Personnel Decontamination: Understanding the 90% Solution

E Titus[1,2], J Slagley[2], R Eninger[3]

[1]Centauri, Beavercreek, OH, [2]Air Force Institute of Technology, Wright-Patterson AFB, OH, [3]United States Air Force, Wright-Patterson AFB, OH

Chemical and biological warfare have long been practiced, and although these types of warfare are not acceptable in modern times, this does not prevent them from occurring. This makes it important for societies to prepare to effectively decontaminate victims to keep them and emergency responders safe in the event of such an attack. It is often stated that there is a 90% reduction in contamination provided simply by disrobing. This work aims characterize the aerosol exposure chamber to be used during the work, as well as to develop a whole-body scale decontamination methodology which is semi-quantifiable.

*The views expressed in this presentation are the work of the authors and do not necessarily reflect the official policy or position of the US Government, the US Department of Defense, or the US Air Force.

Aerosol Chamber Characterization

Background/Motivation: Aerosol test chambers are often used when lofting aerosol contaminants during research. These contain the aerosol to protect the health of researchers. Before research begins, researchers should understand the characteristics of their test chamber [1]–[3]. Characteristics of interest include the air velocity, airflow patterns, and spatial and temporal variability of particle movements [3], [4].

Research Objective: Understand the behavior of the test environment in order to understand uncertainties inherent in an experiment. Characteristics of the aerosol chamber studied include air velocity mapping, spatial variability by gravimetric methods, and flow visualization.

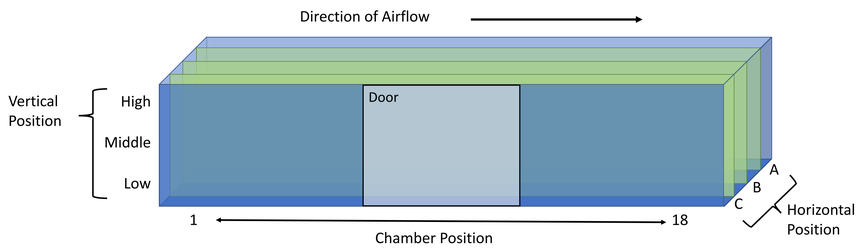

Figure 1. Aerosol test chamber layout. Representation of the chamber showing the planes which are represented in the velocity profiles (Figure 2). Measurements were taken every 1-2 feet along the chamber length and at three vertical and three horizontal positions. A door is located in the middle section for ease of access. Optionally, a flow straightener was located just upstream from the door.

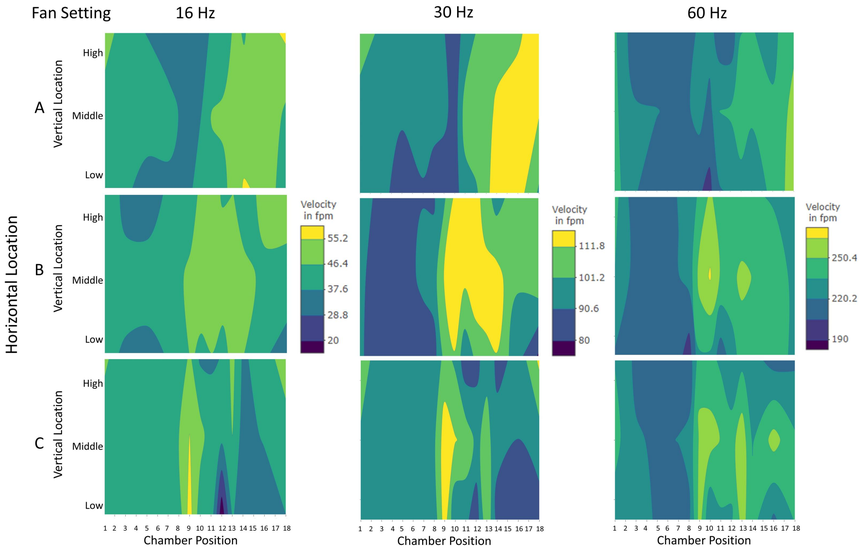

Figure 2. (above) Contour map of velocity profiles. Color cut-points were determined using the instrument uncertainty (±3% ± 7 fpm). Velocity profiles were more similar vertically than horizontally or down the length of the chamber. In addition, there are several points of interest. The door is located in the C plane and significant effects were noted from the door. A significant velocity spike is seen at position 9, as well as a dead spot at position 12 due to physical characteristics of the door fitting. Fan settings equate to approximately 0.2 m/s (39.4 fpm), 0.5 m/s (98.4 fpm), and 1 m/s (196.9 fpm).

Full-Scale Decontamination

Background/Motivation: The first recommendation in all decontamination guidelines is to disrobe, which is often stated to remove 70-90% of the initial contamination [5]–[7]. Although this is often quoted, there seems to be no scientific basis for this statistic. While it seems intuitive that this could be true, there are many characteristics of CBRN agents and the disrobing and decontamination process that may affect the efficacy of this step. Due to the difficulties of quantifying contamination levels on the large surface area of a mannequin, relatively few studies have been done on this scale [8], [9]. However, in order to determine the accuracy of the 90% solution, it is necessary to contaminate and decontaminate a full mannequin.

To facilitate quantification of whole-body contamination a fluorescent, powder/dye will be used, pictures taken before and after contamination and decontamination, and then image analysis software leveraged to determine the percentage of the body contaminated and decontaminated. There is a precedent for using fluorescent markers in training hospital workers on how to not contaminate themselves when dealing with highly infectious patients [10].

Research Objective: This work aims to establish a methodology which can be used in full-scale experiments to quantify decontamination. A clothed mannequin will be contaminated with a solution containing an ultraviolet fluorescent tracer (both oil- and water-based tracers will be tested). The mannequin will then be imaged before and after disrobing or other decontamination procedures. Image analysis will be used to semi-quantitatively determine the efficacy of decontamination.

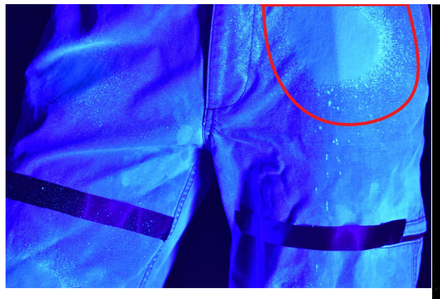

Figure 1. Image of fluorescent tracer under UV light. This image shows a representative image of a mannequin wearing pants contaminated with a fluorescent tracer. On the right side of the image the large spot (circled in red) represents two squirts from a spray bottle containing a 1:1 dilution of a water-based fluorescent dye.

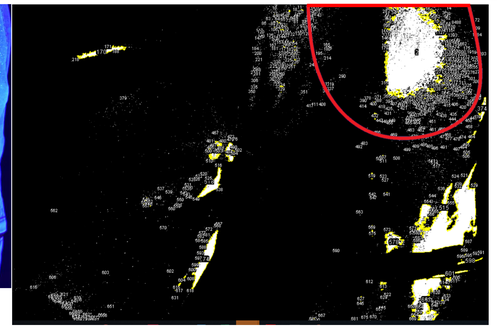

Figure 3. ImageJ results. This shows the results of using the Analyze Particles function in ImageJ. It was set to detect particles of any circularity, but to exclude particles smaller than 100 pixels^2. Each particle it finds larger than this cutoff is numbered, and the area calculated and tabulated, along with the total area of all particles.

ImageJ Results				
Area Circled (pixels^2)	Total Threshold Area (C) (pixels^2)	Total Clothing Area (B) (pixels^2)	Percent Circled	Percent at Threshold
766373	1510861	21772083	3.52%	6.94%

Table 1. ImageJ results, comparison of threshold to actual contamination area. This table shows the results of preliminary data processing. All particles contained within the outlined area were included in the Area Circled column. The Total Threshold Area column includes all red highlighted areas from Figure 2, C. The Total Clothing Area column contains all red highlighted areas from Figure 2, B. Roughly half of the pixels included in the threshold set in Figure 2, C were determined to be noise based on both visual inspection and numerical data.

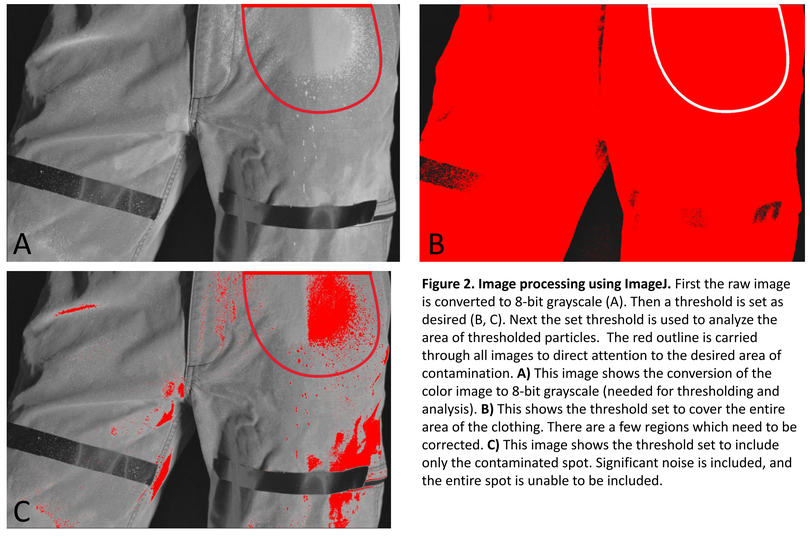

Figure 2. Image processing using ImageJ. First the raw image is converted to 8-bit grayscale (A). Then a threshold is set as desired (B, C). Next the set threshold is used to analyze the area of thresholded particles. The red outline is carried through all images to direct attention to the desired area of contamination. **A)** This image shows the conversion of the color image to 8-bit grayscale (needed for thresholding and analysis). **B)** This shows the threshold set to cover the entire area of the clothing. There are a few regions which need to be corrected. **C)** This image shows the threshold set to include only the contaminated spot. Significant noise is included, and the entire spot is unable to be included.

Conclusions

This preliminary work shows that fluorescence can be used as a feasible semi-quantitative method for observing contamination on a whole-body scale. More work needs to be done to improve contrast between the fluorescent areas of contamination and the background clothing to allow for more accurate thresholding to be done. Additional work includes determining the compatibility of aerosol chamber materials with the fluorescent tracer (including cleaning methods between tests), acceptable dilutions for the tracer, and the suitability for an oil-based tracer in comparison to the water-based one shown here.

References and Acknowledgements

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