same PPV fan configuration was calculated for each building location and for the average of all building locations. This data is presented in the main body of the report.

The concentration versus time data was also analyzed to determine the percentage concentration reduction that was achieved in the first ten minutes for each PPV fan combination used. This was calculated by first determining the percentage that remained in the building after ten minutes. The calculation procedures used were to divide the concentration at the ten-minute interval by the initial concentration present when the PPV fans were started. This value was then subtracted from one to yield the Concentration Reduction.

$$\text{Concentration Reduction} = \left[1 - \frac{\text{Concentration at 10 minutes}}{\text{Initial Concentration}} \right]$$

The percentage concentration reduction was then calculated by multiplying the concentration reduction by 100.

APPENDIX B. MAN IN SIMULANT TEST (MIST) PROCEDURES

1. INTRODUCTION

Man In Simulant Testing (MIST) is the preferred method of determining the overall Protection Factor (PF) of protective suit ensembles to be used for protection against Chemical Warfare Agents (CWA). This document outlines the test procedures that are used at the Edgewood MIST Facility. Extensive modelling has been performed by Fedele and Nelson[3] to determine an appropriate method for the evaluation of protection based upon a Body Region Hazard Analysis (BRHA). This method uses actual skin adsorption data on agents and simulants to predict the Minimum Required Exposure Dosage (MRED) an individual must be exposed to in order to produce end-point reactions in the body for systemic (nerve agent) and localized (mustard) exposure to agents. All tests performed at the Edgewood Chemical and Biological Center (ECBC) MIST Test Facility followed the BRHA model and the procedures listed within this document. Similar testing has been conducted on various other protective suit ensembles[7] from 1995 to the present.

2. SCOPE

Testing was conducted according to guidelines set forth by the Joint Services Lightweight Integrated Suit Technology (JSLIST) working group, specifying test methods capable of accurately measuring a protection factor (PF) greater than 1,000 (the maximum PF that can accurately be measured in these tests is approximately 10,000). Passive sampling devices (PSDs) are mounted beneath the clothing of the test subjects to sample chemical simulant vapors at a rate consistent with the body's uptake rate of agent. The uptake rate of the PSDs has been determined in an earlier JSLIST research study[8]. These test procedures were validated when the Kappler First Responder© suit[7] was evaluated in July of 1995 for possible use by emergency personnel in the event of a chemical agent release at the Tooele Army Depot's demilitarization facility. Other testing using these procedures has also been conducted on a variety of protective suit ensembles including Level A and Level B HazMat suits, military clothing, and fire fighter protective clothing at the Edgewood MIST Facility.

In this testing, test subjects dressed up in the appropriate protective ensemble (standard Fire Fighter Protective Clothing (FFPE) with Self-Contained Breathing Apparatus (SCBA) and a Quick-Fix of Duct Tape in the Self-Taped mode) and were exposed to a high concentration of methyl salicylate (MeS) vapor. Methyl salicylate (Oil of Wintergreen) is a mustard (HD) agent simulant used widely in test programs. It has been selected by the JSLIST working group for use in testing under the JSLIST program. Each trial exposed the test subjects to an MeS concentration of approximately 50 mg/m^3 for 30 minutes while performing a series of exercises to simulate typical movements of personnel during rescue operations in burning buildings. Vapor concentrations were measured at seventeen body locations beneath the suit with passive sampling devices (PSDs) that contain the solid adsorbent Tenax® TA. Test subjects, wearing shorts and T-shirts, had the PSDs affixed to their bodies before donning the protective suit ensemble. All closures of the suit were sealed according to the manufacturer's specifications and checked prior to testing. The Quick-Fix was applied at the scene of the rescue immediately before entry to the building while the PPV fans were set in place and running.

3. TEST EQUIPMENT AND PROCEDURES

3.1 Test Facility.

Tests were conducted at the Edgewood MIST Facility for evaluating the protection offered by the suits. The standard Clean-Room area of the MIST facility was used for application of the test samples and dressing up in the FFPE protective suit ensembles, and building E5840 was used as the vapor exposure chamber. The vapor exposure chamber normally used is the north test chamber of building E5354 in the Edgewood Area of Aberdeen Proving Ground, MD; however, building E5840 was used because it provided a realistic environment for rescue operations (See Figure B-1). A set of heated metal cookie sheets was used to vaporize MeS and create a vapor challenge inside the building before the Fire Fighters arrived. Mixing fans were used to circulate the vapor produced inside the building; the fans were operated before the Rescue Mission began and were shut off once the mission started. These were controlled by a Data Acquisition System (DAS) located in the instrument room with feedback concentration readings generated by several Foxboro Miniature Infra-Red Analyzers (MIRAN®). A weather station was used to monitor temperature, relative humidity (both inside and outside the building), wind conditions, rain, and barometric pressure. The challenge concentration in the chamber was measured during the rescue mission using six MIRAN®s. The location of each MIRAN®'s sampling point was as follows: three were in the front of the building (near the entrance) one was in the center, and the other two were at the opposite end of the building (see Figure B-1). All MIRAN® readings were recorded by the DAS throughout the entire time of the test, with readings taken before entry (when the PPV fans were first started) and for the duration of the rescue mission (30 minutes).

The Clean-Room area (see Figure B-2) is a custom built, 5-stage system that consists of two rooms and three sets of protective entrances (airlocks) for controlled entry into the facility (to prevent cross contamination). The clean-room area is ventilated by 800 cfm of filtered, purified air and is located within the main MIST facility in building E5354. It was occupied by test subjects during application and removal of the sampling devices and during dressing with the protective suit ensembles. It was also used as a controlled vapor area for removal of the ensembles after the rescue mission was completed.

3.2 Air Sampling Devices for Measuring Concentration Inside the Suit.

Concentration of MeS inside the suits was measured with the Natick patch sampler PSDs. The Natick sampler is the passive sampler used in this testing and has been approved by the JSLIST committee for sampling individual protective equipment suits[8]. This PSD contains the solid adsorbent material Tenax® TA in a small plastic pouch and samples air by capturing the MeS vapors in the adsorbent material. The PSDs were used to sample for MeS vapors beneath the suit on the surface of the test subject's skin. This device samples by diffusion (molecular transport) with the rate of diffusion into the adsorbent controlled by the exposed layer of polyethylene film. The diffusive sampling rate for these PSDs is about 15 ml/min. The sampling rate for the lot of PSDs used in this testing was determined experimentally; the average rate was found to be 14.63 ml/min with a standard deviation o f 0.13 ml/min. The adsorption

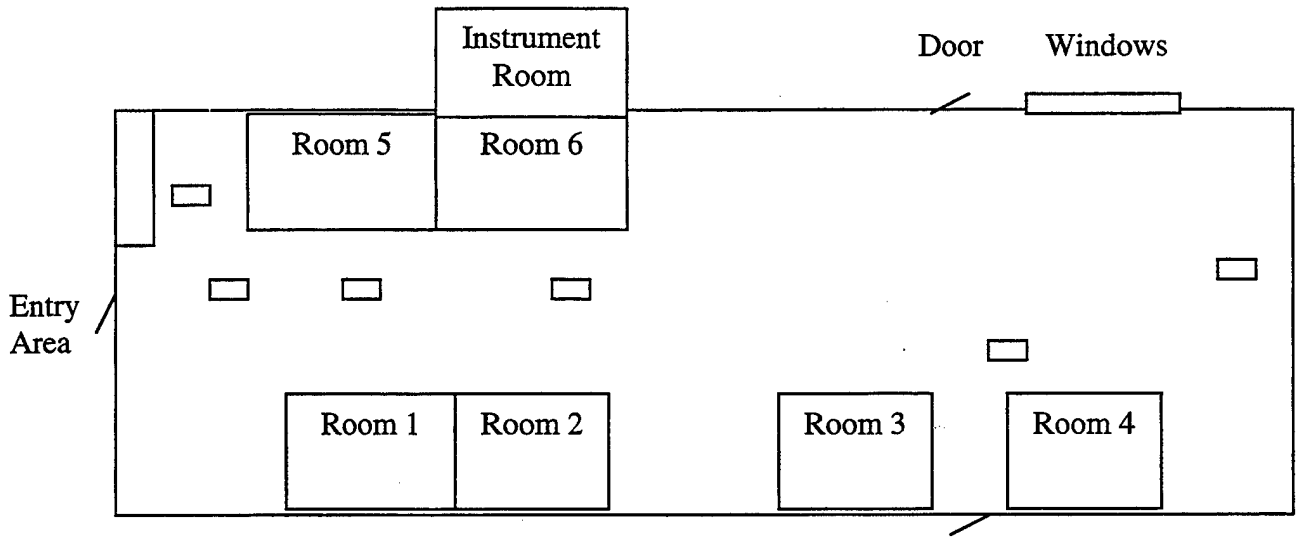

Figure B-1. Floor Layout of Building E5840

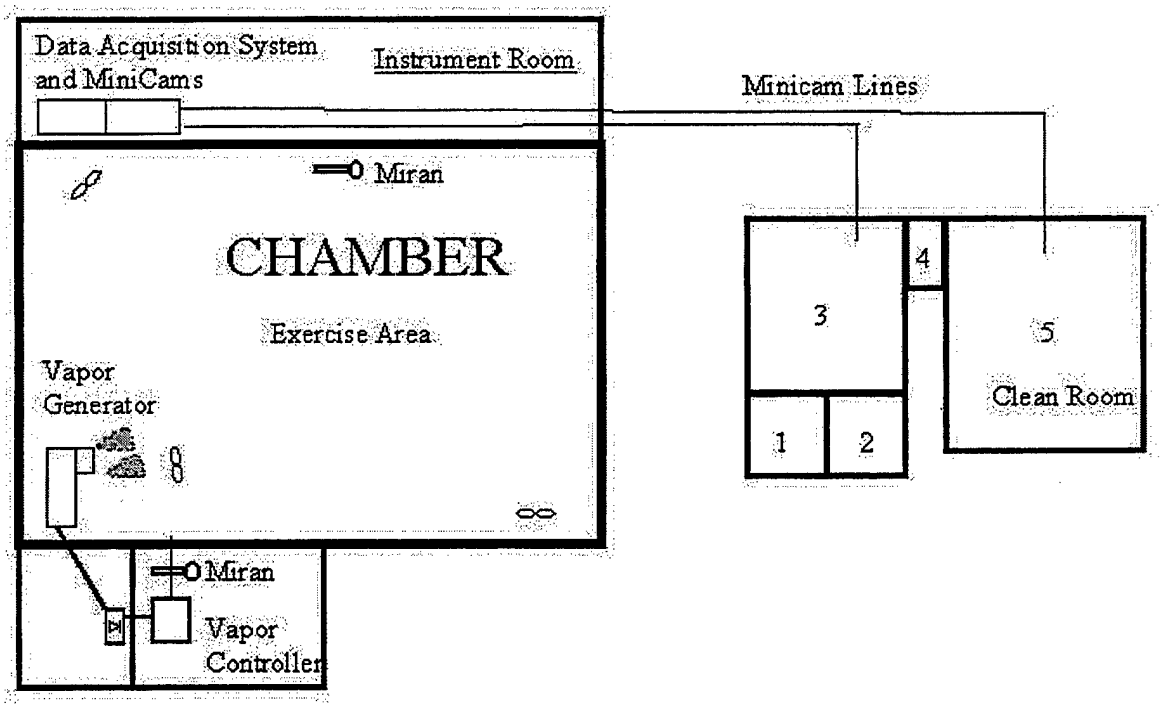

Figure B-2. Chamber and Clean-Room Layout

velocity (or uptake rate) of the PSDs (sampling rate divided by the effective sampling surface area of 3.78 cm^2) is 3.86 cm/min. This adsorption velocity is very similar to the skin's adsorption rate of chemical agents.

The PSDs were handled with specific procedures to minimize the potential for contamination. The filter units that pressurized the Clean-Room areas were run overnight to ensure that trace levels of MeS were not present during testing. The concentration in the

Clean-Room (and in the Doffing-Room) where the PSDs were applied to the subjects was monitored throughout the entire test period. Test technicians who worked in the Clean-Room area washed their hands prior to handling any PSDs and were not allowed to come into any contact with the MeS vapor generation equipment. The PSDs were applied to test subjects in the fifth stage of the Clean-Room as the subjects put on the suit and were removed in this same area at the completion of each trial. When the patch samplers were removed, they were placed on a data sheet that lists the body location they occupied. After removing the PSDs, the plastic pouch of the patch samplers was opened with a razor knife and the tenax adsorbent was removed with a sorbent tube connected to a vacuum pump. A fine mesh gauze screen was then inserted into the sorbent tube to hold the adsorbent in place and teflon caps were placed on both ends of the tube to seal the sample and prevent contamination. The tube ID was recorded to ensure accurate PSD sample identification. The tubes were then analyzed with a flame ionization detector (FID) on the Perkin Elmer Autosystems gas chromatograph (GC) and the ATD-400 thermal tube desorber according to standard lab procedures adopted at the MIST Facility. Background samples within the Clean-Room were also analyzed.

3.3 **Applying PSDs to Test Subjects.**

The PSDs were placed at 17 locations beneath the suit of each test subject, on the skin (or on top of underclothing) as depicted in Figure B-3 and as listed in Table B-1.

3.4 Applying PSDs to Test Subjects.

The following procedures were used during the testing when test subjects were instrumented with the PSDs. These procedures minimized the potential for contaminating the samplers and were designed so that background levels of simulant can be accounted for during the analysis.

The Clean-Room dressing area used for mounting PSDs on the test subjects and for transferring the adsorbent to sample tubes was prepared for the testing by running the clean-air filter system at least 24 hours prior to testing. Test subjects were dressed in gym shorts and T-shirts before entering the Clean-Room for dressing. The FFPE, duty uniform, SCBA mask, and gloves were pre-positioned in the Clean-Room along with the PSDs and data forms. The PSDs (Natick patch samplers with two-sided medical adhesive tape) were placed on each subject directly to the skin. Three PSDs (designated as the open blanks) were removed from the storage container and exposed to the Clean-Room environment while the subjects were fitted with the PSDs and also at the end of the test when the PSDs were removed and sealed back in the containers. These samplers were analyzed to determine residual levels of MeS that were not related to the exposure in the vapor area but were the result of exposure to trace amounts of MeS during instrumentation, dressing, doffing, and removal of samplers. The locations of PSD placement, along with PSD ID numbers, were recorded on data sheets.

Once the badge application operation was started, it was completed as rapidly as possible. Once the suit was donned, each subject's garment was checked to ensure proper closure and fit of the wrist closures, boot closures, any zipper/velcro closures, and hood closure. The subjects then proceeded directly to building E5840 for the Rescue Mission and applied the Quick-Fix of Duct Tape in the Self-Taped mode before entry.

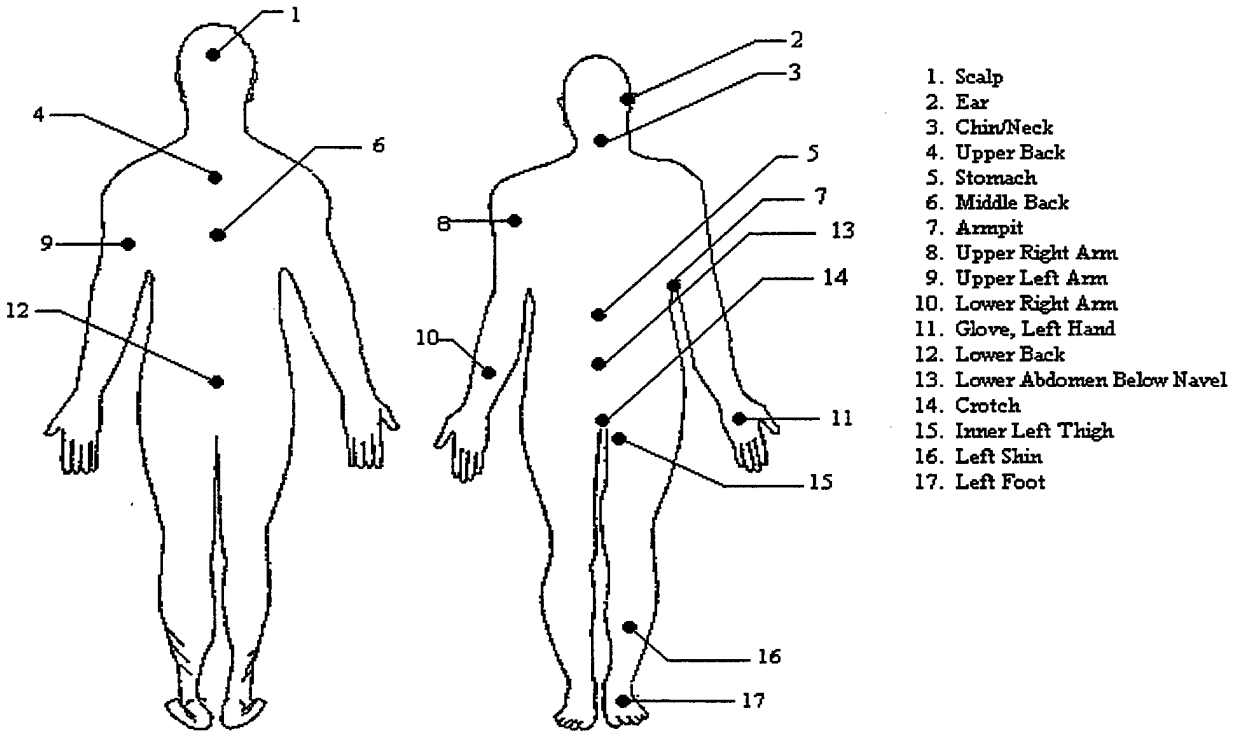

Figure B-3. Location of PSDs on Test Subjects during MIST Testing.

Table B-1. Location of PSDs on Test Subjects during MIST Testing.

(1) Scalp
(2) Ear
(3) Chin/Neck (Front Center)
(4) Upper back, between shoulder blades
(5) Stomach/Abdomen
(6) Middle of Back
(7) Left Axilla, on ribs
(8) Upper Right Arm, Inner
(9) Upper Left Arm, Outer
(10) Lower Right Arm, Inner
(11) Glove, Left Hand
(12) Lower Back, Lumbar
(13) Lower abdomen, below navel
(14) Crotch
(15) Inner Left Thigh
(16) Inner Left Calf
(17) Left Foot/Boot

3.5 Procedures for Challenging the Suit.

The exposure area of building E5840 was prepared before the subjects arrived by bringing the MeS concentration up to around 50 mg/m^3 while the subjects were dressing and having PSDs applied. Temperature, relative humidity, and concentration readings were recorded on the data acquisition system (DAS). The DAS was started and its proper functioning verified before the subjects arrived at the scene.

The subjects arrived at the scene and proceeded to set up the PPV fan and apply the Quick-Fix to their bunker gear before entry. This allowed the concentration inside the rescue building to be brought down a good deal before they entered because the Quick-Fix was applied after the PPV fan was started (it took approximately five minutes to apply the Quick-Fix). Once entry was initiated, the subjects performed the rest of the activities for the rescue mission as listed in Table B-2. The rescue mission was performed for a total duration of 30 minutes for each test; all activities were performed on a continuous basis with some rest periods.

Table B-2. Rescue Mission Activities.

a) Arrive at building and set up Positive Pressure Ventilation (PPV) fans to purge building.
b) Finish suiting up with respirator and suit Quick-Fixes (self-taped duct tape).
c) Initial entry and evaluation of the building conditions to include evaluation of the number of personnel that must be rescued.
d) Climb ladder to evaluate second floor building conditions.
e) Crawl to recessed areas of building and evaluate those areas.
f) Secondary entry to building for rescue operations.
g) Rescue six mannequins from various locations (ground floor only) inside the building:
    1.) Perform rescue by placing 'victims' on litter stretchers and performing a two man carry out of the building.
    2.) Perform rescue operations by utilizing the standard Fireman drag rescue procedures.
h) Shutdown of PPV fans and retreat from the building area.

3.6 Procedures for Removing PSDs.

Doffing the suit after exposure is the critical stage in the process, therefore, care must be taken to prevent contamination of the samples. This is because the suit adsorbs significant quantities of MeS when exposed to a high concentration of vapor, and will desorb this vapor in clean air areas. After the subjects left the rescue scenario building, the FFPE suits and SCBA were doffed in a ventilated area of building E5354 (main MIST Facility) before entry into the Doffing-Room and The Clean-Room areas. After the FFPE was doffed, the subjects entered the Doffing-Room (see Figure B-2) and removed their standard duty uniform. Then they entered the Clean-Room and removed the PSD samples. The exact procedures used during this time are outlined below.

Stage 1 --Airlock. The subjects entered the 5 ft by 4 ft airlock (enclosure 1), and set the purge timer for 2 minutes. They remained dressed in their duty uniform while airflow through the airlock purged vapor brought in with them and vapors that may have been desorbing from the outer surfaces of the uniform.

Stage 2 --Airlock. After the purge timer rang, the subjects proceeded into the second 5 ft by 4 ft airlock (enclosure 2), and set the purge timer for 2 minutes here also. Additional airflow purged out any remaining vapors brought in with them.

Stage 3 - After the purge timer rang, the subjects entered the Doffing-Room (enclosure 3) and removed their duty uniform. After the uniform was removed, they proceeded directly to the Clean-Room.

Stage 4 - Transition airlock. In this 4 ft by 4 ft airlock (enclosure 4), the subjects proceeded without delay through the airlock to the final stage to remove the PSD samplers.

Stage 5 – Clean-Room. In this 10 ft by 12 ft shelter (enclosure 5), the PSDs were removed from the subjects; the test subjects then left the Clean-Room area). The adsorbent was transferred from the passive samplers to individually numbered sorbent tubes. The sorbent tubes were capped to preserve each sample for analysis.

3.7 Procedures for Analyzing Samples.

Each tube was analyzed on the Perkin Elmer Autosystem GC system, which includes the Automatic Thermal Tube Desorber (ATD-400) and the Turbochrom data acquisition system according to guidelines determined in the JSLIST research study[9]. Tubes were desorbed on the ATD-400 by heating them up to 250°C and passing carrier gas through the sorbent tubes for 5 minutes; the gases were condensed onto the cold trap of the ATD-400 (held at -30°C). The cold trap was then heated rapidly to 320°C and held there for 2 minutes to flush the sample from the cold trap and send it directly to the GC. The sample was separated on the GC column, which was a 15-m, 0.53 mm ID, 3.00 μm film thickness, fused Silica Capillary column Supelco model SPB-1. The column was held at 100°C for 1 minute, heated to 150°C at a rate of 10 °C/min, and then heated to 200 °C at a rate of 25°C/min (MeS eluted from the column at 2.11 minutes).

The gases from the column were sent to the Flame Ionization Detector (FID), which measured the number of ions given off (in millivolts) and transmitted the data to the Turbochrom computer data acquisition system, which graphs voltage (millivolts) versus time (minutes). The computer then integrated the area beneath the peaks to determine the mass of each individual component in terms of ηg.

3.8 Quality Assurance/Quality Control Procedures.

Tenax®TA sorbent provided to the manufacturer of the PSDs was purified and certified clean by an independent laboratory at Pennsylvania State University. The purification process involved supercritical liquid extraction followed by heating and purging with a carrier gas. The adsorbent was then sampled and analyzed by gas chromatograph analysis to ensure adequacy of the cleaning; strict purity protocol requirements were followed.

Following receipt of the samplers from the manufacturer, the sorbent was sampled again at the ECBC lab. One set of samplers from each lot was analyzed for verification by removing the sorbent, placing it in sorbent tubes, and analyzing the tubes for residual levels of MeS with the GC.

During each pre- and post-trial period in which the PSDs were being mounted, removed, and transferred to sorbent tubes in clean room area, three PSDs designated as

"Backgrounds", were removed from their storage containers and exposed to the Clean-Room environment. These samples were analyzed to measure background levels of MeS present during patching, dressing, doffing, and removal of samplers and not related to the exposure in the rescue scenario building.

The Turbochrom data system was calibrated by injecting chemical standards of known concentrations (MeS in isopropanol) onto cleaned sorbent tubes and analyzing them on the ATD-400/Autosystems GC system. The data system calibration uses a linear regression equation for the lower range and square or quadratic equations for the higher ranges.

Quality Control checks were performed each test day to ensure that the GC was properly calibrated and functioning properly. Injections of standards were made throughout the mass range that samples were anticipated to be analyzed on. Tubes were not analyzed if the QC checks showed a deviation greater than 10% from the mass injected.

The MIRAN®s used to monitor the level of MeS vapor in Building E5840 were calibrated before the testing.

4. METHOD OF ANALYSIS.

4.1 PSD Concentrations and Protection Factors.

The mass analyzed from each PSD was examined to determine if it was significantly different from the mass of the averaged background samples. This process was performed by subtracting the averaged background mass plus one standard deviation (of the average) from the mass of each PSD and determining if the result was greater than zero. If the resulting mass was greater than zero, then the analysis methods outlined below were performed. If the resulting mass was less than zero, then the PSD was considered not to have sampled any MeS during the exposure period and the maximum PF for that test was assigned for that PSD sample.

The concentration of MeS sampled by the PSDs at each sample location was calculated by dividing the total mass of MeS (in ηg) by the product of the sampling rate of the PSDs (in ml/min) multiplied by the total sampling time of each PSD (in minutes) (see equation 1). The averaged mass from the open background PSD samples was subtracted from each samples' mass before calculating the concentration to correct for incidental exposure of the PSDs during donning, doffing, transfer, and storage. Background samples were exposed to the air inside the Clean-Room during the entire dressing/undressing/PSD removal time. The PSD sample location concentration for each body area was calculated using equation 1.

$$C_{SL} = \frac{\text{Mass of MeS from PSD - Mass of MeS from Background}}{\text{Sampling Rate of PSD x Exposure Time}} \quad (1)$$

Each PSD concentration was converted to a dosage by multiplying by the exposure time. Sample Location PFs were determined by dividing the exposure dosage by the dosage detected inside the suit at each location. The PF calculation is expressed mathematically in equation 2:

$$PF_{SL} = \frac{\text{Average Exterior Concentration x Time}}{\text{Average Concentration Inside Suit x Time}} = \frac{\text{Exposure Dosage}}{\text{Dosage Inside Suit}} \quad (2)$$

Normally the exposure dosage is calculated by measuring the concentration of MeS in the exposure area, averaging the values from all MIRAN® readings measured in that area, and multiplying by the exposure time. In this test, however, a "Standardized" exposure dosage was used so that the effectiveness of the use of the PPV fans could accurately be evaluated. If the actual concentration dosage the test subjects were exposed to in each test was used, it would produce inaccurate results in the evaluation of the protection offered through use of the PPV by producing very low individual skin sample location PFs_{SL}. This is because the concentration in the exposure area was reduced through use of the PPV fans, and therefore, the exposure dosage was reduced during these tests in proportion to how well the PPV fans ventilated the building. Since the individual sample location PFs_{SL} are directly proportional to the exposure dosage, using PPV fans would reduce the values of these PFs_{SL} (since the exposure dosage was reduced). This would then show a negative effect from using the fans (when PFs_{SL} went down), although we know that when the skin is exposed to less chemical vapor, it's protection is increased.

The Standardized exposure dosage used for the analysis of the individual skin PFs_{SL} in this test was the average values of the exposure dosages the test subjects were exposed to in the initial FFPE suit testing during eight tests at the Edgewood MIST Facility in March 1998*. This value (1670.32 mg-min/m^3) was used in all calculations of the protection factor (PF_{SL}) at each body area. Since this value was the same for all tests, the increase in PFs_{SL} because of the use of the PPV fans was more accurately calculated. The higher Overall PFs do not actually represent an increase in the actual PF of the turnout gear, but merely represent the increased protection provided through use of the PPV fans.

The maximum PF_{SL} for each test was determined by dividing the exposure dosage by the minimum dosage capable of being analyzed by the gas chromatograph. The smallest detectable amount of MeS that can be measured with the combined PSD/gas chromatograph system during these tests was determined by measuring the variability of analyzed samples. This variability was measured in a study that determined the overall background mass of MeS on 25 unopened, unused PSDs. In this study, 25 unused PSDs were packed in sample tubes and analyzed. There was very little difference between the readings obtained in this background sample study and the average background masses determined in the MIST tests. The standard deviation of these samples (3.60 ηg) is the value that was used as the smallest detectable mass of MeS on the PSD/GC system. Based upon an average challenge concentration of 54.5 mg/m^3, a 30-minute exposure period, and a PSD sampling rate of 14.6 cm^3/min, the equations listed above yield a maximum detectable PF_{SL} of around 6622.

The Sample Location PF values were tabulated for each different body area. The Overall PF for the suit ensemble was then calculated with the BRHA and the difference from the baseline test (where no PPV fan was used) was evaluated by comparing the Ovarall PFs determined from the different tests (all calculations used the standardized exposure dosage).

* Arca, V.J., *Man In Simulant Testing (MIST) of Fire Fighter Turnout Gear and Quick-Fixes,* U.S. Army Edgewood Chemical Biological Center, Aberdeen Proving Ground, MD 21010-5424, unpublished data, October, 1999.

4.2 Calculation of Overall Protection Factors.

The Overall PF of the suit was determined by using the Body Region Hazard Analysis (BRHA) model developed by Fedele and Nelson[3], which is based upon the amount of agent that must be absorbed percutaneously (through the skin) in each of 27 different body regions to produce mean, end-point reactions. In the model, the mean end-point reaction is taken as the first significant symptom that occurs as a result of exposure to the agent. For nerve agent (VX) exposure, it is a headache or miosis* (constriction of the pupil of the eye) that occurs first, followed by more severe symptoms of nausea and vomiting. Reddening of the skin similar to severe sunburn (erythmea), is the mean, end-point reaction for exposure to blister agent (HD). This model applies data obtained from adsorption studies on human skin with pesticides[4] and the nerve agent VX[5]. A weighting factor is assigned to each of these values based on the dose and the total percentage of that skin area.

The Overall PF for nerve and blister agents requires separate calculations. For nerve agent, the Overall PF is based on a weighted average of the PF measurements from all individual body regions (PF_{BR}). Body Region PFs were calculated by using an appropriate combination of the individual PF_{SL}s (see Table B-3), averaged according to the proportion of body area covered by each sample. This approach is used because nerve agents produce a systemic rather than a localized response in the individual. When the Overall PF for nerve agents is multiplied by 10 mg-min/m^3 (which is the minimum dosage of nerve agent VX an unprotected individual must adsorb through their skin to develop end-point reactions) the first Systemic Minimum Required Exposure Dosage (MRED) value is obtained. The more severe symptoms occur at an exposure dosage of 25 mg-min/m^3, this is the value the Overall PF was multiplied by in order to obtain this second end-point value of the MRED.

The initial effects of blister agent (HD) are localized to specific body regions. Furthermore, the skin in each area of the body has a different level of sensitivity. Because of this, the Overall PF for the blister agent HD is expressed as a localized MRED. This is calculated by multiplying a local exposure dosage (which quantifies the sensitivity of the skin at a particular body region) by the PF_{BR} calculated for that body region. The *lowest* calculated localized MRED value is applied in evaluating the protective suit and is reported (along with the skin area affected) in evaluating the protective capability of the suit and areas of susceptibility.

A detailed description of both of these methods and equations used to calculate Overall PF using the Fedele model is contained below.

4.2.1 Systemic Effect - Nerve Agent (VX).

The BRHA model quantifies the dosage required to cause a systemic nerve agent effect (end-point reaction) for each body area. These dosages are listed in Table B-3 and are divided into the skin area to calculate the area/dosage (A/D) factor, which is also listed in Table B-3. The A/D factor equals the percentage of skin area divided by mass required to be absorbed

* Miosis generally occurs only when nerve agent is absorbed through the eyes or the respiratory tract; it is usually not a result of percutaneous skin absorption of agent.

Table B-3. Model Parameters used to Calculate the Overall Protection Factor

BRHA Calculation Figures					Local
Skin Sample Region	Sample Number	Area (cm^2)	Dose mg/ind	A/D Factor	Exposure Dosage Mg-min/m^3
1 Scalp	1	350	0.76	460.53	271
2 Ears	2	50	0.46	108.70	164
3 Cheeks & Neck	2, 3	100	0.48	208.33	171
4 Chin & Neck	3	200	0.36	555.56	129
5 Nape	4	100	1.72	58.14	614
6 Abdomen	5*2,7,13	2858	2.23	1281.61	796
7 Back	2(4,6,12),7	2540	2.65	958.49	946
8 Axillae	7	200	2.07	96.62	739
9 Upper Arms, medial	8	488	2.80	174.29	1000
10 Upper Arms, lateral	9	706	6.57	107.46	2346
11 Elbowfolds	8,10	50	2.09	23.92	746
12 Elbows	9,10	50	2.25	22.22	804
13 Forearms, volar	10	487	2.80	173.93	1000
14 Forearms, dorsum	10	706	6.57	107.46	2346
15 Hands, dorsum	11	200	2.91	68.73	1039
16 Hands, palmar	11	200	9.24	21.65	3300
17 Buttocks	12	953	4.26	223.71	1521
18 Groin	13,14	300	1.22	245.90	436
19 Scrotum	14	200	0.11	1818.18	39
20 Thighs, anterior	15	2845	6.57	433.03	2346
21 Thighs, posterior	15	1422	4.26	333.80	1521
22 Knees	15,16	200	7.14	28.01	2550
23 Popliteal Space	15,16	100	2.09	47.85	746
24 Shins	16	1897	6.57	288.74	2346
25 Calves	16	948	2.80	338.57	1000
26 Feet, dorsum	17	500	6.60	75.76	2357
27 Feet, plantar	17	300	7.14	42.02	2550
		18950		8303.19	

Overall PF = {Sum of A/D Factors}/{Sum of A/(D*PF) Factors}

Localized Minimum Required Exposure Dosage (MRED) = Local Exp Dosage * PF Factor

at that area to produce the end-point reaction. The Overall PF of the suit is determined by dividing the sum of the A/D factors by the sum of the $A/(D*PF_{BR})$ factors (A/D factor divided by Body Region PF at each area).

The equations used to perform each of these calculations are as follows:

$$(A/D)_i = A_i \div D_i \quad (3)$$

$$A/(D*PF)_i = A_i \div (D_i * (PF_{BR})_i) \quad (4)$$

$$\text{Overall PF} = \frac{\sum (A/D)_i}{\sum A/(D*PF_{BR})_i} \quad (5)$$

where $(PF_{BR})_i$ is the body region protection factor measured at location i = 1, 2,... 27, and PF is the overall protection factor summed over i = 1, 2, ... 27 body areas. The Systemic MREDs are calculated by multiplying the Overall PF by the dosages of nerve agent required to cause effects in individuals. The Overall PF was multiplied by 10 mg-min/m^3, which is the minimum dosage of the nerve agent VX that an unprotected individual must be exposed to in order to develop end-point reactions to determine the first MRED (headache occurs first). The Overall PF is also multiplied by 25 mg-min/m^3, which is the dosage at which the more severe reaction of nausea and vomiting occurs to determine the second MRED. The Systemic MRED is used to predict the dosage exposure required for systemic nerve agent effects, since this part of the BRHA model was developed using data taken from controlled human exposure to the nerve agent VX.

4.2.2 Localized Effect - Blister Agent (HD).

A second data set from the BRHA model was used to determine what exposure dosages are required to cause end-point reactions when the suit wearer is exposed to HD vapor (reddening of the skin occurs first, similar to severe sunburn). Since the effects of HD are not cumulative and generally affect only localized body regions, the model predicts MREDs for each body region (based upon the individual PF_{BR} values). The lowest value of all these dosages is used to predict the lowest response dosage for people wearing this protective suit. Listed in Table B-3 are the local exposure dosages for HD provided by the model. The local exposure dosage column in Table B-3 contains values of agent dosages (LEDs) to which each individual skin area must be exposed to in order to attain a localized skin reaction. These values were multiplied by the appropriate PF_{BR} value to obtain the MRED required to cause localized skin reactions at each body location. Thus, the localized MRED for the protective suit was calculated using the following equation:

$$\text{Localized MRED} = LED_i * (PF_{BR})_i \quad (6)$$

where LED_i is the localized exposure dosage for skin area i=1,2,...27, and $(PF_{BR})_i$ is the body region protection factor measured at skin area i=1, 2,...27. The site with the lowest value is used in the evaluation of the data for the tests, i.e., the site with the smallest MRED value is the area that is least protected by the suit.

Observations of the test subjects' performance throughout the test were recorded by the test technicians. Subjects' opinions were also recorded through direct questions and interviews after the testing.

Appendix B

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APPENDIX C. VENTILATION STUDY TEST DATA

Summary of Natural Building Ventilation Rates

	Test 1a 16 Sep 98	Test 2a 17 Sep 98	Test 3a 18 Sep 98	Test 4a 20 Sep 98	Test 6a 21 Sep 98	Test 9a 22 Sep 98	Test 12a 23 Sep 98
Bldg Location 1	0.6163	0.1790	0.2589	0.1928	0.2337	0.1906	0.8718
Bldg Location 2	0.3886	0.1937	0.2982	0.2323	0.2916	0.1588	0.8100
Bldg Location 3	0.4841	0.1860	0.2671	0.2039	0.2615	0.1423	0.7309
Bldg Location 4	0.4690	0.1870	0.2616	0.2210	0.2635	0.1528	0.7440
Bldg Location 5	0.4229	0.2196	0.2312	0.1833	0.2391	0.1268	0.7185
Bldg Location 6	0.4369	0.1691	0.2221	0.1744	0.2139	0.1516	0.7596
Average:	**0.4696**	**0.1891**	**0.2565**	**0.2013**	**0.2505**	**0.1538**	**0.7725**
Stnd Dev:	0.0725	0.0156	0.0248	0.0203	0.0249	0.0193	0.0531
Wind Speed	4.77	0.88	4.76	0.00	0.48	0.06	12.65

Conditions at Nominal Wind Speed

	Average	Stnd Dev
Bldg Location 1	0.1990	0.0207
Bldg Location 2	0.2191	0.0493
Bldg Location 3	0.1984	0.0428
Bldg Location 4	0.2061	0.0410
Bldg Location 5	0.1922	0.0427
Bldg Location 6	0.1773	0.0228
Average:	**0.1987**	**0.0365**
Stnd Dev:	0.0127	0.0108

	Test 1b 11 Dec 98	Test 2b 14 Dec 98	Test 5b 15 Dec 98	Test 8b 16 Dec 98
Bldg Location 1	0.6863	1.0710	0.2008	0.1267
Bldg Location 2	0.6885	1.2244	0.2021	0.0975
Bldg Location 3	0.7246	1.1308	0.1940	0.1153
Bldg Location 4	0.6794	1.0964	0.2016	0.1319
Bldg Location 5	0.6904	1.0972	0.2002	0.1639
Bldg Location 6	0.6876	1.2354	0.1843	0.1371
Average:	**0.6928**	**1.1425**	**0.1972**	**0.1287**
Stnd Dev:	0.0147	0.0643	0.0063	0.0203
Room 1	1.3431	1.5385	0.1245	0.0904
Room 2	0.2159	0.3879	0.0367	0.0227
Wind Speed	7.8	11.1	0.0	0.1

Average and Stnd Dev (nominal wind conditions)

Room 1	Room 2
0.1074	0.0171
0.0297	0.0070

Concentration Reduction After Ten Minutes Through use of PPV/NPV fans

	Percentage of original concentration						
	Average	Bldg 1	Bldg 2	Bldg 3	Bldg 4	Bldg 5	Bldg 6
Two 16" Electric Fans at 10' 4", PPV	47.39%	47.12%	52.83%	51.81%	46.53%	50.10%	35.93%
Two 16" Electric Fans at 10' 4", PPV	44.91%	43.64%	52.08%	40.88%	41.30%	48.91%	42.68%
Two 16" Electric Fans at 10' 4", PPV	50.05%	52.23%	51.94%	49.28%	50.31%	59.41%	37.14%
Average:	**47.45%**	47.66%	52.28%	47.32%	46.05%	52.81%	38.58%
One 20" Gas Fan at 9', PPV	57.95%	69.28%	62.35%	60.69%	36.51%	62.62%	56.24%
One 20" Gas Fan at 9', PPV	58.71%	65.60%	64.64%	58.66%	52.20%	59.78%	51.38%
One 20" Gas Fan at 9', PPV	53.29%	64.73%	54.04%	50.77%	51.55%	47.92%	50.73%
Average:	**56.65%**	66.54%	60.35%	56.71%	46.75%	56.77%	52.78%
One 30" Gas Fan at 9', PPV	72.39%	83.16%	81.71%	60.00%	51.87%	79.36%	78.22%
One 30" Gas Fan at 9', PPV	72.05%	85.62%	80.27%	57.73%	56.92%	71.98%	79.80%
Average:	**72.22%**	84.39%	80.99%	58.86%	54.40%	75.67%	79.01%
Two 20" Gas Fans at 3'6" and 9', PPV	62.01%	64.24%	60.09%	59.46%	63.32%	68.47%	56.48%
Two 20" Gas Fans at 3'6" and 9', PPV	64.01%	63.34%	66.21%	62.82%	63.20%	75.21%	53.26%
Two 20" Gas Fans at 3'6" and 9', PPV	68.69%	69.34%	70.09%	67.79%	65.27%	80.82%	58.84%
Average:	**64.90%**	65.64%	65.46%	63.36%	63.93%	74.83%	56.19%
One 24" Electric Fan at 9', PPV	57.43%	54.98%	58.31%	58.04%	56.07%	65.37%	51.82%
One 24" Electric Fan at 9', PPV	56.89%	58.59%	55.18%	52.79%	58.39%	64.67%	51.74%
One 24" Electric Fan at 9', PPV	51.73%	52.01%	52.18%	50.40%	50.57%	64.45%	40.75%
Average:	**55.35%**	55.19%	55.22%	53.75%	55.01%	64.83%	48.11%
One 20" Gas Fan, tilted 20° at 5', PPV	61.96%	63.72%	61.69%	52.30%	53.25%	79.29%	61.52%
One 20" Gas Fan, tilted 20° at 5', PPV	63.33%	67.78%	69.82%	57.33%	53.79%	67.55%	63.72%
Average:	**62.64%**	65.75%	65.75%	54.81%	53.52%	73.42%	62.62%
Two 20" Gas Fans, 1st tilted 20° at 5', 2nd straight at 9', PPV	74.33%	80.40%	75.05%	69.56%	69.88%	72.64%	78.44%
Two 20" Gas Fans, 1st tilted 20° at 5', 2nd straight at 9', PPV	72.71%	80.47%	76.89%	62.15%	63.90%	76.36%	76.47%
Two 20" Gas Fans, 1st tilted 20° at 5', 2nd straight at 9', PPV	66.94%	73.95%	73.66%	55.46%	58.03%	70.61%	69.91%
Average:	**71.32%**	78.27%	75.20%	62.39%	63.94%	73.20%	74.94%
One 24" Electric Fan, at 4', NPV	46.19%	34.32%	47.15%	49.21%	53.51%	54.19%	38.77%
One 24" Electric Fan, at 4', NPV	51.12%	43.62%	48.05%	51.02%	55.21%	55.65%	53.19%
One 24" Electric Fan, at 4', NPV	53.75%	44.77%	52.48%	50.99%	53.88%	72.11%	48.28%
Average:	**50.36%**	40.90%	49.23%	50.41%	54.20%	60.65%	46.75%
One 20" Gas Fan, tilted 20°, at 4', NPV	67.40%	58.30%	68.48%	76.25%	76.14%	69.84%	55.42%
One 20" Gas Fan, tilted 20°, at 4', NPV	65.53%	58.75%	65.07%	71.34%	72.62%	69.41%	55.98%
One 20" Gas Fan, tilted 20°, at 4', NPV	60.38%	56.66%	65.99%	72.18%	72.98%	40.96%	53.49%
Average:	**64.44%**	57.90%	66.51%	73.26%	73.91%	60.07%	54.97%

Summary of Phase 1 Ventilation Tests With PPV Fans

	Normalized Rate of Ventilation Improvement				
	Test Series 1	**Test Series 2**	**Test Series 3**	**Test Series 4**	**Test Series 5**
	Two 16"			**Two 20"**	**24"**
	Electric	**20" Gas**	**30" Gas**	**Gas**	**Electric**
Building Location 1	24.62	28.84	46.32	38.07	27.30
Building Location 2	19.91	23.55	34.42	35.75	23.64
Building Location 3	21.93	24.88	37.89	33.07	23.45
Building Location 4	20.44	25.06	44.96	32.96	24.46
Building Location 5	20.53	23.23	28.66	38.96	34.28
Building Location 6	23.27	32.06	63.45	41.73	27.42
Average:	**21.78**	**26.27**	**42.62**	**36.76**	**26.76**
Standard Deviation:	**1.69**	**3.17**	**11.09**	**3.17**	**3.72**

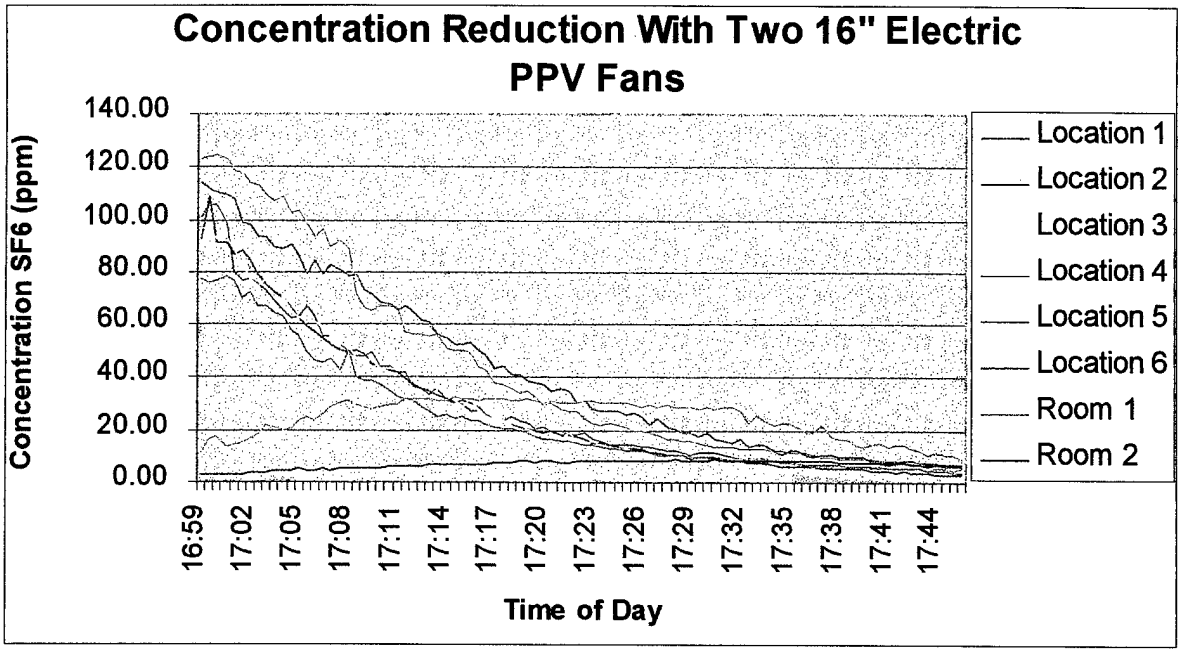
. Summary of Negative Pressure Ventilation and Tilted PPV Fan Tests

	Normalized Rate of Ventilation Improvement			
	Test Series 6	**Test Series 7**	**Test Series 8**	**Test Series 9**
	20" Gas Tilt	**Tilted Series**	**24" Electric**	**20" Gas Tilt**
	PPV	**PPV**	**NPV**	**NPV**
Building Location 1	28.22	41.42	21.35	32.19
Building Location 2	28.54	40.50	18.51	28.26
Building Location 3	27.15	39.46	23.48	39.91
Building Location 4	27.23	41.81	23.50	34.24
Building Location 5	39.51	40.33	26.22	33.52
Building Location 6	38.37	48.73	28.64	39.31
Average:	**31.50**	**42.04**	**23.62**	**34.57**
Standard Deviation:	**5.29**	**3.09**	**3.25**	**4.03**

Appendix C

Concentration reduction after ten minutes through use of PPV/NPV fans

Test		Average	Bldg 1 Location	Bldg 2 Location	Bldg 3 Location	Bldg 4 Location	Bldg 5 Location	Bldg 6 Location
1a	Two 16" Electric Fans	**47.39%**	47.12%	52.83%	51.81%	46.53%	50.10%	35.93%
2a	Two 16" Electric Fans	**44.91%**	43.64%	52.08%	40.88%	41.30%	48.91%	42.68%
3a	Two 16" Electric Fans	**50.05%**	52.23%	51.94%	49.28%	50.31%	59.41%	37.14%
	Average:	**47.45%**	**47.66%**	**52.28%**	**47.32%**	**46.05%**	**52.81%**	**38.58%**
	Standard Deviation:	**2.57%**						
5a	One 20" Gas Fan at 9 ft	**58.71%**	65.60%	64.64%	58.66%	52.20%	59.78%	51.38%
6a	One 20" Gas Fan at 9 ft	**53.29%**	64.73%	54.04%	50.77%	51.55%	47.92%	50.73%
	Average:	**56.65%**	**66.54%**	**60.35%**	**56.71%**	**46.75%**	**56.77%**	**52.78%**
	Standard Deviation:	**2.94%**						
7a	Single 30" Gas Fan	**72.39%**	83.16%	81.71%	60.00%	51.87%	79.36%	78.22%
8a	Single 30" Gas Fan	**72.05%**	85.62%	80.27%	57.73%	56.92%	71.98%	79.80%
	Average:	**72.22%**	**84.39%**	**80.99%**	**58.86%**	**54.40%**	**75.67%**	**79.01%**
	Standard Deviation:	**0.24%**						
9a	Two 20" Gas Fans in series, 3'6" and 9'	**62.01%**	64.24%	60.09%	59.46%	63.32%	68.47%	56.48%
10a	Two 20" Gas Fans in series, 3'6" and 9'	**64.01%**	63.34%	66.21%	62.82%	63.20%	75.21%	53.26%
11a	Two 20" Gas Fans in series, 3'6" and 9'	**68.69%**	69.34%	70.09%	67.79%	65.27%	80.82%	58.84%
	Average:	**64.90%**	**65.64%**	**65.46%**	**63.36%**	**63.93%**	**74.83%**	**56.19%**
	Standard Deviation:	**3.43%**						
12a	Single 24" Electric Fan	**57.43%**	54.98%	58.31%	58.04%	56.07%	65.37%	51.82%
13a	Single 24" Electric Fan	**56.89%**	58.59%	55.18%	52.79%	58.39%	64.67%	51.74%
14a	Single 24" Electric Fan	**51.73%**	52.01%	52.18%	50.40%	50.57%	64.45%	40.75%
	Average:	**55.35%**	**55.19%**	**55.22%**	**53.75%**	**55.01%**	**64.83%**	**48.11%**
	Standard Deviation:	**3.15%**						
1b	One 24" Electric Fan, negative pressure	**46.19%**	34.32%	47.15%	49.21%	53.51%	54.19%	38.77%
2b	One 24" Electric Fan, negative pressure	**51.12%**	43.62%	48.05%	51.02%	55.21%	55.65%	53.19%
3b	One 24" Electric Fan, negative pressure	**53.75%**	44.77%	52.48%	50.99%	53.88%	72.11%	48.28%
	Average:	**50.36%**	**40.90%**	**49.23%**	**50.41%**	**54.20%**	**60.65%**	**46.75%**
	Standard Deviation:	**3.84%**						
4b	One 20" Gas Fan, tilted	**61.96%**	63.72%	61.69%	52.30%	53.25%	79.29%	61.52%
5b	One 20" Gas Fan, tilted	**63.33%**	67.78%	69.82%	57.33%	53.79%	67.55%	63.72%
	Average:	**62.64%**	**65.75%**	**65.75%**	**54.81%**	**53.52%**	**73.42%**	**62.62%**
	Standard Deviation:	**0.97%**						
6b	One 20" Gas Fan, tilted, 4 ft, NPV	**67.40%**	58.30%	68.48%	76.25%	76.14%	69.84%	55.42%
7b	One 20" Gas Fan, tilted, 4 ft, NPV	**65.53%**	58.75%	65.07%	71.34%	72.62%	69.41%	55.98%
8b	One 20" Gas Fan, tilted, 4 ft, NPV	**60.38%**	56.66%	65.99%	72.18%	72.98%	40.96%	53.49%
	Average:	**64.44%**	**57.90%**	**66.51%**	**73.26%**	**73.91%**	**60.07%**	**54.97%**
	Standard Deviation:	**3.64%**						
9b	Two 20" Gas Fans, 1st tilted, 5 ft, 2nd level, 9 ft	**74.33%**	80.40%	75.05%	69.56%	69.88%	72.64%	78.44%
10b	Two 20" Gas Fans, 1st tilted, 5 ft, 2nd level, 9 ft	**72.71%**	80.47%	76.89%	62.15%	63.90%	76.36%	76.47%
11b	Two 20" Gas Fans, 1st tilted, 5 ft, 2nd level, 9 ft	**66.94%**	73.95%	73.66%	55.46%	58.03%	70.61%	69.91%
	Average:	**71.32%**	**78.27%**	**75.20%**	**62.39%**	**63.94%**	**73.20%**	**74.94%**
	Standard Deviation:	**3.88%**						



Summary Test Series 1: Two 16" Electric Fans, stacked at 10'4"

	Normalized Rate of Ventilation Improvement			
	Test 1a	Test 2a	Test 3	Average
Bldg Location 1	23.44	25.06	25.37	24.62
Bldg Location 2	20.24	18.81	20.69	19.91
Bldg Location 3	25.67	18.99	21.13	21.93
Bldg Location 4	23.11	17.95	20.25	20.44
Bldg Location 5	21.75	19.84	20.01	20.53
Bldg Location 6	22.21	23.28	24.30	23.27
Average:	**22.74**	**20.66**	**21.96**	**21.78**
Stnd Dev:	1.67	2.60	2.09	1.69
Room 1*	19.95	18.36	13.81	17.37
Room 2**	21.94	14.69	12.36	16.33

* All references to Room 1 from this page forward refer to Room 3 on the building layout diagram. This note also applies to all figures showing concentration decay curves in this report.

** All references to Room 2 from this page forward refer to Room 1 on the building layout diagram. This note also applies to all figures showing concentration decay curves in this report.

Test 1a, 16 Sep 98 Two 16" Electric Fans, stacked at 10'4"

	Natural	W/PPV	Pressure: 0.012 Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	0.6163	4.6636	7.57	23.44
Bldg Location 2	0.3886	4.4351	11.41	20.24
Bldg Location 3	0.4841	5.0940	10.52	25.67
Bldg Location 4	0.4690	4.7622	10.15	23.11
Bldg Location 5	0.4229	4.1795	9.88	21.75
Bldg Location 6	0.4369	3.9373	9.01	22.21
Average:	**0.4696**	**4.5119**	**9.76**	**22.74**
Stnd Dev:	0.0725	0.3810	1.21	1.67
Room 1	0.3223	3.9633	12.30	19.95
Room 2	0.3647	4.3594	11.95	21.94

	Weather Conditions	
	Natural	w/PPV
Temperature (°F):	88.7	85.3
Relative Humidity:	48.8	63.0
Dew Point (°F):	67.0	71.2
Wind Speed (mph):	4.8	0.0
Barometer:	30.0	30.0

Test 2a, 17 Sep 98 Two 16" Electric Fans, stacked at 10'4"

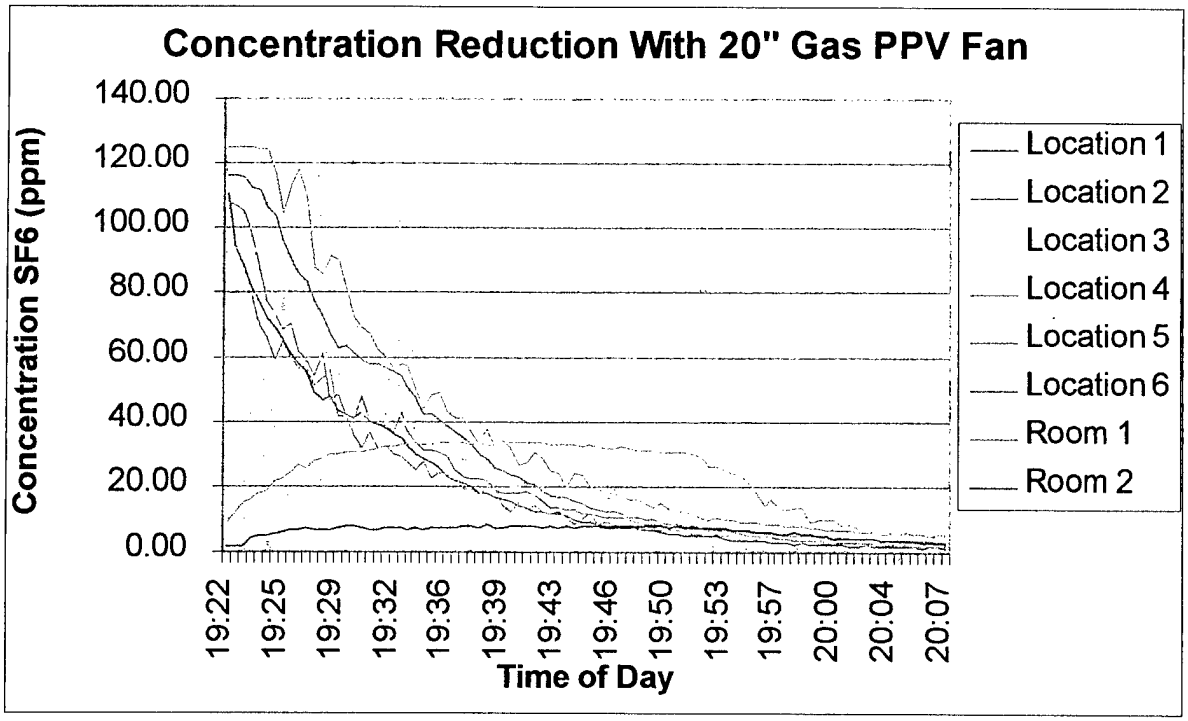
	Natural	W/PPV	Pressure: 0.012 Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	0.1790	4.9865	27.86	25.06
Bldg Location 2	0.1937	4.1206	21.27	18.81
Bldg Location 3	0.1860	3.7677	20.26	18.99
Bldg Location 4	0.1870	3.6993	19.78	17.95
Bldg Location 5	0.2196	3.8140	17.37	19.84
Bldg Location 6	0.1691	4.1270	24.40	23.28
Average:	**0.1891**	**4.0858**	**21.82**	**20.66**
Stnd Dev:	0.0156	0.4356	3.41	2.60
Room 1	0.1891	3.6468	19.29	18.36
Room 2	0.1891	2.9185	15.44	14.69

	Weather Conditions	
	Natural	w/PPV
Temperature (°F):	81.2	82.5
Relative Humidity:	61.3	61.6
Dew Point (°F):	66.6	68.0
Wind Speed (mph):	0.9	0.0
Barometer	30.0	30.0

Test 3a; 18 Sep 98 Two 16" Electric Fans, stacked at 10'4"

	Natural (Air Changes/Hour)	W/PPV	Rate of Improvement Current	Normalized
Bldg Location 1	0.2589	5.0482	19.50	25.37
Bldg Location 2	0.2982	4.5342	15.21	20.69
Bldg Location 3	0.2671	4.1933	15.70	21.13
Bldg Location 4	0.2616	4.1725	15.95	20.25
Bldg Location 5	0.2312	3.8458	16.64	20.01
Bldg Location 6	0.2221	4.3075	19.39	24.30
Average:	**0.2565**	**4.3503**	**17.06**	**21.96**
Stnd Dev:	0.0248	0.3727	1.74	2.09
Room 1	0.2565	2.7434	10.69	13.81
Room 2	0.2565	2.4551	9.57	12.36

	Weather Conditions Natural	w/PPV
Temperature (oF):	78.1	79.6
Relative Humidity:	66.0	63.8
Dew Point (oF):	65.8	66.3
Wind Speed (mph):	4.8	1.5
Barometer	30.1	30.0



Summary Test Series 2: Single 20" Gas Fan at 9'

	Normalized Rate of Ventilation Improvement			
	Test 4a	Test 5a	Test 6a	Average
Bldg Location 1	26.61	31.56	28.35	28.84
Bldg Location 2	22.99	24.66	22.99	23.55
Bldg Location 3	24.57	23.40	26.68	24.88
Bldg Location 4	26.69	24.51	23.97	25.06
Bldg Location 5	19.98	28.17	21.54	23.23
Bldg Location 6	25.58	35.24	35.38	32.06
Average:	**24.40**	**27.92**	**26.48**	**26.27**
Stnd Dev:	2.35	4.27	4.57	3.17
Room 1	22.18	29.57	22.82	24.85
Room 2	19.45	18.87	16.10	18.14

Test 4a, 20 Sep 98 **Single 20" Gas Fan at 9'**

Pressure = 0.016

	Natural	W/PPV	Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	0.1928	5.2952	27.47	26.61
Bldg Location 2	0.2323	5.0382	21.69	22.99
Bldg Location 3	0.2039	4.8758	23.91	24.57
Bldg Location 4	0.2210	5.4993	24.89	26.69
Bldg Location 5	0.1833	3.8393	20.94	19.98
Bldg Location 6	0.1744	4.5341	26.00	25.58
Average:	**0.2013**	**4.8470**	**24.15**	**24.40**
Stnd Dev:	0.0203	0.5442	2.29	2.35
Room 1	0.2013	4.4062	21.89	22.18
Room 2	0.2013	3.8650	19.20	19.45

Weather Conditions

	Natural	w/PPV
Temperature (°F):	76.6	77.1
Relative Humidity:	74.2	71.0
Dew Point (°F):	67.6	67.0
Wind Speed (mph):	0.0	0.0
Barometer:	30.0	29.9

Test 5a, 20 Sep 98 **Single 20" Gas Fan at 9'**

Pressure = 0.016

	Natural	W/PPV	Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	0.1928	6.2801	32.58	31.56
Bldg Location 2	0.2323	5.4044	23.26	24.66
Bldg Location 3	0.2039	4.6429	22.77	23.40
Bldg Location 4	0.2210	5.0508	22.86	24.51
Bldg Location 5	0.1833	5.4143	29.53	28.17
Bldg Location 6	0.1744	6.2458	35.81	35.24
Average:	**0.2013**	**5.5064**	**27.80**	**27.92**
Stnd Dev:	0.0203	0.5941	5.17	4.27
Room 1	0.2013	5.8749	29.19	29.57
Room 2	0.2013	3.7490	18.63	18.87

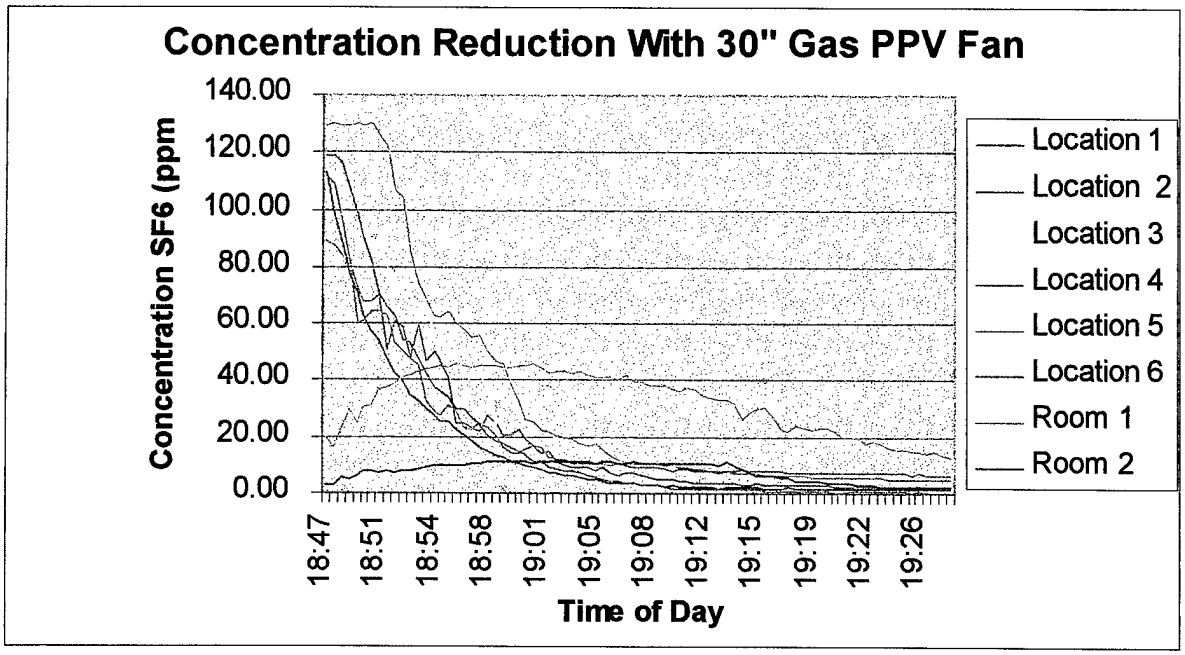
Weather Conditions

	Natural	w/PPV
Temperature (°F):	76.6	74.9
Relative Humidity:	74.2	76.7
Dew Point (°F):	67.6	67.1
Wind Speed (mph):	0.0	0.0
Barometer:	30.0	29.9

Test 6a **Single 20" Gas Fan at 9'**

	Natural	W/PPV	Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	0.2337	5.641	24.14	28.35
Bldg Location 2	0.2916	5.0367	17.28	22.99
Bldg Location 3	0.2615	5.2936	20.24	26.68
Bldg Location 4	0.2635	4.9402	18.75	23.97
Bldg Location 5	0.2391	4.1397	17.32	21.54
Bldg Location 6	0.2139	6.2707	29.32	35.38
Average:	**0.25053**	**5.22033**	**21.174**	**26.48**
Stnd Dev:	0.02494	0.65391	4.3204	4.57
Room 1	0.2505	4.533	18.09	22.82
Room 2	0.2505	3.1996	12.77	16.10

	Weather Conditions	
	Natural	w/PPV
Temperature (°F):	81.3	82.9
Relative Humidity:	69.5	67.0
Dew Point (°F):	70.3	70.9
Wind Speed (mph):	0.5	0.3
Barometer:	29.9	29.8



Summary Test Series 3: Single 30" Gasoline fan at 9'

	Normalized Rate of Ventilation Improvement		
	Test 7a	Test 8a	Average
Bldg Location 1	42.22	50.41	46.32
Bldg Location 2	28.10	40.75	34.42
Bldg Location 3	35.29	40.50	37.89
Bldg Location 4	47.90	42.02	44.96
Bldg Location 5	26.84	30.49	28.66
Bldg Location 6	62.12	64.78	63.45
Average:	**40.41**	**44.82**	**42.62**
Stnd Dev:	12.20	10.63	11.09
Room 1	17.71	18.22	17.96
Room 2	37.75	34.35	36.05

Test 7a; 21 Sep 98 **Single 30" Gasoline fan at 9'**

Pressure = 0.045

	Natural	W/PPV	Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	0.2337	8.4016	35.95	42.22
Bldg Location 2	0.2916	6.1562	21.12	28.10
Bldg Location 3	0.2615	7.0021	26.78	35.29
Bldg Location 4	0.2635	9.8710	37.46	47.90
Bldg Location 5	0.2391	5.1582	21.58	26.84
Bldg Location 6	0.2139	11.0113	51.49	62.12
Average:	**0.2505**	**7.9334**	**32.39**	**40.41**
Stnd Dev:	0.0249	2.0484	10.63	12.20
Room 1	0.2505	3.5182	14.04	17.71
Room 2	0.2505	7.4996	29.94	37.75

Weather Conditions

	Natural	w/PPV
Temperature (°F):	80.3	81.3
Relative Humidity:	71.5	73.3
Dew Point (°F):	70.1	71.9
Wind Speed (mph):	0.4	0.3
Barometer:	29.9	29.8

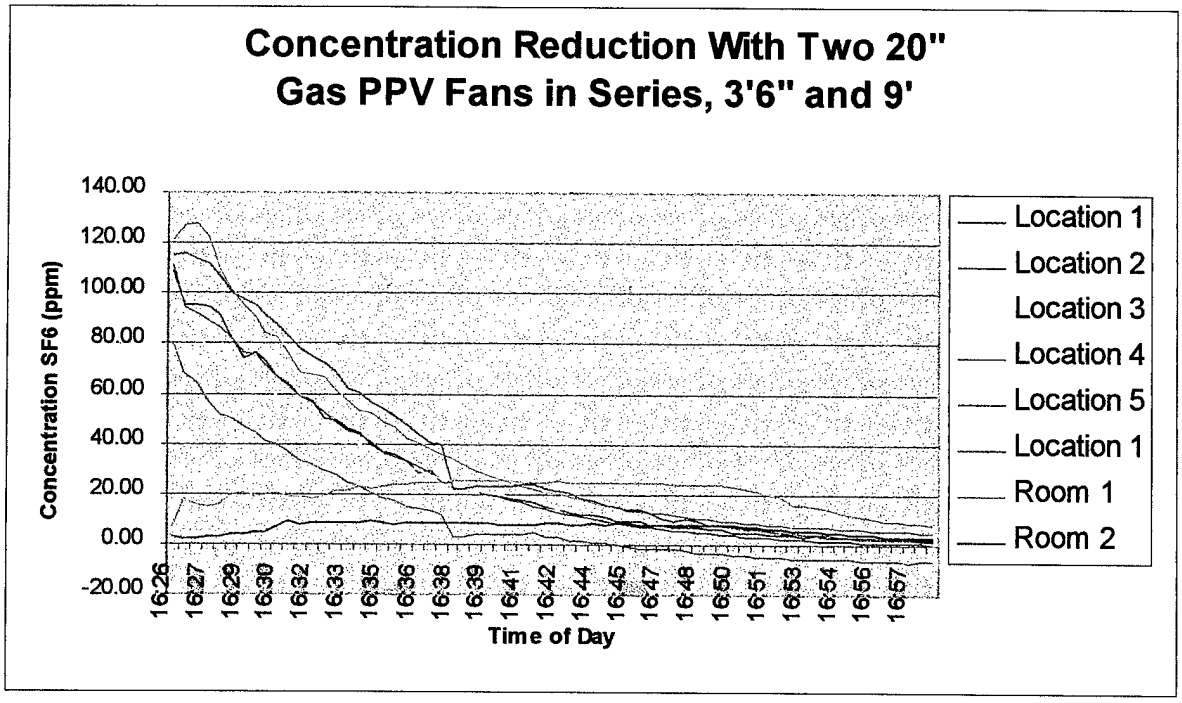
Test 8a; 21 Sep 98 **Single 30" Gasoline fan at 9'**

Pressure = 0.046

	Natural	W/PPV	Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	0.2337	10.0323	42.93	50.41
Bldg Location 2	0.2916	8.9298	30.63	40.75
Bldg Location 3	0.2615	8.0361	30.73	40.50
Bldg Location 4	0.2635	8.6588	32.86	42.02
Bldg Location 5	0.2391	5.8592	24.51	30.49
Bldg Location 6	0.2139	11.4822	53.69	64.78
Average:	**0.2505**	**8.8331**	**35.89**	**44.82**
Stnd Dev:	0.0249	1.7308	9.66	10.63
Room 1	0.2505	3.6192	14.45	18.22
Room 2	0.2505	6.8246	27.24	34.35

Weather Conditions

	Natural	w/PPV
Temperature (°F):	80.3	80.2
Relative Humidity:	71.5	77.5
Dew Point (°F):	70.1	72.5
Wind Speed (mph):	0.4	0.0
Barometer:	29.9	29.8



Summary Test Series 4: Two 20" Gas Fans in series, 3'6" and 9'

Normalized Rate of Ventilation Improvement

	Test 9a	Test 10a	Test 11a	Average
Bldg Location 1	37.34	37.38	39.49	38.07
Bldg Location 2	35.79	34.52	36.94	35.75
Bldg Location 3	32.25	32.37	34.58	33.07
Bldg Location 4	31.65	32.73	34.50	32.96
Bldg Location 5	34.58	41.49	40.80	38.96
Bldg Location 6	40.82	37.15	47.22	41.73
Average:	**35.40**	**35.94**	**38.92**	**36.76**
Stnd Dev:	3.11	3.15	4.38	3.17
Room 1	36.42	37.78	37.10	37.10
Room 2	27.39	24.10	33.25	28.25

Test 9a; 22 Sep 98 Two 20" Gas Fans in series, 3'6" and 9'

Pressure = 0.022

	Natural	W/PPV	Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	0.1906	7.4304	38.99	37.34
Bldg Location 2	0.1588	7.8425	49.38	35.79
Bldg Location 3	0.1423	6.3985	44.96	32.25
Bldg Location 4	0.1528	6.5213	42.68	31.65
Bldg Location 5	0.1268	6.6469	52.42	34.58
Bldg Location 6	0.1516	7.2356	47.73	40.82
Average:	**0.1538**	**7.0125**	**46.03**	**35.40**
Stnd Dev:	0.0193	0.5268	4.41	3.11
Room 1	0.1538	7.2357	47.04	36.42
Room 2	0.1538	5.4419	35.38	27.39

Weather Conditions

	Natural	w/PPV
Temperature (°F):	76.4	76.1
Relative Humidity:	82.5	84.0
Dew Point (°F):	70.6	70.9
Wind Speed (mph):	0.1	5.3
Barometer	29.8	29.7

Test 10a; 22 Sep 98 Two 20" Gas Fans in series, 3'6" and 9'

Pressure = 0.023

	Natural	W/PPV	Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	0.1906	7.4393	39.04	37.38
Bldg Location 2	0.1588	7.5631	47.62	34.52
Bldg Location 3	0.1423	6.4227	45.13	32.37
Bldg Location 4	0.1528	6.7454	44.15	32.73
Bldg Location 5	0.1268	7.9743	62.89	41.49
Bldg Location 6	0.1516	6.5851	43.44	37.15
Average:	**0.1538**	**7.1217**	**47.04**	**35.94**
Stnd Dev:	0.0193	0.5688	7.54	3.15
Room 1	0.1538	7.5053	48.79	37.78
Room 2	0.1538	4.7882	31.13	24.10

Weather Conditions

	Natural	w/PPV
Temperature (°F):	76.4	75.6
Relative Humidity:	82.5	84.0
Dew Point (°F):	70.6	70.4
Wind Speed (mph):	0.1	6.3
Barometer:	29.8	29.7

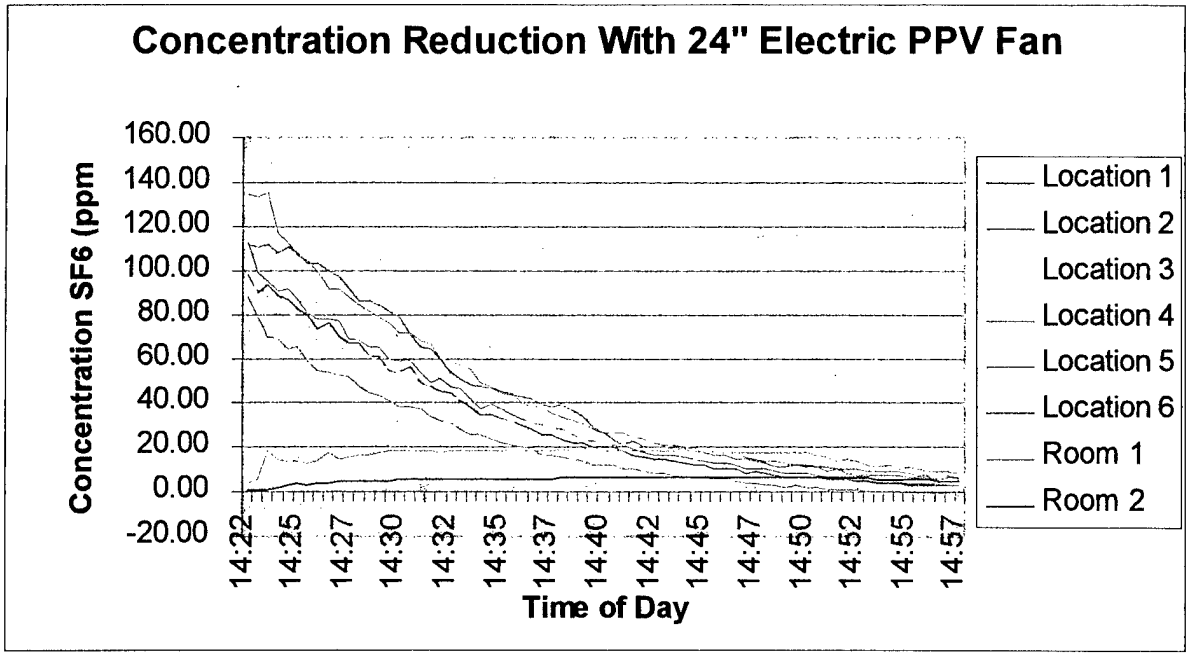
Test 11a; 22 Sep 98 Two 20" Gas Fans in series, 3'6" and 9'

Pressure= 0.02682

	Natural	W/PPV	Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	0.1906	7.8580	41.23	39.49
Bldg Location 2	0.1588	8.0936	50.96	36.94
Bldg Location 3	0.1423	6.8614	48.21	34.58
Bldg Location 4	0.1528	7.1097	46.53	34.50
Bldg Location 5	0.1268	7.8417	61.85	40.80
Bldg Location 6	0.1516	8.3692	55.21	47.22
Average:	**0.1538**	**7.6889**	**50.67**	**38.92**
Stnd Dev:	0.0193	0.5321	6.56	4.38
Room 1	0.1538	7.3702	47.92	37.10
Room 2	0.1538	6.6052	42.94	33.25

Weather Conditions

	Natural	w/PPV
Temperature (°F):	76.4	74.7
Relative Humidity:	82.5	80.0
Dew Point (°F):	70.6	68.1
Wind Speed (mph):	0.1	9.3
Barometer:	29.8	29.8



Summary Test Series 5: Single 24" Electric Fan at 9'

	Normalized Rate of Ventilation Improvement			
	Test 12a	Test 13a	Test 14a	Average
Bldg Location 1	30.57	29.67	21.65	27.30
Bldg Location 2	26.15	25.55	19.22	23.64
Bldg Location 3	25.76	24.83	19.77	23.45
Bldg Location 4	27.20	25.46	20.74	24.46
Bldg Location 5	36.59	37.48	28.77	34.28
Bldg Location 6	33.70	26.75	21.80	27.42
Average:	**29.99**	**28.29**	**21.99**	**26.76**
Stnd Dev:	4.04	4.40	3.17	3.72
Room 1	22.40	22.20	25.90	23.50
Room 2	17.14	20.42	21.71	19.76

Test 12a; 23 Sep 98 **Single 24" Electric Fan at 9'**

Pressure = 0.023

	Natural (Air Changes/Hour)	W/PPV (Air Changes/Hour)	Rate of Improvement Current	Rate of Improvement Normalized
Bldg Location 1	0.8718	6.0827	6.98	30.57
Bldg Location 2	0.8100	5.7297	7.07	26.15
Bldg Location 3	0.7309	5.1108	6.99	25.76
Bldg Location 4	0.7440	5.6053	7.53	27.20
Bldg Location 5	0.7185	7.0321	9.79	36.59
Bldg Location 6	0.7596	5.9738	7.86	33.70
Average:	**0.7725**	**5.9224**	**7.70**	**29.99**
Stnd Dev:	0.0531	0.5854	0.99	4.04
Room 1	0.7725	4.4504	5.76	22.40
Room 2	0.7725	3.4059	4.41	17.14

Weather Conditions	Natural	w/PPV
Temperature (°F):	69.8	72.6
Relative Humidity:	34.8	31.5
Dew Point (°F):	40.6	40.7
Wind Speed (mph):	12.6	12.0
Barometer	30.2	30.1

Test 13a; 23 Sep 98 **Single 24" Electric Fan at 9'**

Pressure = 0.023

	Natural (Air Changes/Hour)	W/PPV (Air Changes/Hour)	Rate of Improvement Current	Rate of Improvement Normalized
Bldg Location 1	0.8718	5.9053	6.77	29.67
Bldg Location 2	0.8100	5.5990	6.91	25.55
Bldg Location 3	0.7309	4.9269	6.74	24.83
Bldg Location 4	0.7440	5.2455	7.05	25.46
Bldg Location 5	0.7185	7.2033	10.03	37.48
Bldg Location 6	0.7596	4.7418	6.24	26.75
Average:	**0.7725**	**5.6036**	**7.29**	**28.29**
Stnd Dev:	0.0531	0.8143	1.25	4.40
Room 1	0.7725	4.4116	5.71	22.20
Room 2	0.7725	4.0578	5.25	20.42

Weather Conditions	Natural	w/PPV
Temperature (°F):	69.8	72.0
Relative Humidity:	34.8	30.7
Dew Point (°F):	40.6	39.5
Wind Speed (mph):	12.6	10.3
Barometer:	30.2	30.1

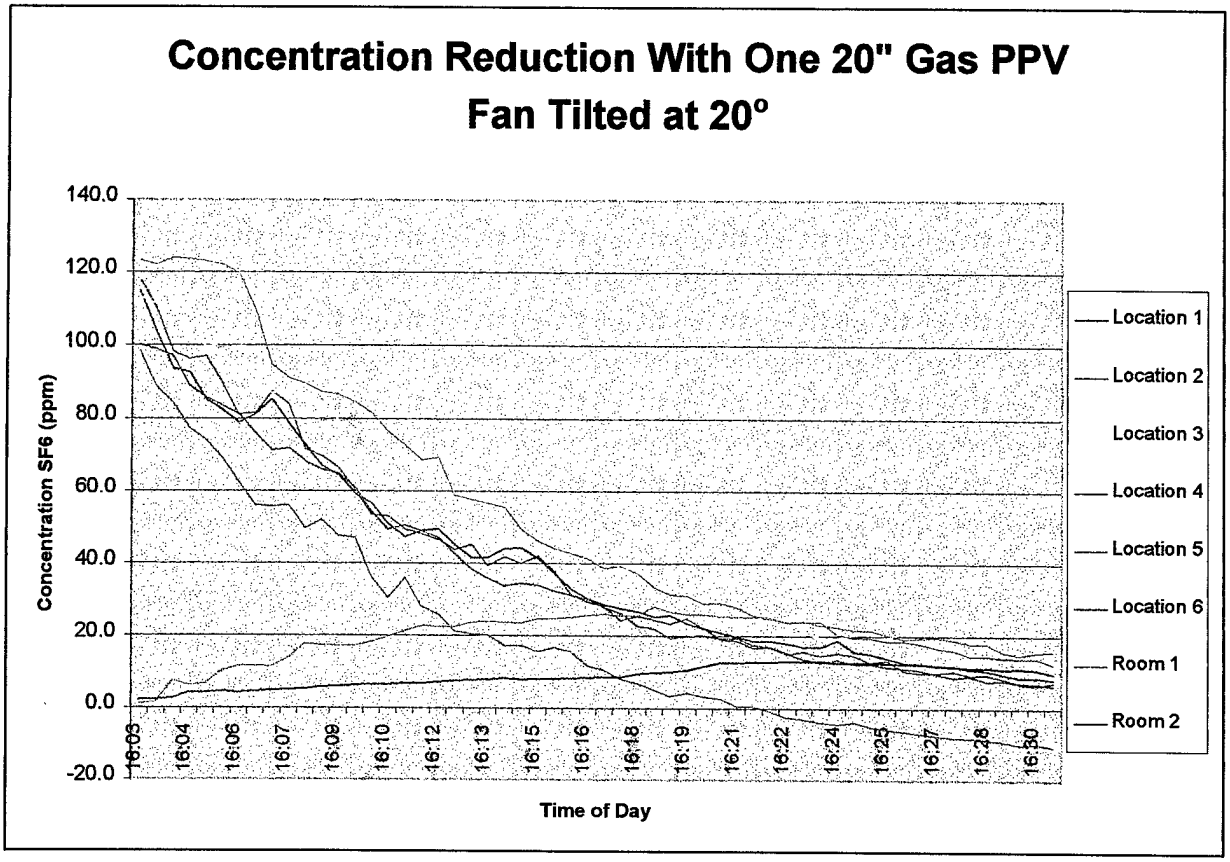
Test 14a; 23 Sep 98 **Single 24" Electric Fan at 9'**

Pressure = 0.018

	Natural	W/PPV	Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	0.8718	4.3077	4.94	21.65
Bldg Location 2	0.8100	4.2125	5.20	19.22
Bldg Location 3	0.7309	3.9234	5.37	19.77
Bldg Location 4	0.7440	4.2737	5.74	20.74
Bldg Location 5	0.7185	5.5297	7.70	28.77
Bldg Location 6	0.7596	3.8647	5.09	21.80
Average:	**0.7725**	**4.3519**	**5.67**	**21.99**
Stnd Dev:	0.0531	0.5531	0.94	3.17
Room 1	0.7725	5.1455	6.66	25.90
Room 2	0.7725	4.3142	5.58	21.71

Weather Conditions

	Natural	w/PPV
Temperature (°F):	69.8	70.7
Relative Humidity:	34.8	32.5
Dew Point (°F):	40.6	39.8
Wind Speed (mph):	12.6	8.0
Barometer:	30.2	30.1



Summary Test Series 6: Single 20" Gas Fan at 5', tilted 20°; Positive Pressure

	Normalized Rate of Ventilation Improvement		
	Test 4b	Test 5b	Average
Bldg Location 1	28.17	28.27	28.22
Bldg Location 2	28.47	28.62	28.54
Bldg Location 3	26.50	27.80	27.15
Bldg Location 4	26.26	28.20	27.23
Bldg Location 5	39.90	39.12	39.51
Bldg Location 6	35.23	41.51	38.37
Average:	30.75	32.25	31.50
Stnd Dev:	5.06	5.75	5.29
Room 1	34.12	52.43	43.28
Room 2	72.85	195.17	134.01

Test 4b, 14 Dec 98, Single 20" Gas Fan at 5', tilted 20°; Positive Pressure

Pressure = 0.016

	Natural	W/PPV	Rate of Improvement		
	(Air Changes/Hour)		Current	Normalized	
Bldg Location 1	1.0710	5.6068	5.24	28.17	
Bldg Location 2	1.2244	6.2381	5.09	28.47	
Bldg Location 3	1.1308	5.2582	4.65	26.50	
Bldg Location 4	1.0964	5.4109	4.94	26.26	
Bldg Location 5	1.0972	7.6676	6.99	39.90	Room
Bldg Location 6	1.2354	6.2445	5.05	35.23	Infiltration
Average:	**1.1425**	**6.0710**	**5.33**	**30.75**	Rate
Stnd Dev:	0.0643	0.8082	0.76	5.06	
Room 1	1.5385	3.6653	2.38	34.12	-2.7853
Room 2	0.3879	2.1602	5.57	72.85	-2.5412

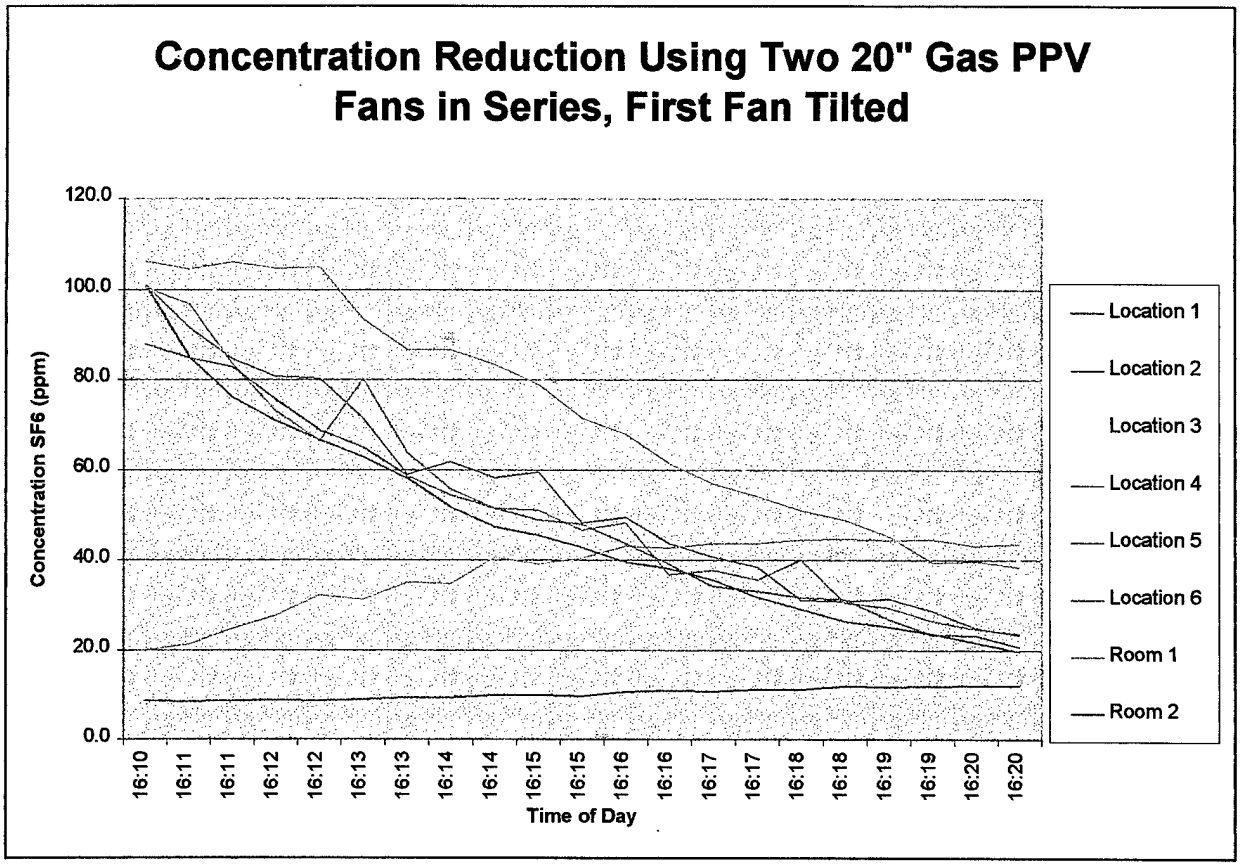
	Weather Conditions	
	Natural	W/PPV
Temperature (°F):	49.9	45.7
Relative Humidity:	32.8	32.7
Dew Point (°F):	21.8	18.0
Wind Speed (mph):	11.1	6.0
Barometer	30.4	30.4

Test 5b, 14 Dec 98, Single 20" Gas Fan at 5', tilted 20°; Positive Pressure

Pressure = 0.016

	Natural	w/PPV	Rate of Improvement		
	(Air Changes/Hour)		Current	Normalized	
Bldg Location 1	1.0710	5.6263	5.25	28.27	
Bldg Location 2	1.2244	6.2706	5.12	28.62	
Bldg Location 3	1.1308	5.5156	4.88	27.80	
Bldg Location 4	1.0964	5.8108	5.30	28.20	
Bldg Location 5	1.0972	7.5187	6.85	39.12	Room
Bldg Location 6	1.2354	7.3573	5.96	41.51	Infiltration
Average:	**1.1425**	**6.3499**	**5.56**	**32.25**	Rate
Stnd Dev:	0.0643	0.8060	0.66	5.75	
Room 1	1.5385	5.6321	3.66	52.43	-3.6899
Room 2	0.3879	5.7875	14.92	195.17	-3.0997

	Weather Conditions	
	Natural	W/PPV
Temperature (°F):	49.9	44.5
Relative Humidity:	32.8	36.0
Dew Point (°F):	21.8	19.2
Wind Speed (mph):	11.1	1.3
Barometer	30.4	30.4



Test Series 7: Two 20" Gas Fans in series, first tilted 20° at 5', second straight at 9'

Normalized Rate of Ventilation Improvement

	Test 9b	Test 10b	Test 11b	Average
Bldg Location 1	43.71	44.89	35.67	41.42
Bldg Location 2	37.59	45.25	38.65	40.50
Bldg Location 3	44.99	37.07	36.33	39.46
Bldg Location 4	52.49	38.24	34.71	41.81
Bldg Location 5	39.84	41.98	39.16	40.33
Bldg Location 6	50.10	54.47	41.63	48.73
Average:	**44.79**	**43.65**	**37.69**	**42.04**
Stnd Dev:	5.24	5.72	2.36	3.09
Room 1	43.84	54.21	66.11	54.72
Room 2	150.53	185.51	169.88	168.64

Test 9b; 16 Dec 98, Two 20" Gas Fans in series, first tilted 20° at 5', second straight at 9'

Pressure = 0.030

	Natural	w/PPV	Rate of Improvement		
	(Air Changes/Hour)		Current	Normalized	
Bldg Location 1	0.1267	8.6984	68.66	43.71	
Bldg Location 2	0.0975	8.2370	84.47	37.59	
Bldg Location 3	0.1153	8.9274	77.44	44.99	
Bldg Location 4	0.1319	10.8161	81.99	52.49	
Bldg Location 5	0.1639	7.6574	46.72	39.84	Room
Bldg Location 6	0.1371	8.8808	64.79	50.10	Infiltration
Average:	**0.1287**	**8.8695**	**70.68**	**44.79**	Rate
Stnd Dev:	0.0203	0.9739	12.76	5.24	
Room 1	0.0904	4.7091	52.12	43.84	-3.1583
Room 2	0.0227	4.4638	197.06	150.53	-12.1858

	Weather Conditions	
	Natural	W/PPV
Temperature (°F):	41.1	54.8
Relative Humidity:	59.9	41.5
Dew Point (°F):	28.1	31.9
Wind Speed (mph):	0.1	8.3
Barometer	30.1	29.9

Test 10b; 16 Dec 98, Two 20" Gas Fans in series, first tilted 20° at 5', second straight at 9'

Pressure = 0.032

	Natural	w/PPV	Rate of Improvement		
	(Air Changes/Hour)		Current	Normalized	
Bldg Location 1	0.1267	8.9325	70.51	44.89	
Bldg Location 2	0.0975	9.9149	101.68	45.25	
Bldg Location 3	0.1153	7.3557	63.81	37.07	
Bldg Location 4	0.1319	7.8805	59.74	38.24	
Bldg Location 5	0.1639	8.0690	49.23	41.98	Room
Bldg Location 6	0.1371	9.6543	70.44	54.47	Infiltration
Average:	**0.1287**	**8.6345**	**69.23**	**43.65**	Rate
Stnd Dev:	0.0203	0.9391	16.20	5.72	
Room 1	0.0904	5.8228	64.44	54.21	-3.3009
Room 2	0.0227	5.5010	242.85	185.51	-2.5026

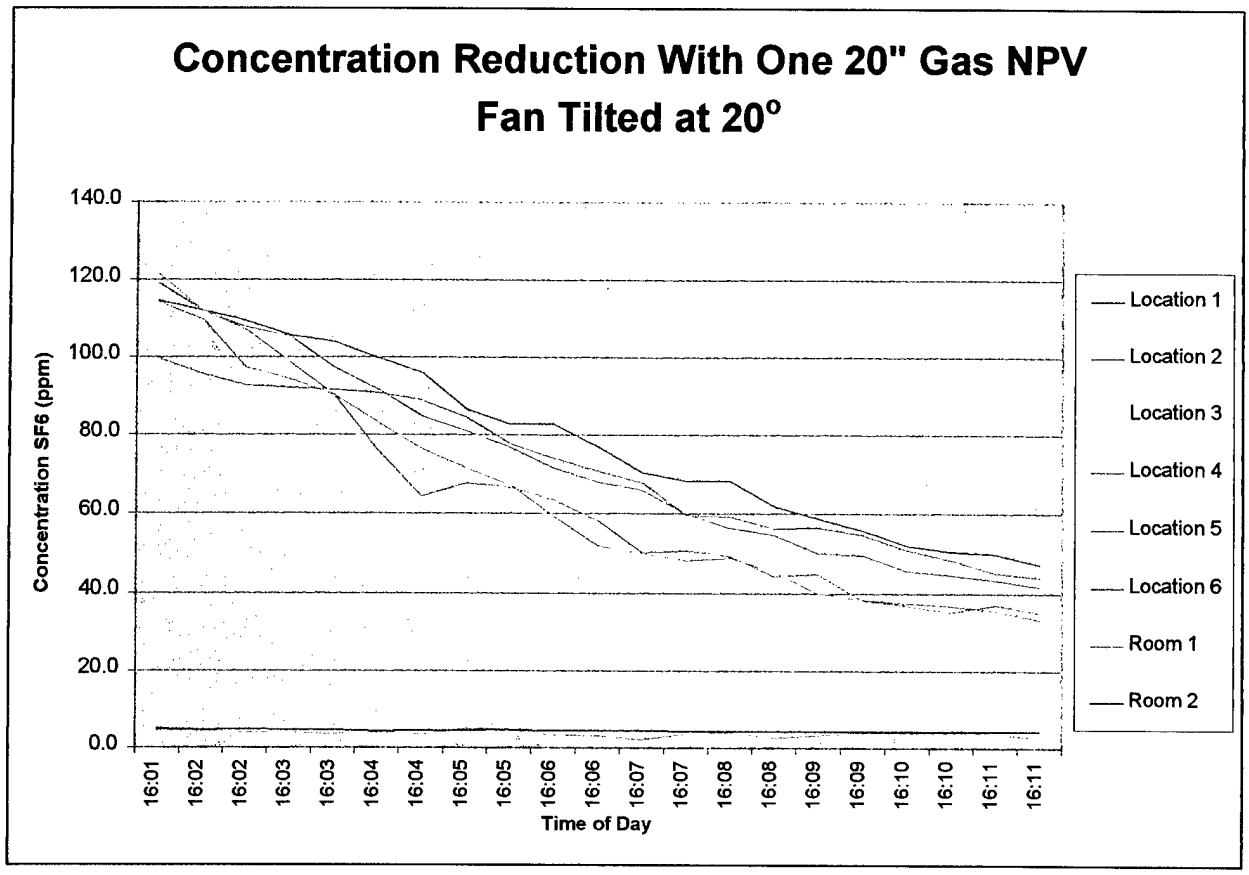
	Weather Conditions	
	Natural	W/PPV
Temperature (°F):	41.1	53.1
Relative Humidity:	59.9	44.0
Dew Point (°F):	28.1	31.8
Wind Speed (mph):	0.1	4.5
Barometer	30.1	29.9

Test 11b; 16 Dec 98, Two 20" Gas Fans in series, first tilted 20° at 5', second straight at 9'

Pressure = 0.029

	Natural (Air Changes/Hour)	w/PPV	Rate of Improvement Current	Normalized	
Bldg Location 1	0.1267	7.0976	56.02	35.67	
Bldg Location 2	0.0975	8.4693	86.85	38.65	
Bldg Location 3	0.1153	7.2086	62.53	36.33	
Bldg Location 4	0.1319	7.1530	54.22	34.71	
Bldg Location 5	0.1639	7.5256	45.92	39.16	Room
Bldg Location 6	0.1371	7.3796	53.84	41.63	Infiltration
Average:	**0.1287**	**7.4723**	**59.90**	**37.69**	Rate
Stnd Dev:	0.0203	0.4686	12.99	2.36	
Room 1	0.0904	7.1017	78.60	66.11	-7.4695
Room 2	0.0227	5.0377	222.40	169.88	-7.3707

	Weather Conditions Natural	W/PPV
Temperature (°F):	41.1	50.3
Relative Humidity:	59.9	48.3
Dew Point (°F):	28.1	31.5
Wind Speed (mph):	0.1	0.3
Barometer	30.1	29.9



Summary Test Series 8: Single 20" Gas Fan at 4', tilted 20°; Negative Pressure

	Normalized Rate of Ventilation Improvement			
	Test 6b	Test 7b	Test 8b	Average
Bldg Location 1	30.18	32.66	33.74	32.19
Bldg Location 2	28.79	27.00	28.99	28.26
Bldg Location 3	36.68	38.90	44.14	39.91
Bldg Location 4	32.47	34.86	35.39	34.24
Bldg Location 5	31.90	28.81	39.84	33.52
Bldg Location 6	37.38	38.41	42.14	39.31
Average:	**32.90**	**33.44**	**37.37**	**34.57**
Stnd Dev:	3.16	4.47	5.20	4.03
Room 1	14.57	10.48	26.55	17.20
Room 2	13.41	14.79	13.31	13.84

Test 6b; 15 Dec 98, Single 20" Gas Fan at 4', tilted 20°; Negative Pressure

Pressure = -0.022

	Natural	w/PPV	Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	0.2008	6.0054	29.90	30.18
Bldg Location 2	0.2021	6.3077	31.21	28.79
Bldg Location 3	0.1940	7.2773	37.50	36.68
Bldg Location 4	0.2016	6.6910	33.20	32.47
Bldg Location 5	0.2002	6.1304	30.63	31.90
Bldg Location 6	0.1843	6.6257	35.95	37.38
Average:	**0.1972**	**6.5062**	**33.06**	**32.90**
Stnd Dev:	0.0063	0.4232	2.81	3.16
Room 1	0.1245	1.5654	12.57	14.57
Room 2	0.0367	0.3975	10.84	13.41

	Weather Conditions	
	Natural	W/PPV
Temperature (°F):	51.3	50.2
Relative Humidity:	36.1	52.0
Dew Point (°F):	25.3	33.2
Wind Speed (mph):	0.0	0.0
Barometer	30.4	30.3

Test 7b; 15 Dec 98, Single 20" Gas Fan at 4', tilted 20°; Negative Pressure

Pressure = -0.030

	Natural	w/PPV	Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	0.2008	6.5003	32.37	32.66
Bldg Location 2	0.2021	5.9166	29.27	27.00
Bldg Location 3	0.1940	7.7192	39.78	38.90
Bldg Location 4	0.2016	7.1838	35.64	34.86
Bldg Location 5	0.2002	5.5380	27.67	28.81
Bldg Location 6	0.1843	6.8081	36.94	38.41
Average:	**0.1972**	**6.6110**	**33.61**	**33.44**
Stnd Dev:	0.0063	0.7349	4.26	4.47
Room 1	0.1245	1.1262	9.05	10.48
Room 2	0.0367	0.4386	11.96	14.79

	Weather Conditions	
	Natural	W/PPV
Temperature (°F):	51.3	48.6
Relative Humidity:	36.1	56.5
Dew Point (°F):	25.3	33.8
Wind Speed (mph):	0.0	0.0
Barometer	30.4	30.3

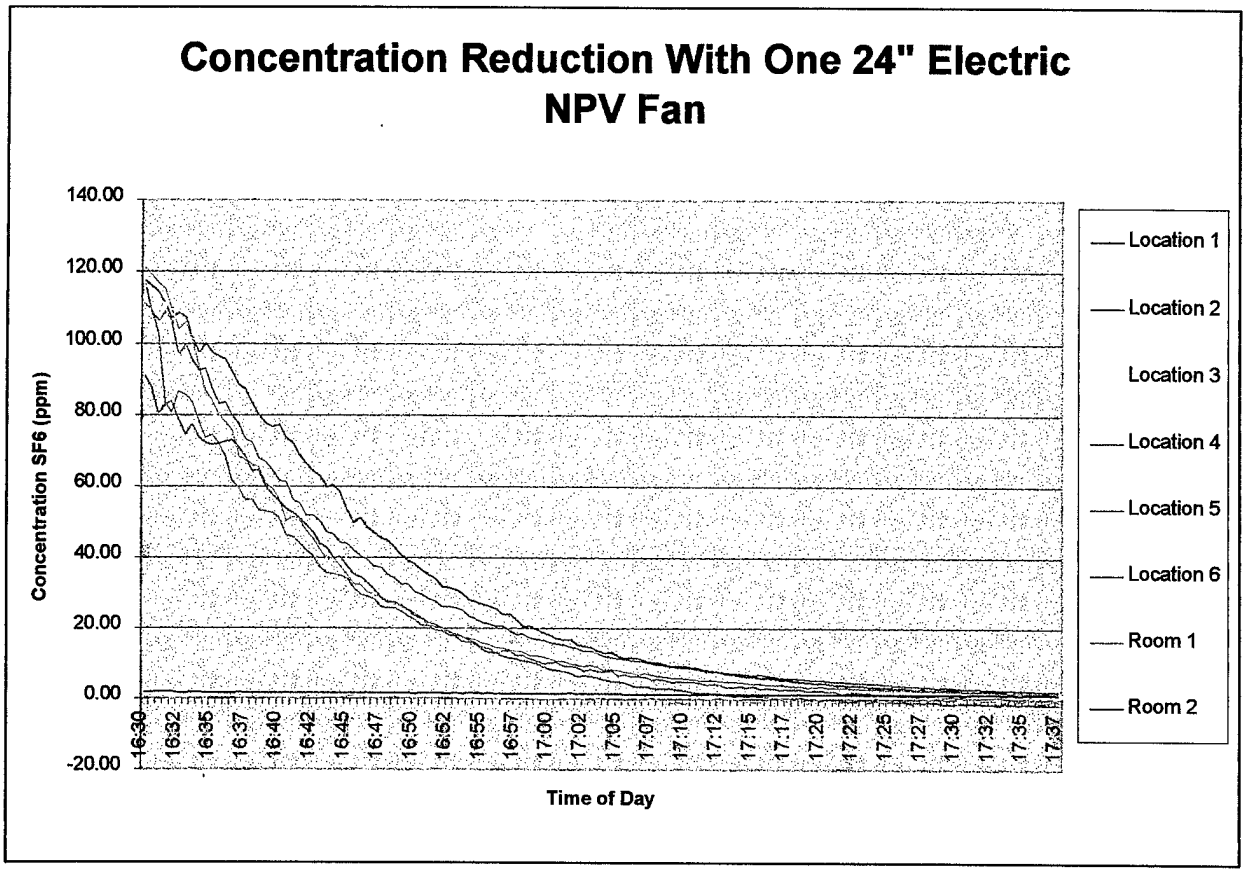
Test 8b; 15 Dec 98, Single 20" Gas Fan at 4', tilted 20°; Negative Pressure

Pressure = -0.030

	Natural	w/PPV	Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	0.2008	6.7137	33.43	33.74
Bldg Location 2	0.2021	6.3519	31.43	28.99
Bldg Location 3	0.1940	8.7592	45.14	44.14
Bldg Location 4	0.2016	7.2920	36.18	35.39
Bldg Location 5	0.2002	7.6574	38.25	39.84
Bldg Location 6	0.1843	7.4697	40.53	42.14
Average:	**0.1972**	**7.3740**	**37.49**	**37.37**
Stnd Dev:	0.0063	0.7633	4.53	5.20
Room 1	0.1245	2.8524	22.91	26.55
Room 2	0.0367	0.3948	10.77	13.31

Weather Conditions

	Natural	W/PPV
Temperature (°F):	51.3	47.4
Relative Humidity:	36.1	61.0
Dew Point (°F):	25.3	34.6
Wind Speed (mph):	0.0	0.0
Barometer	30.4	30.3



Summary Test Series 9: Single 24" Electric Fan at 4'; Negative Pressure

	Normalized Rate of Ventilation Improvement			
	Test 1b	Test 2b	Test 3b	Average
Bldg Location 1	21.39	21.18	21.47	21.35
Bldg Location 2	18.50	18.99	18.03	18.51
Bldg Location 3	23.82	24.10	22.53	23.48
Bldg Location 4	24.83	24.21	21.45	23.50
Bldg Location 5	24.66	17.82	36.19	26.22
Bldg Location 6	30.20	25.58	30.14	28.64
Average:	**23.90**	**21.98**	**24.97**	**23.62**
Stnd Dev:	3.57	2.87	6.21	3.25
Room 1	126.87	12.29	-1.74	45.81
Room 2	14.68	28.26	15.93	19.62

Test 1b, 11 Dec 98, Single 24" Electric Fan at 4'; Negative Pressure

Pressure = -0.028

	Natural	w/PPV	Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	0.6863	4.2567	6.20	21.39
Bldg Location 2	0.6885	4.0545	5.89	18.50
Bldg Location 3	0.7246	4.7262	6.52	23.82
Bldg Location 4	0.6794	5.1170	7.53	24.83
Bldg Location 5	0.6904	4.7391	6.86	24.66
Bldg Location 6	0.6876	5.3529	7.78	30.20
Average:	**0.6928**	**4.7077**	**6.80**	**23.90**
Stnd Dev:	0.0147	0.4500	0.68	3.57
Room 1	1.3431	13.6288	10.15	126.87
Room 2	0.2159	0.4352	2.02	14.68

Weather Conditions

	Natural	w/PPV
Temperature (°F):	53.6	48.8
Relative Humidity:	29.5	33.8
Dew Point (°F):	22.5	21.5
Wind Speed (mph):	7.8	3.0
Barometer:	30.4	30.4

Test 2b, 11 Dec 98, Single 24" Electric Fan at 4'; Negative Pressure

Pressure = -0.036

	Natural	w/PPV	Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	1.0710	4.2154	3.94	21.18
Bldg Location 2	1.2244	4.1603	3.40	18.99
Bldg Location 3	1.1308	4.7811	4.23	24.10
Bldg Location 4	1.0964	4.9885	4.55	24.21
Bldg Location 5	1.0972	3.4242	3.12	17.82
Bldg Location 6	1.2354	4.5349	3.67	25.58
Average:	**1.1425**	**4.3507**	**3.82**	**21.98**
Stnd Dev:	0.0643	0.5065	0.48	2.87
Room 1	1.5385	1.3203	0.86	12.29
Room 2	0.3879	0.8380	2.16	28.26

Weather Conditions

	Natural	W/PPV
Temperature (°F):	49.9	49.9
Relative Humidity:	32.8	29.7
Dew Point (°F):	21.8	19.4
Wind Speed (mph):	11.1	12.0
Barometer	30.4	30.3

Test 3b, 11 Dec 98, Single 24" Electric Fan at 4'; Negative Pressure

Pressure = -0.017

	Natural	w/PPV	Rate of Improvement	
	(Air Changes/Hour)		Current	Normalized
Bldg Location 1	1.0710	4.2733	3.99	21.47
Bldg Location 2	1.2244	3.9497	3.23	18.03
Bldg Location 3	1.1308	4.4702	3.95	22.53
Bldg Location 4	1.0964	4.4204	4.03	21.45
Bldg Location 5	1.0972	6.9564	6.34	36.19
Bldg Location 6	1.2354	5.3417	4.32	30.14
Average:	**1.1425**	**4.9020**	**4.31**	**24.97**
Stnd Dev:	0.0643	1.0111	0.97	6.21
Room 1	1.5385	-0.1874	-0.12	-1.74
Room 2	0.3879	0.4725	1.22	15.93

	Weather Conditions	
	Natural	W/PPV
Temperature (°F):	49.9	48.9
Relative Humidity:	32.8	29.0
Dew Point (°F):	21.8	18.1
Wind Speed (mph):	11.1	8.8
Barometer	30.4	30.3

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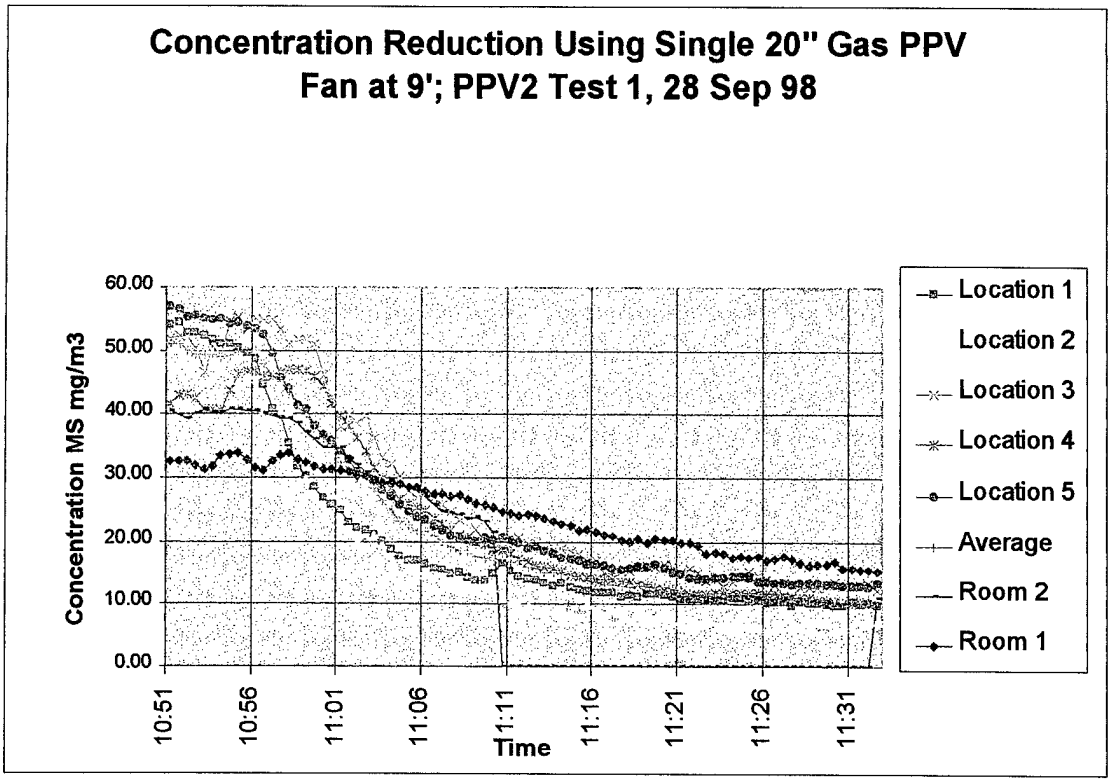
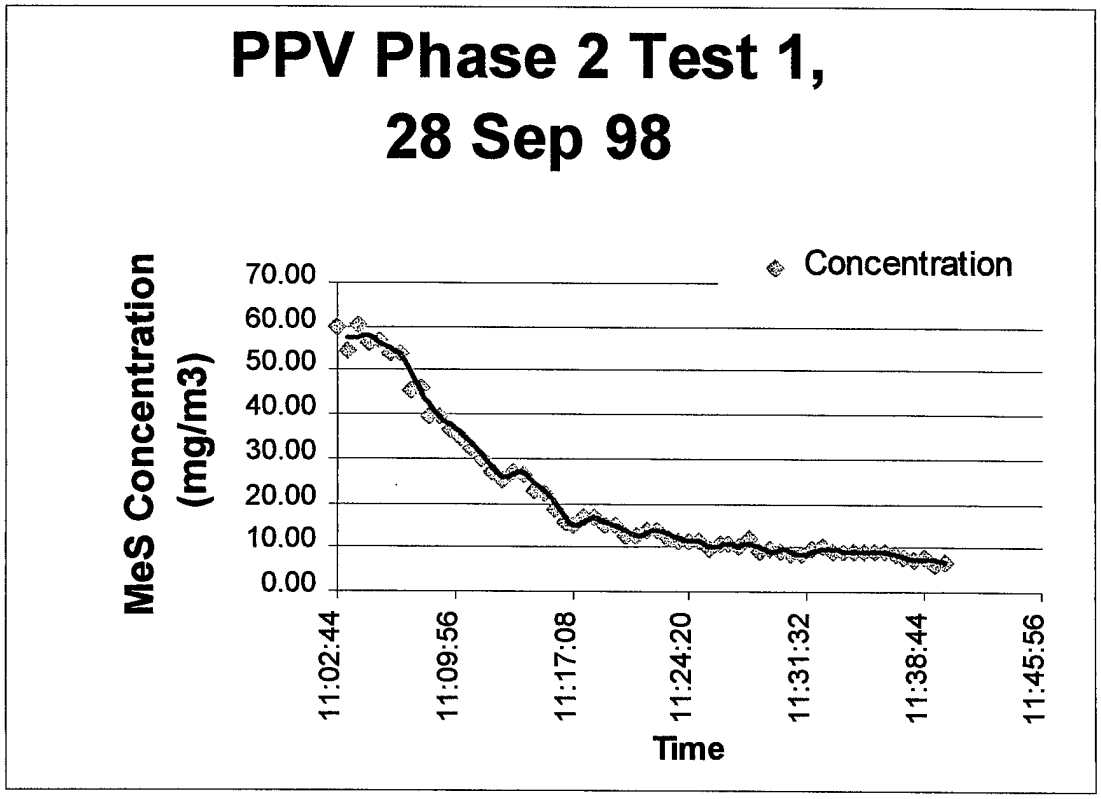
APPENDIX D. RESCUE MISSION SCENARIO TEST DATA





Concentrations Outside of Building Near Air Exit Point (FTIR Data)

Suit No.	1	2	3	4
Size:				
Test Participant:	M	E	T	S
Suit Configuration:	New PBI Bunker Gear w/tape	New PBI Bunker Gear w/tape	New PBI Bunker Gear w/tape	New PBI Bunker Gear w/tape
Mean Background Mass, ng:	18.84	18.84	18.84	18.84
Mean Clean Room Concentration, mg/m^3:	0.00013	0.00013	0.00014	0.00014
Mean Doff Room Concentration, mg/m^3:	0.00217	0.00217	0.09173	0.09173
Suit Exposure Duration, min:	30	30	30	30
Mean Exposure Concentration, mg/m^3:	54.50	54.50	54.50	54.50
Exposure Dosage, mg-min/m^3:	1670.32	1670.32	1670.32	1670.32
Minimum Detectable Concentration, mg/m^3:	0.00823	0.0159	0.0159	0.00823
Maximum Measureable PF:	6622	6622	6622	6622
Overall PF:	**71.46**	**83.68**	**62.67**	**74.47**
Systemic MRED (Headache), mg-min/m^3:	**144.07**	**132.43**	**714.60**	**836.78**
Systemic MRED (Nausea), mg-min/m^3:	**1786.49**	**2091.95**	**1566.65**	**1861.68**
Minimum Localized MRED, mg-min/m^3:	**1665.42**	**4768.57**	**2601.17**	**4974.42**
Location of Minimum Localized MRED:	**Scrotum**	**Chin & Neck**	**Scrotum**	**Scrotum**

PPV2 Test 1; 20" Gas Fan **28 Sep 98**

Suit 1: Subject M
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	1320.4	0.3488	0.3%	357836.3	214.86
2	Ears	67.9	1.6008	1.4%	11135.5	6.69
3	Cheeks & Neck	67.9	3.0683	2.6%	11610.8	6.97
4	Chin & Neck	48.8	11.3844	9.8%	6295.2	3.78
5	Nape	58.6	0.9923	0.9%	35976.3	21.60
6	Abdomen	99.0	12.9465	11.1%	78798.3	47.31
7	Back	118.6	8.0849	7.0%	112151.7	67.34
8	Axillae	82.3	1.1736	1.0%	60839.4	36.53
9	Upper Arms, medial	81.1	2.1478	1.8%	81145.7	48.72
10	Upper Arms, lateral	108.5	0.9909	0.9%	254424.4	152.77
11	Elbowfolds	70.5	0.3392	0.3%	52614.0	31.59
12	Elbows	84.2	0.2640	0.2%	67681.1	40.64
13	Forearms, volar	59.9	2.9031	2.5%	59910.6	35.97
14	Forearms, dorsum	59.9	1.7936	1.5%	140550.3	84.39
15	Hands, dorsum	155.4	0.4424	0.4%	161413.3	96.92
16	Hands, palmar	155.4	0.1393	0.1%	512669.9	307.83
17	Buttocks	106.5	2.1007	1.8%	161976.9	97.26
18	Groin	105.2	2.3367	2.0%	45883.0	27.55
19	Scrotum	42.7	42.5772	36.6%	1665.4	1.00
20	Thighs, anterior	68.3	6.3357	5.5%	160343.3	96.28
21	Thighs, posterior	68.3	4.8839	4.2%	103956.6	62.42
22	Knees	86.5	0.3238	0.3%	220624.8	132.47
23	Popliteal Space	86.5	0.5530	0.5%	64543.6	38.76
24	Shins	104.7	2.7580	2.4%	245606.3	147.47
25	Calves	104.7	3.2340	2.8%	104691.5	62.86
26	Feet, dorsum	47.7	1.5896	1.4%	112333.3	67.45
27	Feet, plantar	47.7	0.8816	0.8%	121531.6	72.97
	Sum (A/D Factor/PF):		116.1940	100%		

Overall PF **71.46**

Systemic MRED
Headache **714.60**
Nausea/Vomiting **1786.49**

Localized MRED **1665.42** **Scrotum**

PPV2 Test 1; 20" Gas Fan **28 Sep 98**

Suit 2: Subject E
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	168.1	2.7399	2.8%	45550.0	9.55
2	Ears	149.8	0.7257	0.7%	24564.6	5.15
3	Cheeks & Neck	149.8	1.3909	1.4%	25613.0	5.37
4	Chin & Neck	37.0	15.0290	15.1%	4768.6	1.00
5	Nape	43.0	1.3530	1.4%	26383.4	5.53
6	Abdomen	51.3	24.9981	25.2%	40809.7	8.56
7	Back	81.1	11.8177	11.9%	76726.9	16.09
8	Axillae	58.9	1.6400	1.7%	43537.5	9.13
9	Upper Arms, medial	95.3	1.8284	1.8%	95319.5	19.99
10	Upper Arms, lateral	83.9	1.2802	1.3%	196926.6	41.30
11	Elbowfolds	83.1	0.2880	0.3%	61965.3	12.99
12	Elbows	77.4	0.2872	0.3%	62208.9	13.05
13	Forearms, volar	70.8	2.4564	2.5%	70807.2	14.85
14	Forearms, dorsum	70.8	1.5176	1.5%	166113.7	34.84
15	Hands, dorsum	70.8	0.9706	1.0%	73568.7	15.43
16	Hands, palmar	70.8	0.3057	0.3%	233663.8	49.00
17	Buttocks	61.3	3.6471	3.7%	93297.0	19.57
18	Groin	210.7	1.1669	1.2%	91874.7	19.27
19	Scrotum	347.3	5.2355	5.3%	13543.8	2.84
20	Thighs, anterior	116.7	3.7111	3.7%	273740.7	57.41
21	Thighs, posterior	116.7	2.8607	2.9%	177476.4	37.22
22	Knees	93.4	0.2999	0.3%	238178.3	49.95
23	Popliteal Space	93.4	0.5123	0.5%	69678.8	14.61
24	Shins	70.1	4.1176	4.1%	164507.3	34.50
25	Calves	70.1	4.8283	4.9%	70122.5	14.71
26	Feet, dorsum	27.9	2.7146	2.7%	65777.7	13.79
27	Feet, plantar	27.9	1.5056	1.5%	71163.9	14.92
	Sum (A/D Factor/PF):		99.2280	100%		

Overall PF **83.68**

Systemic MRED
Headache **836.78**
Nausea/Vomiting **2091.95**

Localized MRED **4768.57** **Chin & Neck**

PPV2 Test 1; 20" Gas Fan **28 Sep 98**

Suit 3: Subject T
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	529.1	0.8704	0.7%	143382.5	55.12
2	Ears	103.4	1.0512	0.8%	16958.0	6.52
3	Cheeks & Neck	103.4	2.0148	1.5%	17681.8	6.80
4	Chin & Neck	60.5	9.1855	6.9%	7802.1	3.00
5	Nape	33.7	1.7259	1.3%	20683.2	7.95
6	Abdomen	143.0	8.9613	6.8%	113841.7	43.77
7	Back	73.5	13.0442	9.8%	69512.5	26.72
8	Axillae	48.8	1.9794	1.5%	36071.6	13.87
9	Upper Arms, medial	64.3	2.7100	2.0%	64312.9	24.72
10	Upper Arms, lateral	58.9	1.8229	1.4%	138292.3	53.17
11	Elbowfolds	49.6	0.4823	0.4%	37004.7	14.23
12	Elbows	46.9	0.4736	0.4%	37725.1	14.50
13	Forearms, volar	34.9	4.9843	3.8%	34895.3	13.42
14	Forearms, dorsum	34.9	3.0794	2.3%	81864.5	31.47
15	Hands, dorsum	111.0	0.6192	0.5%	115320.7	44.33
16	Hands, palmar	111.0	0.1950	0.1%	366273.7	140.81
17	Buttocks	137.0	1.6324	1.2%	208439.8	80.13
18	Groin	264.9	0.9283	0.7%	115497.7	44.40
19	Scrotum	66.7	27.2605	20.6%	2601.2	1.00
20	Thighs, anterior	26.4	16.3887	12.4%	61987.1	23.83
21	Thighs, posterior	26.4	12.6333	9.5%	40188.6	15.45
22	Knees	31.9	0.8788	0.7%	81279.1	31.25
23	Popliteal Space	31.9	1.5011	1.1%	23778.1	9.14
24	Shins	37.3	7.7356	5.8%	87566.5	33.66
25	Calves	37.3	9.0707	6.8%	37325.9	14.35
26	Feet, dorsum	92.7	0.8174	0.6%	218456.1	83.98
27	Feet, plantar	92.7	0.4533	0.3%	236344.1	90.86
	Sum (A/D Factor/PF):		132.4995	100%		

Overall PF **62.67**

Systemic MRED
Headache **626.66**
Nausea/Vomiting **1566.65**

Localized MRED **2601.17** **Scrotum**

PPV2 Test 1; 20" Gas Fan **28 Sep 98**

Suit 4: Subject S
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	632.6	0.7279	0.7%	171445.2	34.47
2	Ears	165.8	0.6556	0.6%	27189.4	5.47
3	Cheeks & Neck	165.8	1.2566	1.1%	28349.9	5.70
4	Chin & Neck	53.9	10.3109	9.2%	6950.6	1.40
5	Nape	51.2	1.1345	1.0%	31465.4	6.33
6	Abdomen	63.7	20.1086	18.0%	50732.7	10.20
7	Back	77.3	12.3990	11.1%	73129.4	14.70
8	Axillae	69.0	1.4000	1.3%	50999.5	10.25
9	Upper Arms, medial	76.8	2.2700	2.0%	76778.3	15.43
10	Upper Arms, lateral	58.6	1.8339	1.6%	137463.3	27.63
11	Elbowfolds	80.8	0.2962	0.3%	60262.4	12.11
12	Elbows	71.7	0.3100	0.3%	57637.9	11.59
13	Forearms, volar	84.8	2.0515	1.8%	84783.1	17.04
14	Forearms, dorsum	84.8	1.2674	1.1%	198901.1	39.98
15	Hands, dorsum	80.9	0.8491	0.8%	84098.1	16.91
16	Hands, palmar	80.9	0.2674	0.2%	267106.6	53.70
17	Buttocks	103.3	2.1662	1.9%	157075.7	31.58
18	Groin	96.8	2.5414	2.3%	42186.6	8.48
19	Scrotum	127.5	14.2547	12.8%	4974.4	1.00
20	Thighs, anterior	56.1	7.7228	6.9%	131542.9	26.44
21	Thighs, posterior	56.1	5.9532	5.3%	85284.2	17.14
22	Knees	46.6	0.6014	0.5%	118764.9	23.88
23	Popliteal Space	46.6	1.0273	0.9%	34744.6	6.98
24	Shins	37.1	7.7873	7.0%	86984.5	17.49
25	Calves	37.1	9.1314	8.2%	37077.8	7.45
26	Feet, dorsum	37.1	2.0435	1.8%	87377.8	17.57
27	Feet, plantar	37.1	1.1334	1.0%	94532.6	19.00
	Sum (A/D Factor/PF):		111.5015	100%		

Overall PF **74.47**

Systemic MRED
Headache **744.67**
Nausea/Vomiting **1861.68**

Localized MRED **4974.42** **Scrotum**

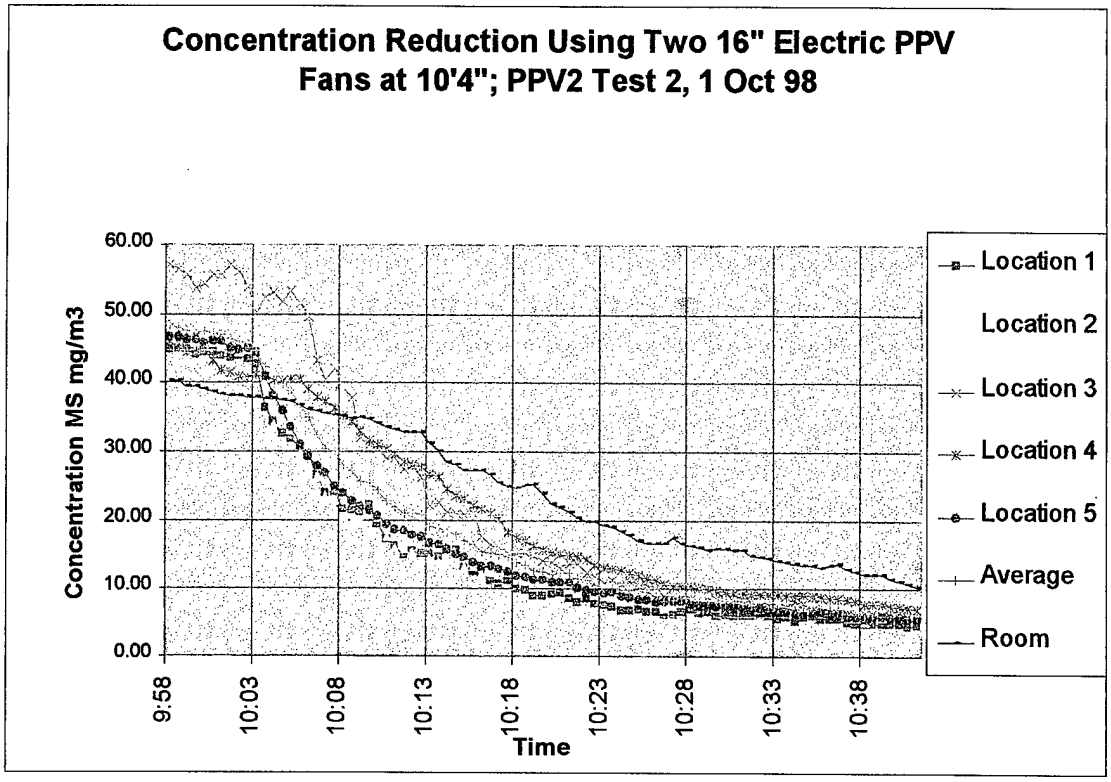
Tube Data

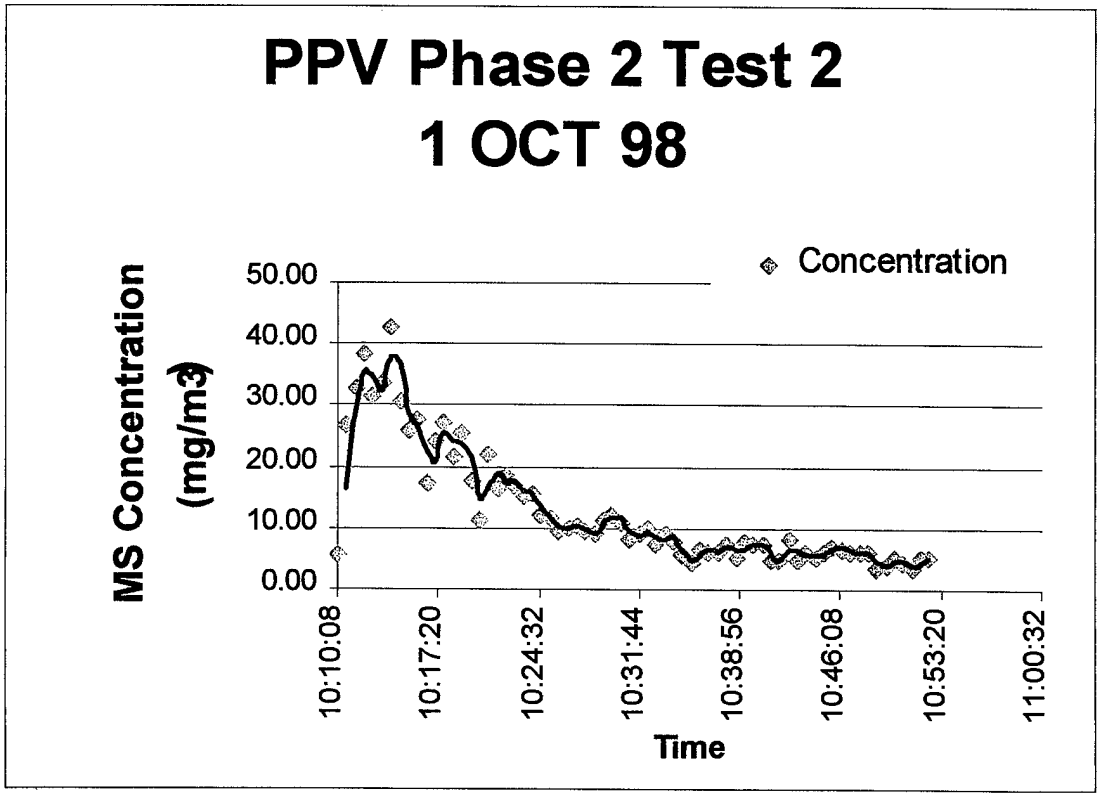
PPV2 Test 1; 20" Gas Fan			28 Sep 98		
Suit 1: Subject M **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage $mg\text{-}min/m^3$	Sampler Location PF
1 Scalp	A1	37.35	0.0422	1.26	1320.4
2 Ear	A2	378.74	0.8200	24.60	67.9
3 Chin/Neck	A3	519.60	1.1409	34.23	48.8
4 Upper Back/Nape	A4	435.90	0.9502	28.51	58.6
5 Abdomen	A4A	353.88	0.7634	22.90	72.9
6 Middle Back	A5	118.62	0.2273	6.82	244.9
7 Armpit (Axillae)	A6	315.67	0.6763	20.29	82.3
8 Right Arm, Inner	A7	319.99	0.6861	20.58	81.1
9 Left Arm, Outer	A8	244.17	0.5134	15.40	108.5
10 Rt Forearm, Inner	A8A	426.73	0.9293	27.88	59.9
11 Left Hand/Glove	A9	176.14	0.3584	10.75	155.4
12 Lower Back	A10	248.31	0.5228	15.68	106.5
13 Groin	F04	164.50	0.3319	9.96	167.8
14 Crotch	F06	591.09	1.3038	39.11	42.7
15 Inner Left Thigh	F07	376.38	0.8146	24.44	68.3
16 Inner Left Shin	F08	252.26	0.5318	15.95	104.7
17 Left Foot/Boot	F11	531.58	1.1682	35.05	47.7

PPV2 Test 1; 20" Gas Fan			28 Sep 98		
Suit 2: Subject E **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage $mg\text{-}min/m^3$	Sampler Location PF
1 Scalp	C2	164.23	0.3313	9.94	168.1
2 Ear	C4	181.99	0.3717	11.15	149.8
3 Chin/Neck	C5	679.91	1.5062	45.19	37.0
4 Upper Back/Nape	C8	587.54	1.2957	38.87	43.0
5 Abdomen	C9	697.70	1.5467	46.40	36.0
6 Middle Back	C10	160.67	0.3231	9.69	172.3
7 Armpit (Axillae)	C13	433.63	0.9451	28.35	58.9
8 Right Arm, Inner	C14	275.21	0.5841	17.52	95.3
9 Left Arm, Outer	C16	309.96	0.6633	19.90	83.9
10 Rt Forearm, Inner	CA1	363.96	0.7863	23.59	70.8
11 Left Hand/Glove	CA2	363.96	0.7863	23.59	70.8
12 Lower Back	CA3	417.23	0.9077	27.23	61.3
13 Groin	CA4	348.33	0.7507	22.52	74.2
14 Crotch	CA5	89.21	0.1603	4.81	347.3
15 Inner Left Thigh	CA6A	228.27	0.4772	14.31	116.7
16 Inner Left Shin	CA7	367.33	0.7940	23.82	70.1
17 Left Foot/Boot	CA8	894.48	1.9951	59.85	27.9

PPV2 Test 1; 20" Gas Fan		28 Sep 98			
Suit 3: Subject T **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage mg-min/m^3	Sampler Location PF
1 Scalp	CH1	65.03	0.1052	3.16	529.1
2 Ear	CH2	255.17	0.5385	16.15	103.4
3 Chin/Neck	CH3	422.88	0.9206	27.62	60.5
4 Upper Back/Nape	CH3A	744.27	1.6528	49.58	33.7
5 Abdomen	CH4	831.40	1.8513	55.54	30.1
6 Middle Back	CH4A	300.64	0.6421	19.26	86.7
7 Armpit (Axillae)	CH9	519.48	1.1407	34.22	48.8
8 Right Arm, Inner	CH9A	398.81	0.8657	25.97	64.3
9 Left Arm, Outer	CH10	433.39	0.9445	28.34	58.9
10 Rt Forearm, Inner	CH11	719.13	1.5955	47.87	34.9
11 Left Hand/Glove	CH12A	239.01	0.5016	15.05	111.0
12 Lower Back	N4	197.16	0.4063	12.19	137.0
13 Groin	N14	71.61	0.1202	3.61	463.1
14 Crotch	N14*	385.23	0.8348	25.04	66.7
15 Inner Left Thigh	N15	943.69	2.1072	63.22	26.4
16 Inner Left Shin	N15*	673.53	1.4917	44.75	37.3
17 Left Foot/Boot	N16	282.50	0.6007	18.02	92.7

PPV2 Test 1; 20" Gas Fan		28 Sep 98			
Suit 4: Subject S **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage mg-min/m^3	Sampler Location PF
1 Scalp	T1	57.47	0.0880	2.64	632.6
2 Ear	T2	166.24	0.3358	10.07	165.8
3 Chin/Neck	T3	472.38	1.0333	31.00	53.9
4 Upper Back/Nape	T4	495.69	1.0865	32.59	51.2
5 Abdomen	T4A	426.26	0.9283	27.85	60.0
6 Middle Back	T5	290.87	0.6198	18.59	89.8
7 Armpit (Axillae)	T6	372.94	0.8068	24.20	69.0
8 Right Arm, Inner	T7	337.12	0.7252	21.76	76.8
9 Left Arm, Outer	T8	435.89	0.9502	28.51	58.6
10 Rt Forearm, Inner	T9	307.07	0.6567	19.70	84.8
11 Left Hand/Glove	T9A	320.75	0.6879	20.64	80.9
12 Lower Back	T10	255.47	0.5391	16.17	103.3
13 Groin	T59	389.28	0.8440	25.32	66.0
14 Crotch	R17	210.43	0.4365	13.10	127.5
15 Inner Left Thigh	R18	454.66	0.9930	29.79	56.1
16 Inner Left Shin	R19	677.91	1.5016	45.05	37.1
17 Left Foot/Boot	R22	678.02	1.5019	45.06	37.1





Concentrations Outside of Building Near Air Exit Point (FTIR Data)

BRHA Data

PPV2 Test 2; Two 16" Electric Fans			**1 Oct 98**	
Suit No.	1	2	3	4
Size:				
Test Participant:	M	E	T	S
Suit Configuration:	New PBI Bunker Gear w/tape	New PBI Bunker Gear w/tape	New PBI Bunker Gear w/tape	New PBI Bunker Gear w/tape
Mean Background Mass, ng:	29.76	29.76	29.76	29.76
Mean Clean Room Concentration, mg/m^3:	0.00119	0.00119	0.00071	0.00071
Mean Doff Room Concentration, mg/m^3:	0.00371	0.00371	0.00367	0.00367
Suit Exposure Duration, min:	30	30	30	30
Mean Exposure Concentration, mg/m^3:	54.50	54.50	54.50	54.50
Exposure Dosage, $mg\text{-}min/m^3$:	1670.32	1670.32	1670.32	1670.32
Minimum Detectable Concentration, mg/m^3:	0.00823	0.0159	0.0159	0.00823
Maximum Measureable PF:	6622	6622	6622	6622
Overall PF:	**71.46**	**83.68**	**62.67**	**74.47**
Systemic MRED (Headache), $mg\text{-}min/m^3$:	**144.07**	**132.43**	**714.60**	**836.78**
Systemic MRED (Nausea), $mg\text{-}min/m^3$:	**1786.49**	**2091.95**	**1566.65**	**1861.68**
Minimum Localized MRED, $mg\text{-}min/m^3$:	**1665.42**	**4768.57**	**2601.17**	**4974.42**
Location of Minimum Localized MRED:	**Scrotum**	**Chin & Neck**	**Scrotum**	**Scrotum**

PPV2 Test 2; Two 16" Electric Fans **1 Oct 98**

Suit 1: Subject M
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	314.3	1.4651	4.7%	85182.3	6.02
2	Ears	376.2	0.2890	0.9%	61690.6	4.36
3	Cheeks & Neck	376.2	0.5538	1.8%	64323.7	4.55
4	Chin & Neck	109.6	5.0687	16.4%	14139.0	1.00
5	Nape	135.2	0.4302	1.4%	82986.1	5.87
6	Abdomen	1794.6	0.7142	2.3%	1428475.9	101.03
7	Back	1591.8	0.6021	2.0%	1505885.4	106.51
8	Axillae	157.0	0.6155	2.0%	116004.2	8.20
9	Upper Arms, medial	139.1	1.2532	4.1%	139071.7	9.84
10	Upper Arms, lateral	252.0	0.4265	1.4%	591118.1	41.81
11	Elbowfolds	147.0	0.1628	0.5%	109653.2	7.76
12	Elbows	203.4	0.1092	0.4%	163563.1	11.57
13	Forearms, volar	154.9	1.1228	3.6%	154904.8	10.96
14	Forearms, dorsum	154.9	0.6937	2.2%	363406.6	25.70
15	Hands, dorsum	154.9	0.4437	1.4%	160946.1	11.38
16	Hands, palmar	154.9	0.1397	0.5%	511185.8	36.15
17	Buttocks	170.7	1.3105	4.2%	259639.7	18.36
18	Groin	6622.0	0.0371	0.1%	2887183.9	204.20
19	Scrotum	6622.0	0.2746	0.9%	258257.3	18.27
20	Thighs, anterior	110.7	3.9101	12.7%	259813.0	18.38
21	Thighs, posterior	110.7	3.0141	9.8%	168446.5	11.91
22	Knees	133.6	0.2096	0.7%	340806.7	24.10
23	Popliteal Space	133.6	0.3580	1.2%	99702.7	7.05
24	Shins	156.6	1.8443	6.0%	367271.3	25.98
25	Calves	156.6	2.1627	7.0%	156552.1	11.07
26	Feet, dorsum	32.3	2.3489	7.6%	76019.8	5.38
27	Feet, plantar	32.3	1.3027	4.2%	82244.6	5.82
	Sum (A/D Factor/PF):		30.8628	100%		

Overall PF **269.04**

Systemic MRED
Headache **2690.36**
Nausea/Vomiting **6725.89**

Localized MRED **14139.01** **Chin & Neck**

PPV2 Test 2; Two 16" Electric Fans **1 Oct 98**

Suit 2: Subject E
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	289.8	1.5889	3.0%	78544.6	14.74
2	Ears	85.0	1.2791	2.5%	13936.5	2.62
3	Cheeks & Neck	85.0	2.4516	4.7%	14531.3	2.73
4	Chin & Neck	41.3	13.4511	25.8%	5327.9	1.00
5	Nape	135.0	0.4306	0.8%	82908.1	15.56
6	Abdomen	239.9	5.3426	10.2%	190950.1	35.84
7	Back	196.5	4.8774	9.4%	185905.7	34.89
8	Axillae	128.5	0.7521	1.4%	94934.5	17.82
9	Upper Arms, medial	270.8	0.6435	1.2%	270847.3	50.84
10	Upper Arms, lateral	365.4	0.2941	0.6%	857143.3	160.88
11	Elbowfolds	314.0	0.0762	0.1%	234239.5	43.96
12	Elbows	361.3	0.0615	0.1%	290446.7	54.51
13	Forearms, volar	357.1	0.4870	0.9%	357140.5	67.03
14	Forearms, dorsum	357.1	0.3009	0.6%	837851.7	157.26
15	Hands, dorsum	433.7	0.1585	0.3%	450626.1	84.58
16	Hands, palmar	433.7	0.0499	0.1%	1431247.6	268.63
17	Buttocks	208.3	1.0739	2.1%	316856.2	59.47
18	Groin	699.1	0.3517	0.7%	304800.1	57.21
19	Scrotum	1086.9	1.6728	3.2%	42388.4	7.96
20	Thighs, anterior	87.8	4.9341	9.5%	205889.7	38.64
21	Thighs, posterior	87.8	3.8035	7.3%	133486.0	25.05
22	Knees	118.6	0.2361	0.5%	302536.1	56.78
23	Popliteal Space	118.6	0.4033	0.8%	88506.6	16.61
24	Shins	149.5	1.9311	3.7%	350776.7	65.84
25	Calves	149.5	2.2644	4.3%	149521.2	28.06
26	Feet, dorsum	36.4	2.0784	4.0%	85910.7	16.12
27	Feet, plantar	36.4	1.1528	2.2%	92945.4	17.44
	Sum (A/D Factor/PF):		52.1471	100%		

Overall PF **159.23**

Systemic MRED
Headache **1592.26**
Nausea/Vomiting **3980.66**

Localized MRED **5327.93** **Chin & Neck**

PPV2 Test 2; Two 16" Electric Fans **1 Oct 98**

Suit 3: Subject T
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	1105.6	0.4166	0.9%	299609.0	22.29
2	Ears	98.5	1.1030	2.3%	16162.2	1.20
3	Cheeks & Neck	98.5	2.1140	4.4%	16852.0	1.25
4	Chin & Neck	104.2	5.3311	11.1%	13443.2	1.00
5	Nape	491.1	0.1184	0.2%	301510.4	22.43
6	Abdomen	157.9	8.1162	16.9%	125694.2	9.35
7	Back	349.7	2.7412	5.7%	330777.2	24.61
8	Axillae	87.0	1.1103	2.3%	64308.8	4.78
9	Upper Arms, medial	159.5	1.0926	2.3%	159515.7	11.87
10	Upper Arms, lateral	134.0	0.8020	1.7%	314347.5	23.38
11	Elbowfolds	112.1	0.2134	0.4%	83646.5	6.22
12	Elbows	99.4	0.2236	0.5%	79889.7	5.94
13	Forearms, volar	64.7	2.6867	5.6%	64737.7	4.82
14	Forearms, dorsum	64.7	1.6599	3.5%	151874.6	11.30
15	Hands, dorsum	2598.7	0.0264	0.1%	2700082.7	200.85
16	Hands, palmar	2598.7	0.0083	0.0%	8575816.2	637.93
17	Buttocks	232.4	0.9627	2.0%	353433.9	26.29
18	Groin	540.0	0.4553	1.0%	235458.1	17.52
19	Scrotum	798.5	2.2770	4.8%	31141.5	2.32
20	Thighs, anterior	122.7	3.5289	7.4%	287876.1	21.41
21	Thighs, posterior	122.7	2.7203	5.7%	186640.9	13.88
22	Knees	98.0	0.2859	0.6%	249852.1	18.59
23	Popliteal Space	98.0	0.4883	1.0%	73094.0	5.44
24	Shins	73.3	3.9416	8.2%	171851.8	12.78
25	Calves	73.3	4.6219	9.6%	73253.1	5.45
26	Feet, dorsum	137.0	0.5530	1.2%	322903.7	24.02
27	Feet, plantar	137.0	0.3067	0.6%	349344.3	25.99
	Sum (A/D Factor/PF):		47.9053	100%		

Overall PF **173.32**

Systemic MRED
Headache **1733.25**
Nausea/Vomiting **4333.12**

Localized MRED **13443.20** **Chin & Neck**

PPV2 Test 2; Two 16" Electric Fans **1 Oct 98**

Suit 4: Subject S
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	6622.0	0.0695	0.2%	1794556.9	131.35
2	Ears	131.1	0.8291	2.1%	21500.9	1.57
3	Cheeks & Neck	131.1	1.5891	4.1%	22418.6	1.64
4	Chin & Neck	126.3	4.3994	11.2%	16290.0	1.19
5	Nape	325.9	0.1784	0.5%	200100.0	14.65
6	Abdomen	196.4	6.5260	16.6%	156323.4	11.44
7	Back	497.7	1.9260	4.9%	470783.7	34.46
8	Axillae	191.6	0.5042	1.3%	141622.5	10.37
9	Upper Arms, medial	161.8	1.0773	2.7%	161775.6	11.84
10	Upper Arms, lateral	167.9	0.6401	1.6%	393812.5	28.82
11	Elbowfolds	147.2	0.1625	0.4%	109844.0	8.04
12	Elbows	150.3	0.1479	0.4%	120832.3	8.84
13	Forearms, volar	132.7	1.3106	3.3%	132712.2	9.71
14	Forearms, dorsum	132.7	0.8097	2.1%	311342.9	22.79
15	Hands, dorsum	1778.1	0.0387	0.1%	1847425.0	135.21
16	Hands, palmar	1778.1	0.0122	0.0%	5867663.7	429.46
17	Buttocks	131.8	1.6973	4.3%	200472.6	14.67
18	Groin	282.1	0.8716	2.2%	123002.5	9.00
19	Scrotum	350.3	5.1899	13.2%	13662.9	1.00
20	Thighs, anterior	174.1	2.4875	6.3%	408401.0	29.89
21	Thighs, posterior	174.1	1.9175	4.9%	264781.7	19.38
22	Knees	174.0	0.1610	0.4%	443708.7	32.48
23	Popliteal Space	174.0	0.2750	0.7%	129806.6	9.50
24	Shins	173.9	1.6601	4.2%	408023.1	29.86
25	Calves	173.9	1.9467	5.0%	173922.9	12.73
26	Feet, dorsum	42.3	1.7896	4.6%	99774.9	7.30
27	Feet, plantar	42.3	0.9926	2.5%	107944.9	7.90
	Sum (A/D Factor/PF):		39.2094	100%		

Overall PF **211.77**

Systemic MRED
Headache **2117.65**
Nausea/Vomiting **5294.14**

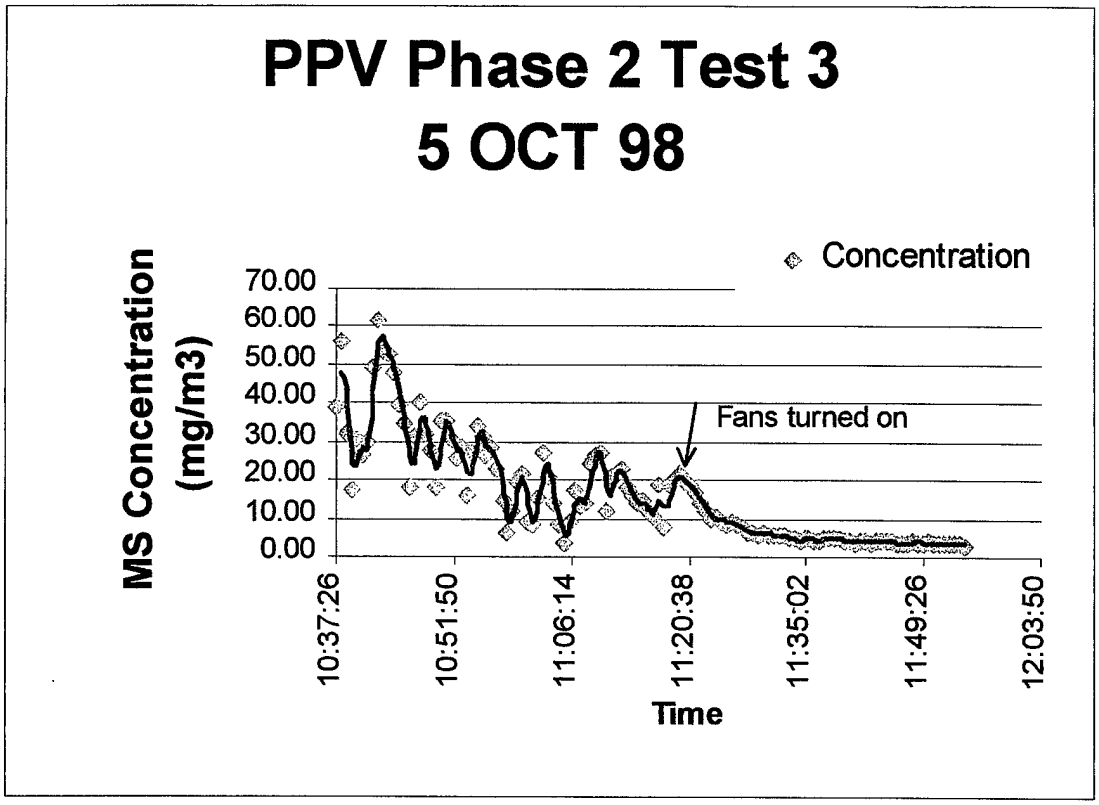
Localized MRED **13662.90** **Scrotum**

PPV2 Test 2; Two 16" Electric Fans				1 Oct 98	
Suit 1: Subject M **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage $mg\text{-}min/m^3$	Sampler Location PF
1 Scalp	G01	107.50	0.1771	5.31	314.3
2 Ear	G03	94.72	0.1480	4.44	376.2
3 Chin/Neck	G05	252.71	0.5080	15.24	109.6
4 Upper Back/Nape	G06	210.56	0.4119	12.36	135.2
5 Abdomen	G07	152.15	0.2789	8.37	199.7
6 Middle Back	G08	19.03	BBL	BBL	6622.0
7 Armpit (Axillae)	G09	185.43	0.3547	10.64	157.0
8 Right Arm, Inner	G10	205.47	0.4003	12.01	139.1
9 Left Arm, Outer	G11	126.74	0.2210	6.63	252.0
10 Rt Forearm, Inner	G12	187.51	0.3594	10.78	154.9
11 Left Hand/Glove	G13	187.51	0.3594	10.78	154.9
12 Lower Back	G14	172.91	0.3262	9.78	170.7
13 Groin	G15	35.19	BBL	BBL	6622.0
14 Crotch	G16	34.31	BBL	BBL	6622.0
15 Inner Left Thigh	G17	250.41	0.5027	15.08	110.7
16 Inner Left Shin	G18	185.85	0.3556	10.67	156.6
17 Left Foot/Boot	G20	787.42	1.7263	51.79	32.3

PPV2 Test 2; Two 16" Electric Fans				1 Oct 98	
Suit 2: Subject E **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage $mg\text{-}min/m^3$	Sampler Location PF
1 Scalp	H*	114.07	0.1921	5.76	289.8
2 Ear	H1	317.32	0.6552	19.66	85.0
3 Chin/Neck	H2	621.42	1.3481	40.44	41.3
4 Upper Back/Nape	H2A	210.73	0.4123	12.37	135.0
5 Abdomen	H3	123.78	0.2142	6.43	259.9
6 Middle Back	H3A	99.92	0.1599	4.80	348.3
7 Armpit (Axillae)	H4	219.98	0.4334	13.00	128.5
8 Right Arm, Inner	H4A	119.98	0.2056	6.17	270.8
9 Left Arm, Outer	H06	96.64	0.1524	4.57	365.4
10 Rt Forearm, Inner	H07	98.18	0.1559	4.68	357.1
11 Left Hand/Glove	H7	86.10	0.1284	3.85	433.7
12 Lower Back	H08	147.06	0.2673	8.02	208.3
13 Groin	H8	108.26	0.1789	5.37	311.3
14 Crotch	H09	52.24	0.0512	1.54	1086.9
15 Inner Left Thigh	H9	308.20	0.6344	19.03	87.8
16 Inner Left Shin	H10	193.19	0.3724	11.17	149.5
17 Left Foot/Boot	H16	700.19	1.5275	45.83	36.4

PPV2 Test 2; Two 16" Electric Fans				1 Oct 98	
Suit 3: Subject T **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage mg-min/m^3	Sampler Location PF
1 Scalp	H5	51.86	0.0504	1.51	1105.6
2 Ear	H9*	277.72	0.5650	16.95	98.5
3 Chin/Neck	*H11	264.25	0.5343	16.03	104.2
4 Upper Back/Nape	H11	79.52	0.1134	3.40	491.1
5 Abdomen	H12	215.57	0.4234	12.70	131.5
6 Middle Back	H14	63.72	0.0774	2.32	719.5
7 Armpit (Axillae)	H15	310.57	0.6398	19.19	87.0
8 Right Arm, Inner	H17	182.95	0.3490	10.47	159.5
9 Left Arm, Outer	H18	212.13	0.4155	12.47	134.0
10 Rt Forearm, Inner	R2	407.23	0.8600	25.80	64.7
11 Left Hand/Glove	R5	39.16	0.0214	0.64	2598.7
12 Lower Back	R8	134.92	0.2396	7.19	232.4
13 Groin	R10	116.54	0.1977	5.93	281.6
14 Crotch	R11	60.36	0.0697	2.09	798.5
15 Inner Left Thigh	R13	228.90	0.4537	13.61	122.7
16 Inner Left Shin	R16	363.35	0.7601	22.80	73.3
17 Left Foot/Boot	R20	208.13	0.4064	12.19	137.0

PPV2 Test 2; Two 16" Electric Fans				1 Oct 98	
Suit 4: Subject S **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage mg-min/m^3	Sampler Location PF
New Nomex Interspiro SCBA		Size:	48-46/40-28		Sampler Location PF
	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage mg-min/m^3	
1 Scalp	K01	21.55	BBL	BBL	6622.0
2 Ear	K02	216.15	0.4247	12.74	131.1
3 Chin/Neck	K4	223.27	0.4409	13.23	126.3
4 Upper Back/Nape	K5	104.74	0.1708	5.13	325.9
5 Abdomen	K6	158.37	0.2930	8.79	190.0
6 Middle Back	K7	46.11	0.0373	1.12	1494.3
7 Armpit (Axillae)	K8	157.27	0.2905	8.72	191.6
8 Right Arm, Inner	K9	180.81	0.3442	10.32	161.8
9 Left Arm, Outer	K10	175.33	0.3317	9.95	167.9
10 Rt Forearm, Inner	K11	213.89	0.4195	12.59	132.7
11 Left Hand/Glove	K12	43.50	0.0313	0.94	1778.1
12 Lower Back	V1	215.16	0.4224	12.67	131.8
13 Groin	V2	144.00	0.2603	7.81	213.9
14 Crotch	V3	99.51	0.1589	4.77	350.3
15 Inner Left Thigh	V4	170.13	0.3198	9.59	174.1
16 Inner Left Shin	V5	170.26	0.3201	9.60	173.9
17 Left Foot/Boot	V6	607.03	1.3153	39.46	42.3



Concentrations Outside of Building Near Air Exit Point (FTIR Data)

PPV2 Test 3; No PPV Fans			**5 Oct 98**	
Suit No.	1	2	3	4
Size:				
Test Participant:	M	E	T	S
Suit Configuration:	New PBI Bunker Gear w/tape	New PBI Bunker Gear w/tape	New PBI Bunker Gear w/tape	New PBI Bunker Gear w/tape
Mean Background Mass, ng:	16.88	16.88	16.88	16.88
Mean Clean Room Concentration, mg/m^3:	0.00298	0.00298	0.00298	0.00298
Mean Doff Room Concentration, mg/m^3:	0.00323	0.00323	0.00323	0.00323
Suit Exposure Duration, min:	30	30	30	30
Mean Exposure Concentration, mg/m^3:	54.50	54.50	54.50	54.50
Exposure Dosage, mg-min/m^3:	1670.32	1670.32	1670.32	1670.32
Minimum Detectable Concentration, mg/m^3:	0.00823	0.0159	0.0159	0.00823
Maximum Measureable PF:	6622	6622	6622	6622
Overall PF:	**21.91**	**20.98**	**20.51**	**21.79**
Systemic MRED (Headache), mg-min/m^3:	**144.07**	**132.43**	**219.07**	**209.82**
Systemic MRED (Nausea), mg-min/m^3:	**547.68**	**524.56**	**512.64**	**544.65**
Minimum Localized MRED, mg-min/m^3:	**1416.81**	**932.25**	**1071.82**	**1182.36**
Location of Minimum Localized MRED:	**Chin & Neck**	**Chin & Neck**	**Chin & Neck**	**Chin & Neck**

PPV2 Test 3; No PPV Fans **5 Oct 98**

Suit 1: Subject M
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	11.0	41.9888	11.1%	2972.3	2.10
2	Ears	10.9	9.9521	2.6%	1791.2	1.26
3	Cheeks & Neck	10.9	19.0748	5.0%	1867.6	1.32
4	Chin & Neck	11.0	50.5831	13.3%	1416.8	1.00
5	Nape	11.5	5.0770	1.3%	7031.2	4.96
6	Abdomen	21.0	61.0082	16.1%	16721.8	11.80
7	Back	54.4	17.6273	4.7%	51439.1	36.31
8	Axillae	22.1	4.3813	1.2%	16296.7	11.50
9	Upper Arms, medial	15.1	11.5551	3.0%	15083.0	10.65
10	Upper Arms, lateral	14.7	7.3334	1.9%	34376.7	24.26
11	Elbowfolds	14.8	1.6120	0.4%	11071.5	7.81
12	Elbows	14.6	1.5193	0.4%	11759.6	8.30
13	Forearms, volar	14.6	11.9135	3.1%	14599.3	10.30
14	Forearms, dorsum	14.6	7.3605	1.9%	34250.0	24.17
15	Hands, dorsum	15.5	4.4341	1.2%	16104.6	11.37
16	Hands, palmar	15.5	1.3964	0.4%	51150.2	36.10
17	Buttocks	46.4	4.8205	1.3%	70586.1	49.82
18	Groin	78.9	3.1159	0.8%	34408.5	24.29
19	Scrotum	124.4	14.6163	3.9%	4851.4	3.42
20	Thighs, anterior	16.3	26.6302	7.0%	38147.9	26.93
21	Thighs, posterior	16.3	20.5280	5.4%	24732.7	17.46
22	Knees	15.9	1.7624	0.5%	40529.3	28.61
23	Popliteal Space	15.9	3.0104	0.8%	11856.8	8.37
24	Shins	15.5	18.5959	4.9%	36426.0	25.71
25	Calves	15.5	21.8055	5.8%	15526.9	10.96
26	Feet, dorsum	16.1	4.7050	1.2%	37951.5	26.79
27	Feet, plantar	16.1	2.6095	0.7%	41059.2	28.98
	Sum (A/D Factor/PF):		379.0165	100%		

Overall PF **21.91**

Systemic MRED
Headache **219.07**
Nausea/Vomiting **547.68**

Localized MRED **1416.81** **Chin & Neck**

PPV2 Test 3; No PPV Fans **5 Oct 98**

Suit 2: Subject E
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	10.8	42.4663	10.7%	2938.9	3.15
2	Ears	10.1	10.7407	2.7%	1659.7	1.78
3	Cheeks & Neck	10.1	20.5863	5.2%	1730.5	1.86
4	Chin & Neck	7.2	76.8748	19.4%	932.3	1.00
5	Nape	9.5	6.1147	1.5%	5838.0	6.26
6	Abdomen	19.3	66.2914	16.8%	15389.1	16.51
7	Back	38.8	24.6914	6.2%	36722.5	39.39
8	Axillae	22.6	4.2829	1.1%	16671.1	17.88
9	Upper Arms, medial	15.5	11.2333	2.8%	15515.1	16.64
10	Upper Arms, lateral	15.6	6.8671	1.7%	36711.1	39.38
11	Elbowfolds	15.6	1.5300	0.4%	11664.9	12.51
12	Elbows	15.7	1.4151	0.4%	12625.4	13.54
13	Forearms, volar	15.8	11.0374	2.8%	15758.1	16.90
14	Forearms, dorsum	15.8	6.8193	1.7%	36968.4	39.65
15	Hands, dorsum	15.4	4.4675	1.1%	15984.2	17.15
16	Hands, palmar	15.4	1.4070	0.4%	50768.0	54.46
17	Buttocks	53.8	4.1597	1.1%	81798.8	87.74
18	Groin	435.1	0.5652	0.1%	189684.7	203.47
19	Scrotum	842.5	2.1582	0.5%	32855.7	35.24
20	Thighs, anterior	17.4	24.8861	6.3%	40821.4	43.79
21	Thighs, posterior	17.4	19.1836	4.8%	26466.0	28.39
22	Knees	17.4	1.6130	0.4%	44283.7	47.50
23	Popliteal Space	17.4	2.7552	0.7%	12955.2	13.90
24	Shins	17.3	16.6592	4.2%	40660.7	43.62
25	Calves	17.3	19.5346	4.9%	17331.9	18.59
26	Feet, dorsum	16.0	4.7477	1.2%	37610.3	40.34
27	Feet, plantar	16.0	2.6332	0.7%	40690.0	43.65
	Sum (A/D Factor/PF):		395.7207	100%		

Overall PF **20.98**

Systemic MRED
Headache **209.82**
Nausea/Vomiting **524.56**

Localized MRED **932.25** **Chin & Neck**

PPV2 Test 3; No PPV Fans **5 Oct 98**

Suit 3: Subject T
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	10.9	42.2792	10.4%	2951.9	2.75
2	Ears	9.6	11.3229	2.8%	1574.3	1.47
3	Cheeks & Neck	9.6	21.7022	5.4%	1641.5	1.53
4	Chin & Neck	8.3	66.8646	16.5%	1071.8	1.00
5	Nape	12.7	4.5696	1.1%	7812.0	7.29
6	Abdomen	19.7	65.0336	16.1%	15686.7	14.64
7	Back	44.1	21.7155	5.4%	41755.1	38.96
8	Axillae	19.5	4.9447	1.2%	14439.9	13.47
9	Upper Arms, medial	13.6	12.8584	3.2%	13554.2	12.65
10	Upper Arms, lateral	13.1	8.2244	2.0%	30652.1	28.60
11	Elbowfolds	13.3	1.8051	0.4%	9886.7	9.22
12	Elbows	13.0	1.7083	0.4%	10458.9	9.76
13	Forearms, volar	13.0	13.4291	3.3%	12951.6	12.08
14	Forearms, dorsum	13.0	8.2969	2.0%	30384.4	28.35
15	Hands, dorsum	15.7	4.3830	1.1%	16292.1	15.20
16	Hands, palmar	15.7	1.3804	0.3%	51746.0	48.28
17	Buttocks	52.1	4.2952	1.1%	79218.6	73.91
18	Groin	66.8	3.6806	0.9%	29129.1	27.18
19	Scrotum	101.8	17.8581	4.4%	3970.7	3.70
20	Thighs, anterior	17.3	24.9843	6.2%	40661.0	37.94
21	Thighs, posterior	17.3	19.2593	4.8%	26362.0	24.60
22	Knees	18.2	1.5415	0.4%	46335.9	43.23
23	Popliteal Space	18.2	2.6332	0.7%	13555.5	12.65
24	Shins	19.0	15.1888	3.8%	44597.2	41.61
25	Calves	19.0	17.8103	4.4%	19009.9	17.74
26	Feet, dorsum	16.5	4.6017	1.1%	38803.2	36.20
27	Feet, plantar	16.5	2.5522	0.6%	41980.6	39.17
	Sum (A/D Factor/PF):		404.9231	100%		

Overall PF **20.51**

Systemic MRED
Headache **205.06**
Nausea/Vomiting **512.64**

Localized MRED **1071.82** **Chin & Neck**

PPV2 Test 3; No PPV Fans **5 Oct 98**

Suit 4: Subject S
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	11.0	41.8322	11.0%	2983	2.52
2	Ears	9.8	11.1164	2.9%	1604	1.36
3	Cheeks & Neck	9.8	21.3064	5.6%	1672	1.41
4	Chin & Neck	9.2	60.6131	15.9%	1182	1.00
5	Nape	12.3	4.7344	1.2%	7540	6.38
6	Abdomen	21.1	60.6964	15.9%	16808	14.22
7	Back	55.1	17.4046	4.6%	52097	44.06
8	Axillae	23.3	4.1516	1.1%	17198	14.55
9	Upper Arms, medial	15.9	10.9635	2.9%	15897	13.44
10	Upper Arms, lateral	15.0	7.1643	1.9%	35188	29.76
11	Elbowfolds	16.0	1.4976	0.4%	11917	10.08
12	Elbows	15.5	1.4313	0.4%	12483	10.56
13	Forearms, volar	16.1	10.8345	2.8%	16053	13.58
14	Forearms, dorsum	16.1	6.6939	1.8%	37661	31.85
15	Hands, dorsum	16.1	4.2578	1.1%	16771	14.18
16	Hands, palmar	16.1	1.3409	0.4%	53268	45.05
17	Buttocks	53.8	4.1575	1.1%	81842	69.22
18	Groin	138.5	1.7760	0.5%	60368	51.06
19	Scrotum	244.5	7.4364	2.0%	9535	8.06
20	Thighs, anterior	19.4	22.3705	5.9%	45412	38.41
21	Thighs, posterior	19.4	17.2445	4.5%	29442	24.90
22	Knees	16.7	1.6750	0.4%	42645	36.07
23	Popliteal Space	16.7	2.8611	0.8%	12476	10.55
24	Shins	14.1	20.4926	5.4%	33055	27.96
25	Calves	14.1	24.0295	6.3%	14090	11.92
26	Feet, dorsum	9.0	8.3916	2.2%	21279	18.00
27	Feet, plantar	9.0	4.6541	1.2%	23021	19.47
	Sum (A/D Factor/PF):		381.1278	100%		

Overall PF **21.79**

Systemic MRED
Headache **217.86**
Nausea/Vomiting **544.65**

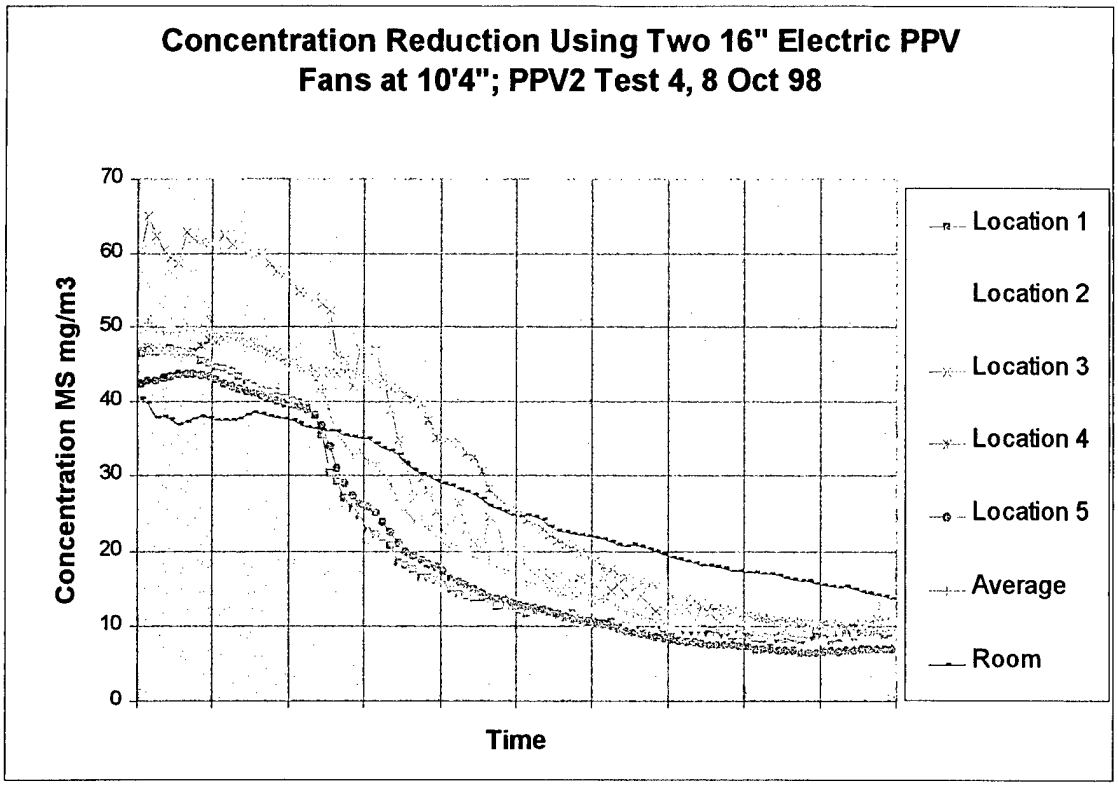
Localized MRED **1182.36** **Chin & Neck**

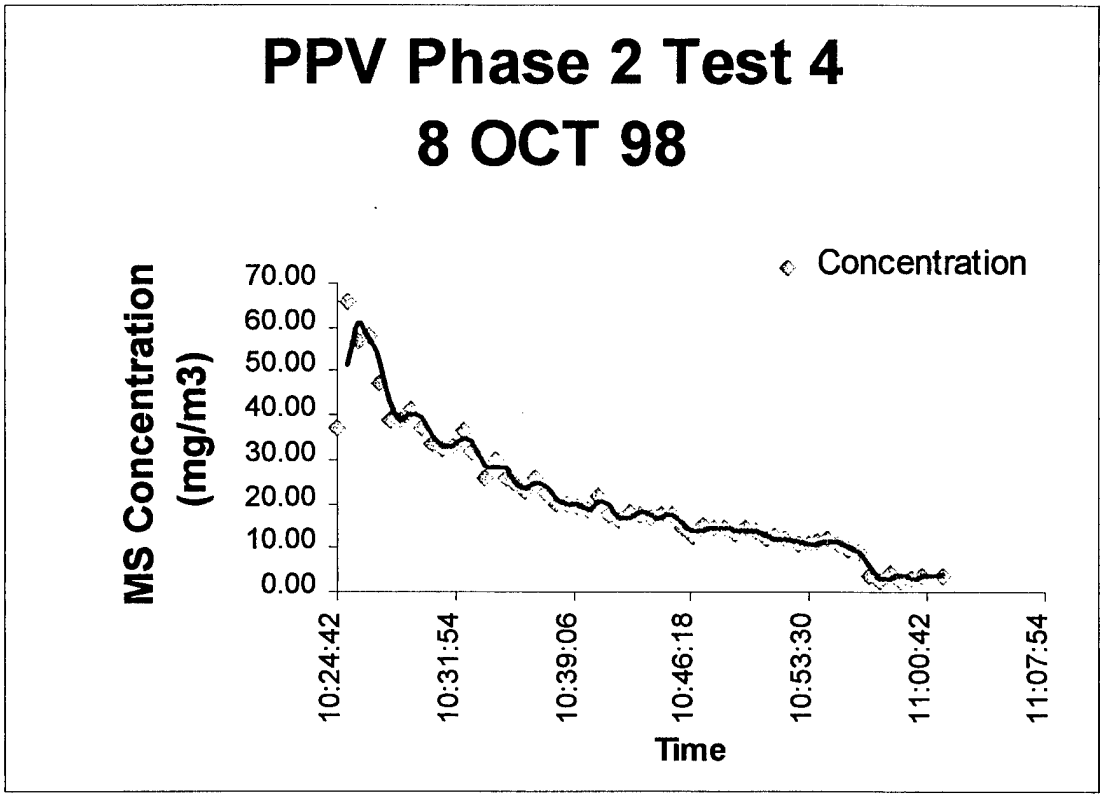
PPV2 Test 3; No PPV Fans				5 Oct 98	
Suit 1: Subject M **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage mg-min/m^3	Sampler Location PF
1 Scalp	N*	2244.92	5.0764	152.29	11.0
2 Ear	N2	2254.29	5.0978	152.93	10.9
3 Chin/Neck	N3	2241.84	5.0694	152.08	11.0
4 Upper Back/Nape	N4	2150.81	4.8620	145.86	11.5
5 Abdomen	N5	1729.75	3.9026	117.08	14.3
6 Middle Back	N7	175.82	0.3621	10.86	153.8
7 Armpit (Axillae)	N8	1125.01	2.5248	75.74	22.1
8 Right Arm, Inner	N9	1637.04	3.6914	110.74	15.1
9 Left Arm, Outer	N10	1684.54	3.7996	113.99	14.7
10 Rt Forearm, Inner	N11	1690.71	3.8137	114.41	14.6
11 Left Hand/Glove	N12	1593.44	3.5921	107.76	15.5
12 Lower Back	N13	543.45	1.1997	35.99	46.4
13 Groin	N14	747.57	1.6648	49.94	33.4
14 Crotch	N14*	213.33	0.4476	13.43	124.4
15 Inner Left Thigh	N15	1519.68	3.4240	102.72	16.3
16 Inner Left Shin	X1	1590.72	3.5859	107.58	15.5
17 Left Foot/Boot	X5	1534.54	3.4579	103.74	16.1

PPV2 Test 3; No PPV Fans				5 Oct 98	
Suit 2: Subject E **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage mg-min/m^3	Sampler Location PF
1 Scalp	T10A	2270.26	5.1341	154.02	10.8
2 Ear	T11	2431.58	5.5017	165.05	10.1
3 Chin/Neck	T11A	3398.31	7.7043	231.13	7.2
4 Upper Back/Nape	T12	2586.97	5.8557	175.67	9.5
5 Abdomen	T13	1819.48	4.1071	123.21	13.6
6 Middle Back	T16	331.96	0.7179	21.54	77.6
7 Armpit (Axillae)	T39	1100.12	2.4681	74.04	22.6
8 Right Arm, Inner	T44	1591.91	3.5886	107.66	15.5
9 Left Arm, Outer	T55	1578.50	3.5580	106.74	15.6
10 Rt Forearm, Inner	T57	1567.63	3.5333	106.00	15.8
11 Left Hand/Glove	T58	1605.31	3.6191	108.57	15.4
12 Lower Back	T60	471.27	1.0353	31.06	53.8
13 Groin	T61	900.34	2.0129	60.39	27.7
14 Crotch	T62	45.89	0.0661	1.98	842.5
15 Inner Left Thigh	T63	1421.26	3.1998	95.99	17.4
16 Inner Left Shin	T64	1426.81	3.2124	96.37	17.3
17 Left Foot/Boot	T65	1548.31	3.4892	104.68	16.0

PPV2 Test 3; No PPV Fans			5 Oct 98		
Suit 3: Subject T **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage $mg\text{-}min/m^3$	Sampler Location PF
1 Scalp	CH1	2260.33	5.1115	153.35	10.9
2 Ear	CH2	2562.47	5.7999	174.00	9.6
3 Chin/Neck	CH3	2958.00	6.7011	201.03	8.3
4 Upper Back/Nape	CH3A	1937.55	4.3761	131.28	12.7
5 Abdomen	CH4A	1795.31	4.0520	121.56	13.7
6 Middle Back	CH5	250.71	0.5328	15.98	104.5
7 Armpit (Axillae)	CH6	1267.50	2.8494	85.48	19.5
8 Right Arm, Inner	CH6A	1819.77	4.1077	123.23	13.6
9 Left Arm, Outer	CH7	1887.18	4.2613	127.84	13.1
10 Rt Forearm, Inner	CH8A	1903.66	4.2989	128.97	13.0
11 Left Hand/Glove	CH9	1575.29	3.5507	106.52	15.7
12 Lower Back	CH9A	486.07	1.0690	32.07	52.1
13 Groin	CH10	785.17	1.7505	52.51	31.8
14 Crotch	CH11A	256.90	0.5469	16.41	101.8
15 Inner Left Thigh	CH12	1426.80	3.2124	96.37	17.3
16 Inner Left Shin	CH12A	1302.36	2.9289	87.87	19.0
17 Left Foot/Boot	CH13	1501.23	3.3820	101.46	16.5

PPV2 Test 3; No PPV Fans			5 Oct 98		
Suit 4: Subject S **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage $mg\text{-}min/m^3$	Sampler Location PF
1 Scalp	A1	2236.61	5.0575	151.72	11.0
2 Ear	A2	2516.05	5.6942	170.82	9.8
3 Chin/Neck	A3	2683.02	6.0746	182.24	9.2
4 Upper Back/Nape	A4	2006.82	4.5339	136.02	12.3
5 Abdomen	A4A	1715.78	3.8708	116.12	14.4
6 Middle Back	A5	183.32	0.3792	11.38	146.8
7 Armpit (Axillae)	A6	1066.91	2.3924	71.77	23.3
8 Right Arm, Inner	A7	1554.09	3.5024	105.07	15.9
9 Left Arm, Outer	A8	1646.10	3.7120	111.36	15.0
10 Rt Forearm, Inner	A8A	1539.12	3.4683	104.05	16.1
11 Left Hand/Glove	A10	1530.77	3.4493	103.48	16.1
12 Lower Back	CA1	471.03	1.0347	31.04	53.8
13 Groin	CA3	770.63	1.7174	51.52	32.4
14 Crotch	CA4	116.83	0.2277	6.83	244.5
15 Inner Left Thigh	CA5	1279.30	2.8763	86.29	19.4
16 Inner Left Shin	CA7	1751.24	3.9516	118.55	14.1
17 Left Foot/Boot	CA8	2723.71	6.1673	185.02	9.0





Concentrations Outside of Building Near Air Exit Point (FTIR Data)

Suit No.	1	2	3
Size:			
Test Participant:	M	T	S
Suit Configuration:	New PBI Bunker Gear w/tape	New PBI Bunker Gear w/tape	New PBI Bunker Gear w/tape
Mean Background Mass, ng:	48.92	48.92	48.92
Mean Clean Room Concentration, mg/m^3:	0.00013	0.00013	0.00014
Mean Doff Room Concentration, mg/m^3:	0.00217	0.00217	0.09173
Suit Exposure Duration, min:	30	30	30
Mean Exposure Concentration, mg/m^3:	54.50	54.50	54.50
Exposure Dosage, mg-min/m^3:	1670.32	1670.32	1670.32
Minimum Detectable Concentration, mg/m^3:	0.00823	0.0159	0.0159
Maximum Measureable PF:	6622	6622	6622
Overall PF:	**79.64**	**137.23**	**199.64**
Systemic MRED (Headache), mg-min/m^3:	**144.07**	**132.43**	**796.37**
Systemic MRED (Nausea), mg-min/m^3:	**1990.93**	**3430.78**	**4991.04**
Minimum Localized MRED, mg-min/m^3:	**2301.99**	**6629.20**	**4184.80**
Location of Minimum Localized MRED:	**Scrotum**	**Chin & Neck**	**Ears**

PPV2 Test 4; Two 16" Electric Fans **8 Oct 98**

Suit 1: Subject M
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	425.6	1.0822	1.0%	115325.2	50.10
2	Ears	22.5	4.8361	4.6%	3686.1	1.60
3	Cheeks & Neck	22.5	9.2691	8.9%	3843.4	1.67
4	Chin & Neck	22.1	25.1146	24.1%	2853.6	1.24
5	Nape	98.4	0.5909	0.6%	60407.3	26.24
6	Abdomen	1804.3	0.7103	0.7%	1436243.7	623.91
7	Back	202.2	4.7405	4.5%	191272.2	83.09
8	Axillae	262.9	0.3674	0.4%	194319.5	84.41
9	Upper Arms, medial	69.0	2.5256	2.4%	69008.3	29.98
10	Upper Arms, lateral	282.6	0.3803	0.4%	662962.8	288.00
11	Elbowfolds	154.3	0.1550	0.1%	115142.8	50.02
12	Elbows	261.1	0.0851	0.1%	209955.9	91.21
13	Forearms, volar	239.7	0.7257	0.7%	239685.6	104.12
14	Forearms, dorsum	239.7	0.4483	0.4%	562302.4	244.27
15	Hands, dorsum	395.2	0.1739	0.2%	410616.4	178.37
16	Hands, palmar	395.2	0.0548	0.1%	1304171.3	566.54
17	Buttocks	111.9	1.9990	1.9%	170213.1	73.94
18	Groin	3340.5	0.0736	0.1%	1456459.5	632.69
19	Scrotum	59.0	30.8033	29.5%	2302.0	1.00
20	Thighs, anterior	80.9	5.3495	5.1%	189903.2	82.50
21	Thighs, posterior	80.9	4.1237	4.0%	123121.4	53.48
22	Knees	79.0	0.3548	0.3%	201326.7	87.46
23	Popliteal Space	79.0	0.6060	0.6%	58897.9	25.59
24	Shins	77.0	3.7520	3.6%	180537.9	78.43
25	Calves	77.0	4.3996	4.2%	76955.6	33.43
26	Feet, dorsum	76.4	0.9916	1.0%	180074.4	78.23
27	Feet, plantar	76.4	0.5500	0.5%	194819.6	84.63
	Sum (A/D Factor/PF):		104.2628	100%		

Overall PF **79.64**

Systemic MRED
Headache **796.37**
Nausea/Vomiting **1990.93**

Localized MRED **2301.99** **Scrotum**

PPV2 Test 4; Two 16" Electric Fans **8 Oct 98**

Suit 2: Subject T
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	6622.0	0.0695	0.1%	1794556.9	270.70
2	Ears	47.3	2.2960	3.8%	7763.8	1.17
3	Cheeks & Neck	47.3	4.4008	7.3%	8095.2	1.22
4	Chin & Neck	51.4	10.8108	17.9%	6629.2	1.00
5	Nape	589.9	0.0986	0.2%	362215.2	54.64
6	Abdomen	1806.4	0.7095	1.2%	1437870.5	216.90
7	Back	3111.5	0.3080	0.5%	2943486.0	444.02
8	Axillae	111.9	0.8632	1.4%	82715.6	12.48
9	Upper Arms, medial	185.5	0.9394	1.6%	185529.8	27.99
10	Upper Arms, lateral	53.9	1.9930	3.3%	126488.1	19.08
11	Elbowfolds	200.2	0.1195	0.2%	149338.3	22.53
12	Elbows	134.4	0.1654	0.3%	108040.6	16.30
13	Forearms, volar	214.8	0.8096	1.3%	214841.1	32.41
14	Forearms, dorsum	214.8	0.5002	0.8%	504017.3	76.03
15	Hands, dorsum	2663.9	0.0258	0.0%	2767781.0	417.51
16	Hands, palmar	2663.9	0.0081	0.0%	8790834.9	1326.08
17	Buttocks	6622.0	0.0338	0.1%	10072033.6	1519.34
18	Groin	3434.1	0.0716	0.1%	1497275.6	225.86
19	Scrotum	246.3	7.3833	12.2%	9604.0	1.45
20	Thighs, anterior	56.1	7.7129	12.7%	131713.2	19.87
21	Thighs, posterior	56.1	5.9455	9.8%	85394.6	12.88
22	Knees	53.7	0.5221	0.9%	136809.5	20.64
23	Popliteal Space	53.7	0.8918	1.5%	40023.5	6.04
24	Shins	51.2	5.6440	9.3%	120016.3	18.10
25	Calves	51.2	6.6182	10.9%	51157.9	7.72
26	Feet, dorsum	75.3	1.0063	1.7%	177439.4	26.77
27	Feet, plantar	75.3	0.5581	0.9%	191968.8	28.96
	Sum (A/D Factor/PF):		60.5051	100%		

Overall PF **137.23**

Systemic MRED
Headache **1372.31**
Nausea/Vomiting **3430.78**

Localized MRED **6629.20** **Chin & Neck**

PPV2 Test 4; Two 16" Electric Fans **8 Oct 98**

Suit 3: Subject S
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	6622.0	0.0695	0.2%	1794556.9	428.83
2	Ears	25.5	4.2597	10.2%	4184.8	1.00
3	Cheeks & Neck	25.5	8.1645	19.6%	4363.4	1.04
4	Chin & Neck	55.5	10.0094	24.1%	7160.0	1.71
5	Nape	266.0	0.2185	0.5%	163349.1	39.03
6	Abdomen	646.7	1.9816	4.8%	514807.4	123.02
7	Back	1812.6	0.5288	1.3%	1714764.2	409.76
8	Axillae	570.2	0.1694	0.4%	421408.4	100.70
9	Upper Arms, medial	325.1	0.5361	1.3%	325072.0	77.68
10	Upper Arms, lateral	112.2	0.9575	2.3%	263297.3	62.92
11	Elbowfolds	450.6	0.0531	0.1%	336158.5	80.33
12	Elbows	344.2	0.0646	0.2%	276732.6	66.13
13	Forearms, volar	576.2	0.3019	0.7%	576157.1	137.68
14	Forearms, dorsum	576.2	0.1865	0.4%	1351664.7	322.99
15	Hands, dorsum	357.8	0.1921	0.5%	371720.9	88.83
16	Hands, palmar	357.8	0.0605	0.1%	1180634.3	282.12
17	Buttocks	413.5	0.5410	1.3%	628976.0	150.30
18	Groin	2015.6	0.1220	0.3%	878803.7	210.00
19	Scrotum	2315.5	0.7852	1.9%	90306.4	21.58
20	Thighs, anterior	104.8	4.1339	9.9%	245746.7	58.72
21	Thighs, posterior	104.8	3.1866	7.7%	159326.8	38.07
22	Knees	168.7	0.1661	0.4%	430111.0	102.78
23	Popliteal Space	168.7	0.2837	0.7%	125828.6	30.07
24	Shins	232.6	1.2414	3.0%	545657.6	130.39
25	Calves	232.6	1.4557	3.5%	232590.6	55.58
26	Feet, dorsum	61.3	1.2358	3.0%	144487.2	34.53
27	Feet, plantar	61.3	0.6854	1.6%	156318.3	37.35
	Sum (A/D Factor/PF):		41.5905	100%		

Overall PF **199.64**

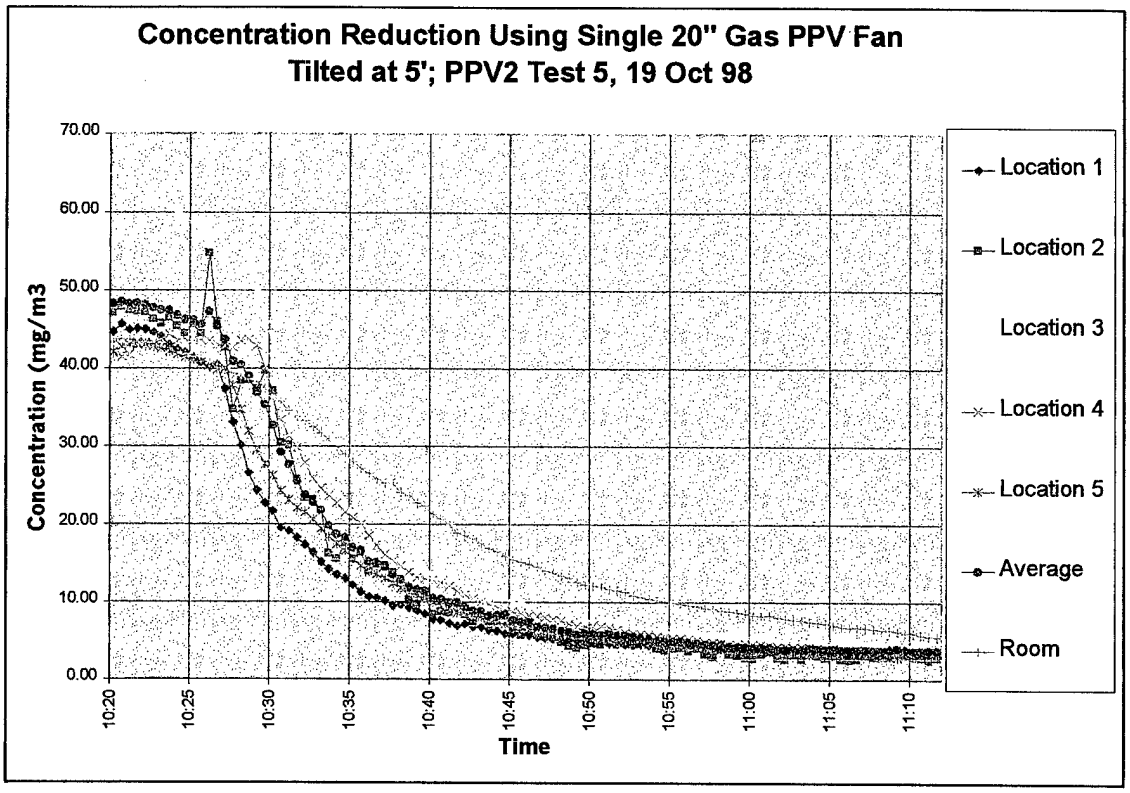
Systemic MRED
Headache **1996.42**
Nausea/Vomiting **4991.04**

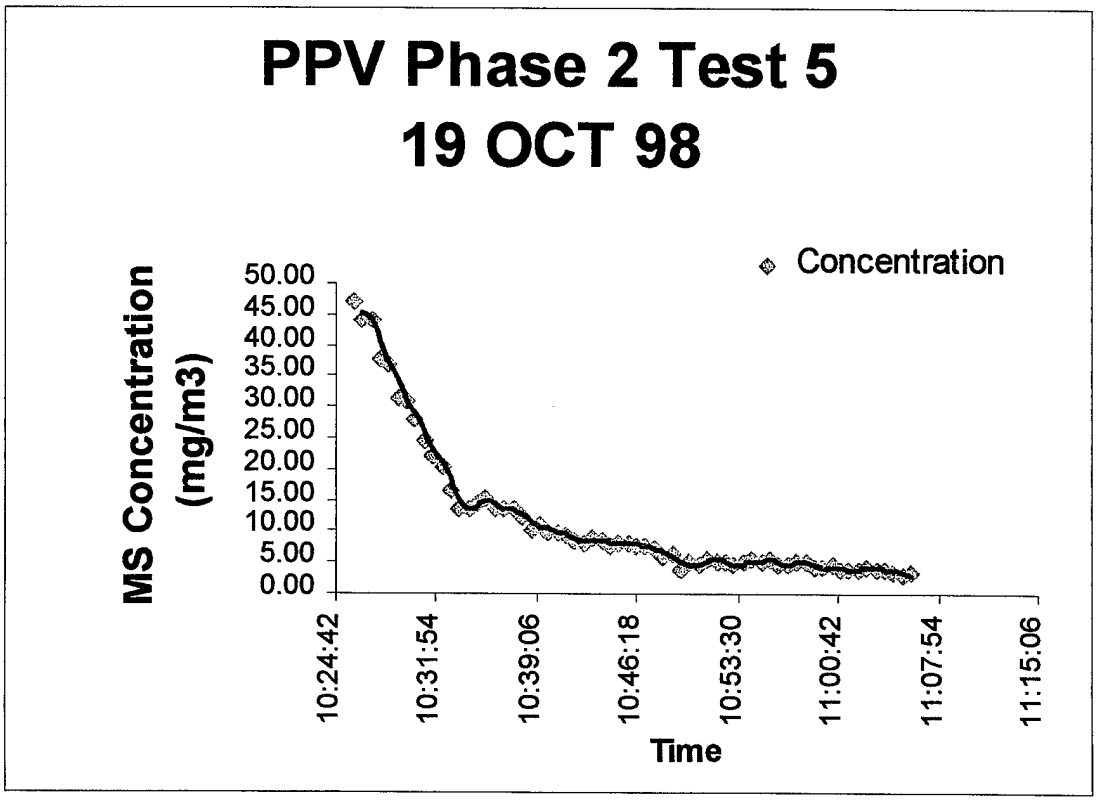
Localized MRED **4184.80** **Ears**

PPV2 Test 4; Two 16" Electric Fans			8 Oct 98		
Suit 1: Subject M **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage mg-min/m^3	Sampler Location PF
1 Scalp	F02	106.34	0.1308	3.93	425.6
2 Ear	F04	1136.15	2.4772	74.32	22.5
3 Chin/Neck	F06	1153.61	2.5170	75.51	22.1
4 Upper Back/Nape	F07	297.30	0.5659	16.98	98.4
5 Abdomen	F08	195.96	0.3350	10.05	166.2
6 Middle Back	F09	129.00	0.1825	5.47	305.1
7 Armpit (Axillae)	F11	141.85	0.2117	6.35	262.9
8 Right Arm, Inner	F12	403.03	0.8068	24.20	69.0
9 Left Arm, Outer	K01	135.39	0.1970	5.91	282.6
10 Rt Forearm, Inner	K02	150.87	0.2323	6.97	239.7
11 Left Hand/Glove	K04	110.75	0.1409	4.23	395.2
12 Lower Back	K05	267.28	0.4975	14.93	111.9
13 Groin	K06	56.54	BBL	BBL	6622.0
14 Crotch	K08	462.92	0.9433	28.30	59.0
15 Inner Left Thigh	K09	350.80	0.6878	20.63	80.9
16 Inner Left Shin	K10	366.46	0.7235	21.70	77.0
17 Left Foot/Boot	K11	368.77	0.7288	21.86	76.4

PPV2 Test 4; Two 16" Electric Fans			8 Oct 98		
Suit 2: Subject T **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage mg-min/m^3	Sampler Location PF
1 Scalp	H1	52.16	BBL	BBL	6622.0
2 Ear	H2	565.11	1.1761	35.28	47.3
3 Chin/Neck	H2A	524.44	1.0834	32.50	51.4
4 Upper Back/Nape	H3	90.34	0.0944	2.83	589.9
5 Abdomen	H3A	148.34	0.2265	6.80	245.8
6 Middle Back	H4	12.04	BBL	BBL	6622.0
7 Armpit (Axillae)	T1	267.24	0.4974	14.92	111.9
8 Right Arm, Inner	T2	180.63	0.3001	9.00	185.5
9 Left Arm, Outer	T3	502.15	1.0327	30.98	53.9
10 Rt Forearm, Inner	T4	162.66	0.2592	7.77	214.8
11 Left Hand/Glove	T4A	58.09	0.0209	0.63	2663.9
12 Lower Back	T5	47.69	BBL	BBL	6622.0
13 Groin	T6	44.86	BBL	BBL	6622.0
14 Crotch	T8	148.15	0.2261	6.78	246.3
15 Inner Left Thigh	T9	484.17	0.9917	29.75	56.1
16 Inner Left Shin	T9A	526.59	1.0883	32.65	51.2
17 Left Foot/Boot	T10	373.52	0.7396	22.19	75.3

PPV2 Test 4; Two 16" Electric Fans			8 Oct 98		
Suit 3: Subject S **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage $mg\text{-}min/m^3$	Sampler Location PF
1 Scalp	G1	36.21	BBL	BBL	6622.0
2 Ear	G2	1006.58	2.1820	65.46	25.5
3 Chin/Neck	G3	489.19	1.0031	30.09	55.5
4 Upper Back/Nape	G5	140.77	0.2093	6.28	266.0
5 Abdomen	G6	211.25	0.3699	11.10	150.5
6 Middle Back	G7	41.82	BBL	BBL	6622.0
7 Armpit (Axillae)	G8	91.77	0.0976	2.93	570.2
8 Right Arm, Inner	G9	124.09	0.1713	5.14	325.1
9 Left Arm, Outer	G10	266.65	0.4961	14.88	112.2
10 Rt Forearm, Inner	G11	91.33	0.0966	2.90	576.2
11 Left Hand/Glove	G12	117.22	0.1556	4.67	357.8
12 Lower Back	G14	108.01	0.1346	4.04	413.5
13 Groin	G15	63.16	0.0325	0.97	1715.7
14 Crotch	G16	59.47	0.0240	0.72	2315.5
15 Inner Left Thigh	G17	282.20	0.5315	15.95	104.8
16 Inner Left Shin	G18	153.98	0.2394	7.18	232.6
17 Left Foot/Boot	G20	447.55	0.9083	27.25	61.3





Concentrations Outside of Building Near Air Exit Point (FTIR Data)

Suit No.	1	2	3
Size:			
Test Participant:	M	T	S
Suit Configuration:	New PBI Bunker Gear w/tape	New PBI Bunker Gear w/tape	New PBI Bunker Gear w/tape
Mean Background Mass, ng:	42.91	42.91	42.91
Mean Clean Room Concentration, mg/m^3:	0.00298	0.00298	0.00298
Mean Doff Room Concentration, mg/m^3:	0.00323	0.00323	0.00323
Suit Exposure Duration, min:	30	30	30
Mean Exposure Concentration, mg/m^3:	54.50	54.50	54.50
Exposure Dosage, $mg\text{-}min/m^3$:	1670.32	1670.32	1670.32
Minimum Detectable Concentration, mg/m^3:	0.00823	0.0159	0.0159
Maximum Measureable PF:	6622	6622	6622
Overall PF:	**410.21**	**555.13**	**727.62**
Systemic MRED (Headache), $mg\text{-}min/m^3$:	**144.07**	**132.43**	**4102.10**
Systemic MRED (Nausea), $mg\text{-}min/m^3$:	**10255.24**	**13878.14**	**18190.58**
Minimum Localized MRED, $mg\text{-}min/m^3$:	**12731.58**	**28619.61**	**21322.65**
Location of Minimum Localized MRED:	**Chin & Neck**	**Scrotum**	**Chin & Neck**

PPV2 Test 5; Single 20" Gas Fans, Fans Tilted at 5' **19 Oct 98**

Suit 1: Subject M
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	6622.0	0.0695	0.3%	1794556.9	140.95
2	Ears	350.6	0.3100	1.5%	57506.5	4.52
3	Cheeks & Neck	350.6	0.5941	2.9%	59961.0	4.71
4	Chin & Neck	98.7	5.6290	27.8%	12731.6	1.00
5	Nape	507.2	0.1146	0.6%	311418.9	24.46
6	Abdomen	3786.6	0.3385	1.7%	3014162.7	236.75
7	Back	469.3	2.0422	10.1%	443989.5	34.87
8	Axillae	333.1	0.2901	1.4%	246166.2	19.34
9	Upper Arms, medial	232.1	0.7509	3.7%	232111.9	18.23
10	Upper Arms, lateral	610.3	0.1761	0.9%	1431783.3	112.46
11	Elbowfolds	3427.0	0.0070	0.0%	2556576.8	200.81
12	Elbows	3616.1	0.0061	0.0%	2907380.4	228.36
13	Forearms, volar	6622.0	0.0263	0.1%	6621981.3	520.12
14	Forearms, dorsum	6622.0	0.0162	0.1%	15535168.2	1220.21
15	Hands, dorsum	471.2	0.1459	0.7%	489583.1	38.45
16	Hands, palmar	471.2	0.0459	0.2%	1554979.9	122.14
17	Buttocks	315.8	0.7083	3.5%	480396.7	37.73
18	Groin	1251.8	0.1964	1.0%	545785.4	42.87
19	Scrotum	934.1	1.9464	9.6%	36430.9	2.86
20	Thighs, anterior	181.6	2.3845	11.8%	426044.9	33.46
21	Thighs, posterior	181.6	1.8381	9.1%	276220.9	21.70
22	Knees	391.2	0.0716	0.4%	997447.1	78.34
23	Popliteal Space	391.2	0.1223	0.6%	291802.2	22.92
24	Shins	600.7	0.4807	2.4%	1409257.7	110.69
25	Calves	600.7	0.5636	2.8%	600706.6	47.18
26	Feet, dorsum	86.2	0.8793	4.3%	203065.2	15.95
27	Feet, plantar	86.2	0.4877	2.4%	219692.9	17.26
	Sum (A/D Factor/PF):		20.2413	100%		

Overall PF **410.21**

Systemic MRED
Headache **4102.10**
Nausea/Vomiting **10255.24**

Localized MRED **12731.58** **Chin & Neck**

PPV2 Test 5; Single 20" Gas Fans, Fans Tilted at 5' 19 Oct 98

Suit 2: Subject T
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	6622.0	0.0695	0.5%	1794556.9	62.70
2	Ears	352.2	0.3086	2.1%	57755.1	2.02
3	Cheeks & Neck	352.2	0.5916	4.0%	60220.3	2.10
4	Chin & Neck	278.6	1.9938	13.3%	35944.6	1.26
5	Nape	839.5	0.0693	0.5%	515429.8	18.01
6	Abdomen	2296.3	0.5581	3.7%	1827892.1	63.87
7	Back	1951.4	0.4912	3.3%	1846044.7	64.50
8	Axillae	493.4	0.1958	1.3%	364602.4	12.74
9	Upper Arms, medial	119.9	1.4540	9.7%	119864.3	4.19
10	Upper Arms, lateral	202.7	0.5301	3.5%	475598.2	16.62
11	Elbowfolds	177.4	0.1349	0.9%	132344.3	4.62
12	Elbows	218.8	0.1015	0.7%	175944.7	6.15
13	Forearms, volar	234.9	0.7403	4.9%	234946.1	8.21
14	Forearms, dorsum	234.9	0.4574	3.1%	551183.6	19.26
15	Hands, dorsum	6622.0	0.0104	0.1%	6880238.6	240.40
16	Hands, palmar	6622.0	0.0033	0.0%	21852538.4	763.55
17	Buttocks	6622.0	0.0338	0.2%	10072033.6	351.93
18	Groin	3677.9	0.0669	0.4%	1603568.2	56.03
19	Scrotum	733.8	2.4776	16.6%	28619.6	1.00
20	Thighs, anterior	258.0	1.6787	11.2%	605179.0	21.15
21	Thighs, posterior	258.0	1.2940	8.7%	392360.3	13.71
22	Knees	344.1	0.0814	0.5%	877341.1	30.66
23	Popliteal Space	344.1	0.1391	0.9%	256665.3	8.97
24	Shins	430.1	0.6712	4.5%	1009128.7	35.26
25	Calves	430.1	0.7871	5.3%	430148.7	15.03
26	Feet, dorsum	6622.0	0.0114	0.1%	15608010.0	545.36
27	Feet, plantar	6622.0	0.0063	0.0%	16886052.4	590.02
	Sum (A/D Factor/PF):		14.9573	100%		

Overall PF **555.13**

Systemic MRED
Headache **5551.26**
Nausea/Vomiting **13878.14**

Localized MRED **28619.61** **Scrotum**

PPV2 Test 5; Single 20" Gas Fans, Fans Tilted at 5' **19 Oct 98**

Suit 3: Subject S
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	6622.0	0.0695	0.6%	1794556.9	84.16
2	Ears	1074.1	0.1012	0.9%	176159.4	8.26
3	Cheeks & Neck	1074.1	0.1940	1.7%	183678.4	8.61
4	Chin & Neck	165.3	3.3611	29.5%	21322.6	1.00
5	Nape	598.5	0.0971	0.9%	367478.8	17.23
6	Abdomen	2078.0	0.6168	5.4%	1654098.1	77.57
7	Back	3421.3	0.2802	2.5%	3236506.8	151.79
8	Axillae	1035.5	0.0933	0.8%	765201.5	35.89
9	Upper Arms, medial	264.8	0.6582	5.8%	264782.2	12.42
10	Upper Arms, lateral	416.3	0.2581	2.3%	976637.2	45.80
11	Elbowfolds	290.6	0.0823	0.7%	216771.3	10.17
12	Elbows	366.3	0.0607	0.5%	294534.6	13.81
13	Forearms, volar	316.4	0.5498	4.8%	316374.2	14.84
14	Forearms, dorsum	316.4	0.3397	3.0%	742213.9	34.81
15	Hands, dorsum	223.1	0.3081	2.7%	231785.4	10.87
16	Hands, palmar	223.1	0.0970	0.9%	736180.9	34.53
17	Buttocks	6622.0	0.0338	0.3%	10072033.6	472.36
18	Groin	6622.0	0.0371	0.3%	2887183.9	135.40
19	Scrotum	6622.0	0.2746	2.4%	258257.3	12.11
20	Thighs, anterior	692.3	0.6255	5.5%	1624039.8	76.17
21	Thighs, posterior	692.3	0.4822	4.2%	1052926.0	49.38
22	Knees	500.6	0.0560	0.5%	1276472.4	59.86
23	Popliteal Space	500.6	0.0956	0.8%	373430.8	17.51
24	Shins	308.9	0.9347	8.2%	724669.5	33.99
25	Calves	308.9	1.0961	9.6%	308895.8	14.49
26	Feet, dorsum	193.4	0.3916	3.4%	455928.2	21.38
27	Feet, plantar	193.4	0.2172	1.9%	493261.3	23.13
	Sum (A/D Factor/PF):		11.4114	100%		

Overall PF **727.62**

Systemic MRED
Headache **7276.23**
Nausea/Vomiting **18190.58**

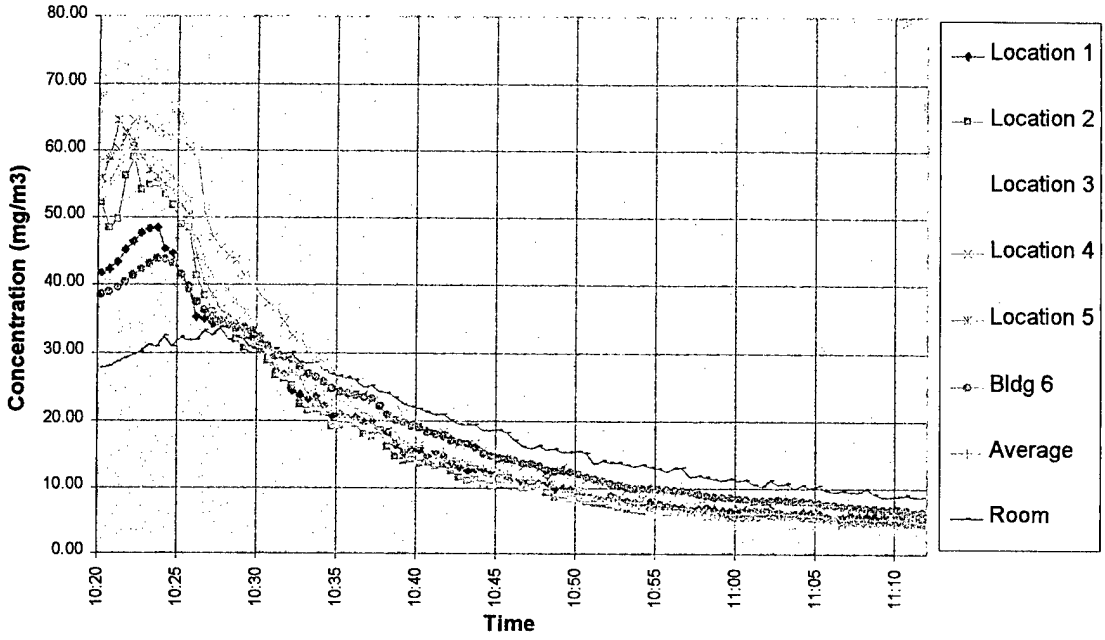
Localized MRED **21322.65** **Chin & Neck**

PPV2 Test 5; Single 20" Gas Fans, Fans Tilted at 5'		19 Oct 98			
Suit 1: Subject M **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage mg-min/m^3	Sampler Location PF
1 Scalp	CH1	31.43	BBL	BBL	6622.0
2 Ear	CH2	112.60	0.1588	4.76	350.6
3 Chin/Neck	CH3	290.51	0.5641	16.92	98.7
4 Upper Back/Nape	CH5	91.09	0.1098	3.29	507.2
5 Abdomen	CH6	53.55	BBL	BBL	6622.0
6 Middle Back	CH6A	73.87	0.0705	2.12	789.3
7 Armpit (Axillae)	CH7	116.27	0.1671	5.01	333.1
8 Right Arm, Inner	CH9	148.19	0.2399	7.20	232.1
9 Left Arm, Outer	CH9A	82.95	0.0912	2.74	610.3
10 Rt Forearm, Inner	CH12A	43.21	BBL	BBL	6622.0
11 Left Hand/Glove	CH13	94.77	0.1182	3.54	471.2
12 Lower Back	G04	120.28	0.1763	5.29	315.8
13 Groin	G13	58.48	0.0355	1.06	1569.5
14 Crotch	HL1	69.07	0.0596	1.79	934.1
15 Inner Left Thigh	N16	177.47	0.3066	9.20	181.6
16 Inner Left Shin	SH8	83.59	0.0927	2.78	600.7
17 Left Foot/Boot	SH12	326.55	0.6463	19.39	86.2

PPV2 Test 5; Single 20" Gas Fans, Fans Tilted at 5'		19 Oct 98			
Suit 2: Subject T **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage mg-min/m^3	Sampler Location PF
1 Scalp	N*	40.24	BBL	BBL	6622.0
2 Ear	N2	112.30	0.1581	4.74	352.2
3 Chin/Neck	N3	130.61	0.1998	5.99	278.6
4 Upper Back/Nape	N4	72.02	0.0663	1.99	839.5
5 Abdomen	N5	66.52	0.0538	1.61	1035.0
6 Middle Back	N7	85.05	0.0960	2.88	579.9
7 Armpit (Axillae)	N8	92.44	0.1129	3.39	493.4
8 Right Arm, Inner	N9	246.78	0.4645	13.94	119.9
9 Left Arm, Outer	N10	163.45	0.2746	8.24	202.7
10 Rt Forearm, Inner	N11	146.92	0.2370	7.11	234.9
11 Left Hand/Glove	N12	36.33	BBL	BBL	6622.0
12 Lower Back	N13	31.52	BBL	BBL	6622.0
13 Groin	N14	33.10	BBL	BBL	6622.0
14 Crotch	N14*	76.21	0.0759	2.28	733.8
15 Inner Left Thigh	N15	137.64	0.2158	6.48	258.0
16 Inner Left Shin	H3A	99.72	0.1294	3.88	430.1
17 Left Foot/Boot	H18	47.50	BBL	BBL	6622.0

PPV2 Test 5; Single 20" Gas Fans, Fans Tilted at 5'		19 Oct 98			
Suit 3: Subject S **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage $mg\text{-}min/m^3$	Sampler Location PF
1 Scalp	T1	37.35	BBL	BBL	6622.0
2 Ear	T2	65.66	0.0518	1.56	1074.1
3 Chin/Neck	T3	190.75	0.3368	10.11	165.3
4 Upper Back/Nape	T4	83.74	0.0930	2.79	598.5
5 Abdomen	T4A	117.57	0.1701	5.10	327.3
6 Middle Back	T5	44.69	BBL	BBL	6622.0
7 Armpit (Axillae)	T6	66.51	0.0538	1.61	1035.5
8 Right Arm, Inner	T8	135.20	0.2103	6.31	264.8
9 Left Arm, Outer	T9	101.61	0.1337	4.01	416.3
10 Rt Forearm, Inner	T9A	120.15	0.1760	5.28	316.4
11 Left Hand/Glove	T10	152.45	0.2496	7.49	223.1
12 Lower Back	ST1	51.78	BBL	BBL	6622.0
13 Groin	ST2	53.18	BBL	BBL	6622.0
14 Crotch	ST3	27.29	BBL	BBL	6622.0
15 Inner Left Thigh	ST5	78.21	0.0804	2.41	692.3
16 Inner Left Shin	ST7	122.02	0.1802	5.41	308.9
17 Left Foot/Boot	ST11	169.24	0.2878	8.63	193.4

Concentration Reduction Using Single 20" Gas PPV Fan Tilted 20o at 12' 6" to Fully Cover the Door; PPV2 Test 6, 18 Nov 98



Suit No.	1	2	3
Size:			
Test Participant:	M	T	S
Suit Configuration:	New PBI Bunker Gear w/tape	New PBI Bunker Gear w/tape	New PBI Bunker Gear w/tape
Mean Background Mass, ng:	39.35	39.35	39.35
Mean Clean Room Concentration, mg/m^3:	0.00298	0.00298	0.00298
Mean Doff Room Concentration, mg/m^3:	0.00323	0.00323	0.00323
Suit Exposure Duration, min:	30	30	30
Mean Exposure Concentration, mg/m^3:	54.50	54.50	54.50
Exposure Dosage, mg-min/m^3:	1670.32	1670.32	1670.32
Minimum Detectable Concentration, mg/m^3:	0.00823	0.0159	0.0159
Maximum Measureable PF:	6622	6622	6622
Overall PF:	**343.18**	**221.50**	**201.23**
Systemic MRED (Headache), mg-min/m^3:	**144.07**	**132.43**	**3431.78**
Systemic MRED (Nausea), mg-min/m^3:	**8579.45**	**5537.62**	**5030.67**
Minimum Localized MRED, mg-min/m^3:	**8383.28**	**3619.43**	**3636.16**
Location of Minimum Localized MRED:	**Chin & Neck**	**Scrotum**	**Chin & Neck**

PPV2 Test 6; Single 20" Gas Fan, Tilted at 12' 6" **18 Nov 98**

Suit 1: Subject M
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	712.9	0.6460	2.7%	193184.3	23.04
2	Ears	51.1	2.1264	8.8%	8383.3	1.00
3	Cheeks & Neck	51.1	4.0756	16.8%	8741.1	1.04
4	Chin & Neck	138.3	4.0163	16.6%	17844.1	2.13
5	Nape	6622.0	0.0088	0.0%	4065896.5	485.00
6	Abdomen	786.3	1.6299	6.7%	625916.1	74.66
7	Back	2134.0	0.4492	1.9%	2018754.8	240.81
8	Axillae	1165.3	0.0829	0.3%	861170.9	102.72
9	Upper Arms, medial	6622.0	0.0263	0.1%	6621981.3	789.90
10	Upper Arms, lateral	610.6	0.1760	0.7%	1432498.8	170.88
11	Elbowfolds	3540.7	0.0068	0.0%	2641396.3	315.08
12	Elbows	535.1	0.0415	0.2%	430189.6	51.32
13	Forearms, volar	459.5	0.3785	1.6%	459510.1	54.81
14	Forearms, dorsum	459.5	0.2339	1.0%	1078010.6	128.59
15	Hands, dorsum	727.1	0.0945	0.4%	755423.3	90.11
16	Hands, palmar	727.1	0.0298	0.1%	2399323.4	286.20
17	Buttocks	600.4	0.3726	1.5%	913225.8	108.93
18	Groin	1076.9	0.2283	0.9%	469527.5	56.01
19	Scrotum	436.5	4.1651	17.2%	17024.5	2.03
20	Thighs, anterior	178.2	2.4300	10.0%	418060.3	49.87
21	Thighs, posterior	178.2	1.8732	7.7%	271044.2	32.33
22	Knees	499.7	0.0561	0.2%	1274143.8	151.99
23	Popliteal Space	499.7	0.0958	0.4%	372749.5	44.46
24	Shins	821.1	0.3516	1.5%	1926364.4	229.79
25	Calves	821.1	0.4123	1.7%	821127.2	97.95
26	Feet, dorsum	627.2	0.1208	0.5%	1478372.9	176.35
27	Feet, plantar	627.2	0.0670	0.3%	1599427.6	190.79
	Sum (A/D Factor/PF):		24.1950	100%		

Overall PF **343.18**

Systemic MRED
Headache **3431.78**
Nausea/Vomiting **8579.45**

Localized MRED **8383.28** **Chin & Neck**

PPV2 Test 6; Single 20" Gas Fan, Tilted at 12' 6" **18 Nov 98**

Suit 2: Subject T
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	417.5	1.1030	2.9%	113144.7	31.26
2	Ears	148.3	0.7331	2.0%	24316.6	6.72
3	Cheeks & Neck	148.3	1.4051	3.7%	25354.6	7.01
4	Chin & Neck	28.1	19.8006	52.8%	3619.4	1.00
5	Nape	133.2	0.4365	1.2%	81788.8	22.60
6	Abdomen	2079.2	0.6164	1.6%	1655072.7	457.27
7	Back	773.5	1.2391	3.3%	731756.2	202.17
8	Axillae	742.1	0.1302	0.3%	548398.3	151.52
9	Upper Arms, medial	811.6	0.2147	0.6%	811582.4	224.23
10	Upper Arms, lateral	1050.6	0.1023	0.3%	2464686.3	680.96
11	Elbowfolds	992.1	0.0241	0.1%	740095.7	204.48
12	Elbows	1111.6	0.0200	0.1%	893718.1	246.92
13	Forearms, volar	1172.6	0.1483	0.4%	1172588.5	323.97
14	Forearms, dorsum	1172.6	0.0916	0.2%	2750892.7	760.04
15	Hands, dorsum	2851.4	0.0241	0.1%	2962634.5	818.54
16	Hands, palmar	2851.4	0.0076	0.0%	9409715.1	2599.78
17	Buttocks	1820.9	0.1229	0.3%	2769619.2	765.21
18	Groin	3771.2	0.0652	0.2%	1644240.2	454.28
19	Scrotum	920.4	1.9754	5.3%	35895.8	9.92
20	Thighs, anterior	434.1	0.9975	2.7%	1018450.9	281.38
21	Thighs, posterior	434.1	0.7689	2.1%	660300.0	182.43
22	Knees	261.7	0.1070	0.3%	667291.8	184.36
23	Popliteal Space	261.7	0.1828	0.5%	195215.6	53.94
24	Shins	89.2	3.2354	8.6%	209366.0	57.85
25	Calves	89.2	3.7938	10.1%	89243.8	24.66
26	Feet, dorsum	842.6	0.0899	0.2%	1986117.5	548.74
27	Feet, plantar	842.6	0.0499	0.1%	2148748.3	593.67
	Sum (A/D Factor/PF):		37.4854	100%		

Overall PF **221.50**

Systemic MRED
Headache **2215.05**
Nausea/Vomiting **5537.62**

Localized MRED **3619.43** **Scrotum**

PPV2 Test 6; Single 20" Gas Fan, Tilted at 12' 6" **18 Nov 98**

Suit 3: Subject S
Bunker Gear w/tape

	Body Skin Region	PF_{BR}	A/D Factor /PF	Region's Percent Contribution	Localized MRED mg-min/m^3	Factor of Minimum
1	Scalp	460.0	1.0011	2.4%	124667.9	34.29
2	Ears	22.2	4.9025	11.9%	3636.2	1.00
3	Cheeks & Neck	22.2	9.3964	22.8%	3791.4	1.04
4	Chin & Neck	92.2	6.0255	14.6%	11893.8	3.27
5	Nape	212.3	0.2738	0.7%	130357.6	35.85
6	Abdomen	546.1	2.3467	5.7%	434714.1	119.55
7	Back	1929.4	0.4968	1.2%	1825189.3	501.96
8	Axillae	948.3	0.1019	0.2%	700766.6	192.72
9	Upper Arms, medial	408.8	0.4263	1.0%	408846.3	112.44
10	Upper Arms, lateral	1240.4	0.0866	0.2%	2910081.4	800.32
11	Elbowfolds	528.3	0.0453	0.1%	394146.2	108.40
12	Elbows	944.1	0.0235	0.1%	759092.5	208.76
13	Forearms, volar	647.8	0.2685	0.7%	647845.8	178.17
14	Forearms, dorsum	647.8	0.1659	0.4%	1519846.3	417.98
15	Hands, dorsum	81.7	0.8413	2.0%	84881.6	23.34
16	Hands, palmar	81.7	0.2649	0.6%	269595.0	74.14
17	Buttocks	425.5	0.5257	1.3%	647192.9	177.99
18	Groin	491.8	0.5000	1.2%	214424.9	58.97
19	Scrotum	272.6	6.6695	16.2%	10631.8	2.92
20	Thighs, anterior	281.4	1.5390	3.7%	660087.6	181.53
21	Thighs, posterior	281.4	1.1864	2.9%	427959.6	117.70
22	Knees	250.6	0.1118	0.3%	638955.9	175.72
23	Popliteal Space	250.6	0.1910	0.5%	186925.9	51.41
24	Shins	219.8	1.3138	3.2%	515591.4	141.80
25	Calves	219.8	1.5405	3.7%	219774.7	60.44
26	Feet, dorsum	115.7	0.6549	1.6%	272650.5	74.98
27	Feet, plantar	115.7	0.3632	0.9%	294976.1	81.12
	Sum (A/D Factor/PF):		41.2629	100%		

Overall PF **201.23**

Systemic MRED
Headache **2012.27**
Nausea/Vomiting **5030.67**

Localized MRED **3636.16** **Chin & Neck**

PPV2 Test 6; Single 20" Gas Fan, Tilted at 12' 6"			18 Nov 98		
Suit 1: Subject M **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage $mg\text{-}min/m^3$	Sampler Location PF
1 Scalp	C1	73.63	0.0781	2.34	712.9
2 Ear	C1*	517.40	1.0892	32.68	51.1
3 Chin/Neck	C2	216.01	0.4025	12.08	138.3
4 Upper Back/Nape	C5	40.69	BBL	BBL	6622.0
5 Abdomen	C8	225.38	0.4239	12.72	131.4
6 Middle Back	C9	77.98	0.0880	2.64	632.6
7 Armpit (Axillae)	C10	60.32	0.0478	1.43	1165.3
8 Right Arm, Inner	C13	46.41	BBL	BBL	6622.0
9 Left Arm, Outer	C14	79.37	0.0912	2.74	610.6
10 Rt Forearm, Inner	C16	92.53	0.1212	3.63	459.5
11 Left Hand/Glove	H1	72.96	0.0766	2.30	727.1
12 Lower Back	H2	80.05	0.0927	2.78	600.4
13 Groin	H3	53.58	0.0324	0.97	1717.3
14 Crotch	H5	95.33	0.1275	3.83	436.5
15 Inner Left Thigh	H07	176.48	0.3124	9.37	178.2
16 Inner Left Shin	H9	69.11	0.0678	2.03	821.1
17 Left Foot/Boot	H11	78.31	0.0888	2.66	627.2

PPV2 Test 6; Single 20" Gas Fan, Tilted at 12' 6"			18 Nov 98		
Suit 2: Subject T **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage $mg\text{-}min/m^3$	Sampler Location PF
1 Scalp	CA1	97.88	0.1334	4.00	417.5
2 Ear	CA2	204.16	0.3755	11.27	148.3
3 Chin/Neck	CA3	910.30	1.9844	59.53	28.1
4 Upper Back/Nape	CA4	222.80	0.4180	12.54	133.2
5 Abdomen	CA5	90.64	0.1169	3.51	476.4
6 Middle Back	CA6	98.43	0.1346	4.04	413.6
7 Armpit (Axillae)	CA6A	72.28	0.0750	2.25	742.1
8 Right Arm, Inner	CA7	69.46	0.0686	2.06	811.6
9 Left Arm, Outer	CA8	62.61	0.0530	1.59	1050.6
10 Rt Forearm, Inner	T44	60.19	0.0475	1.42	1172.6
11 Left Hand/Glove	T55	47.92	0.0195	0.59	2851.4
12 Lower Back	T57	52.77	0.0306	0.92	1820.9
13 Groin	T59	40.79	BBL	BBL	6622.0
14 Crotch	T61	65.90	0.0605	1.81	920.4
15 Inner Left Thigh	T62	95.64	0.1283	3.85	434.1
16 Inner Left Shin	T63	313.17	0.6239	18.72	89.2
17 Left Foot/Boot	T64	68.35	0.0661	1.98	842.6

PPV2 Test 6; Single 20" Gas Fan, Tilted at 12' 6"			18 Nov 98		
Suit 3: Subject S **Bunker Gear w/tape**	Tube	Mass (ng)	MeS Conc mg/m^3	Dosage $mg\text{-}min/m^3$	Sampler Location PF
1 Scalp	A1	92.47	0.1210	3.63	460.0
2 Ear	A2	1141.51	2.5112	75.34	22.2
3 Chin/Neck	A3	304.39	0.6039	18.12	92.2
4 Upper Back/Nape	A4	154.45	0.2622	7.87	212.3
5 Abdomen	A4A	132.40	0.2120	6.36	262.6
6 Middle Back	A6	46.45	BBL	BBL	6622.0
7 Armpit (Axillae)	A7	65.12	0.0587	1.76	948.3
8 Right Arm, Inner	A8	99.12	0.1362	4.09	408.8
9 Left Arm, Outer	A8A	59.05	0.0449	1.35	1240.4
10 Rt Forearm, Inner	A9	77.07	0.0859	2.58	647.8
11 Left Hand/Glove	A10	338.47	0.6815	20.45	81.7
12 Lower Back	R2	96.78	0.1308	3.93	425.5
13 Groin	R4	73.72	0.0783	2.35	711.0
14 Crotch	R16	128.99	0.2042	6.13	272.6
15 Inner Left Thigh	R23	126.20	0.1979	5.94	281.4
16 Inner Left Shin	V5	150.54	0.2533	7.60	219.8
17 Left Foot/Boot	V6	250.60	0.4813	14.44	115.7