UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

OFFICE OF CHEMICAL SAFETY AND
POLLUTION PREVENTION

MEMORANDUM March 21, 2022

SUBJECT: Science Review of the AEATF II Scenario 2b: Electrostatic Spray (ESS) Human Exposure Monitoring Study (AEATF II Project ID AEA14; MRID 51707701).

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FROM: Alexander Kliminsky,
Risk Assessment and Science Branch (RAB1)
OPP/Antimicrobials Division (7510P)

Jonathan Cohen, Ph.D.
Statistician
ICF (EPA Contractor)

Thru: Timothy Dole, CIH
Risk Assessment Branch 2 (RAB2)
OPP/Antimicrobials Division (7510P)

TO: Melissa Panger, Ph.D., Branch Chief
Risk Assessment Branch 1 (RAB1)
Elizabeth Donovan Branch Chief
Risk Assessment Branch 2 (RAB2)
OPP/Antimicrobials Division (7510P)

This memorandum presents the Environmental Protection Agency (EPA)/Office of Pesticide Program (OPP) Antimicrobials Division (AD) science review of the human exposure Electrostatic Spray (ESS) study submitted by the Antimicrobial Exposure Assessment Task Force II (AEATF II). The dermal and inhalation exposure data as represented in this review are acceptable and, subject to the considerations described below, are recommended for use for pesticide handler exposure assessments.

EXECUTIVE SUMMARY

This document represents the EPA OPP AD science review of the AEATF II Electrostatic Sprayer (ESS) study. The AEATF II designed the study to develop unit exposures for people who use ESS to sanitize and/or disinfect indoor surfaces with an antimicrobial product. The results of the study are reported herein. The protocol for this completed study was previously reviewed by the EPA and the Human Studies Review Board (HSRB) under the larger hand-wand sprayer study protocol for ethical and scientific design June 22, 2020, and July 21-22, 2020, respectively. This ESS study is only one of the scenarios from the larger hand-wand study (i.e., Scenario 2b: ESS). The other scenarios within the hand-wand study will be completed and submitted to the EPA at a later date. Both the EPA and the HSRB approved the protocol and provided recommendations for some modifications (discussed within this memo). This memo contains the scientific review, recommended unit exposures, and study limitations. The ethics review is contained in a separate memo. Both reviews will be presented to the HSRB at the planned April 26, 2022, meeting.

The study investigators monitored inhalation and dermal exposures to a total of 18 different test subjects captured in Monitoring Events (ME), which is a single day exposure for a single subject. A single registered product was used in this study, comprised of four different quarternary ammonium compounds (quats). From the four quats, didecyl dimethyl ammonium chloride (DDAC) was used as the active ingredient (a.i.) as the surrogate test compound by all test subjects. This a.i. was selected as the surrogate compound by AEATF II for use in its studies because of its stability, low vapor pressure, low detection limit, and registered use. All test subjects were recruited from a population that indicated that they used ESS as part of their job. All spraying activities were performed indoors. The study included three types of ESS sprayers to increase the diversity of sprayer types covered by the resulting unit exposures (UEs); these were as follows: backpack, cart, and handheld wand. All three sprayer types were utilized to sanitize conference rooms, restrooms, and bedrooms in a hotel for a given concentration of a.i. (215-860 ppm total quats, 36.3 – 145 ppm DDAC) and volume of cleaning solution (0.5, 1, or 2 gallons). Subjects were instructed to work as they normally would. EPA confirms that the data are considered the best available data for assessing handler exposures from antimicrobial treatment solutions for using ESS. The reader is referred to Section 3.0 for a discussion on the data limitations and use of the data as a surrogate for other a.i.s.

EPA intends to use these AEATF II ESS unit exposures for surface sanitizing and disinfectant uses in indoor areas including commercial and institutional spaces such as hotels and hospitals. These scenarios do not cover the pouring of an antimicrobial product into the containers to make up the treatment solutions. Those mixer/loader scenarios were monitored in separate AEATF II studies (the mixer/loader portion was conducted separately because many different formulations can be used such as liquids, powders, flakes, metering systems, etc.).

Select summary statistics for the “unit exposures” (i.e., exposures normalized to the amount of active ingredient handled are presented in Table 1 for the dermal and inhalation routes of exposure. Each test subject wore both inner and outer whole-body dosimeters (WBD) as well as a painter cap and inner patch (the inner patch was two gauze pads stapled to the hat) that were sectioned and analyzed separately for each body part (e.g., lower leg, upper leg, or lower arm,

upper arm, painter cap, etc.). None of the subjects wore gloves. Exposure to hands was measured with a wash while exposure to the face and neck was measured using a wipe. No Cap means that the inner patch and hat were summed for head exposure. Subjects wore two personal air monitoring pumps. One pump had an Occupational Safety and Health Administration (OSHA) Versatile Sampler (OVS) to measure total inhalation exposure while the other pump had a Parallel Particle Impactor (PPI) to measure respirable particle exposure.

Table 1. Unit Exposures (UE) for the AEATF II Electrostatic Sprayer (ESS) Scenarios.

Exposure Route	Clothing and/or Inhalation[a] (Normalization Units)	AEATF II[b, c] (n= 18)	
		Arithmetic Mean[d]	95th Percentile[e]
Dermal	Long pants/Long-sleeves, no hat, no gloves (mg/lbs a.i.)	621	1,720
Inhalation	Total Inhalable Dose (mg/lbs a.i.)[f]	6.01	20.5
	Total Inhalable 8-hr TWA[g] ((mg/m^3)/lb a.i.)[h]	0.751	2.56
Inhalation	Respirable Dose (mg/lbs a.i.)[f]	1.40	5.40
	Respirable Concentration 8-hr TWA ((mg/m^3)/lb a.i.)[h]	0.174	0.674

[a] There have been no exposure data available to assess or compare the unique ESS exposures to antimicrobial products to these data generated by the AEATF II.
[b] Dermal and inhalation UEs are corrected for field recoveries. Each UE contains all 18 MEs monitored, no data were removed as outliers.
[c] Statistics are estimated using a lognormal simple random sampling model as described in Appendix A.
[d] Arithmetic Mean (AM_U) = GM * exp{0.5*(lnGSD)^2}
[e] 95th percentile = GM * GSD *1.645
[f] Inhalation Dose (mg/lb a.i.) = air conc ((mg/m^3) / lb a.i.) * breathing rate (1 m^3/hr) * spraying duration (hrs/day)
[g] 8-hr TWA = 8 Hour Time Weighted Average
[h] 8-hr TWA ((mg/m^3) / lb a.i.) = air conc ((mg/m^3) / lb a.i.) * spraying duration (hrs/day) / 8 (hrs))

The following important points with respect to these data are noted:

- The data are applicable for assessment of exposure to non-volatile pesticides. The cutoff for volatility is reviewed on a case-by-case basis (generally <1E-4 mmHg @ 20° C is considered non-volatile).
- The dermal unit exposures recommended in Table 1 are based on wearing long pants, long-sleeved shirt, no gloves and no hat. No hat means that the measured residues on the hat was included in the estimated exposure and resulting UEs. This reflects a person not wearing a hat or head covering during application of an ESS. Currently, hats or head coverings are not commonly required by registration labels. The hand exposure accounted for 80% of dermal exposure.

- The geometric mean empirical model (GM_S), geometric standard deviation empirical model (GSD_S); arithmetic mean log normal random sample model (AM_U) and arithmetic mean empirical model (AM_S); 95th percentile log normal random sample model ($P95_U$) and the 95th percentile empirical model ($P95_S$) dermal unit exposures are accurate within 3-fold (i.e. the K factor is less than 3) with 95% confidence (Table 5). In statistical analyses, a k-factor is a measure that can be used to determine how well a statistic, such as AM_U, describes its population parameter. The standard EPA benchmark for the k-factor is three. If a particular estimate, such as AMU, has a k-factor of three or less, then it is considered an accurate estimate 95% of the time.
- The average and standard deviation for GM and AM inhalation unit exposures for total inhalable aerosols are accurate to within 3-fold with 95% confidence for both the empirical model and the lognormal random sample model (Table 6). The P95 inhalation unit exposures are accurate within 3-fold with 95% confidence for the lognormal random sample model, but not the empirical model (k=4.18).
- The inhalation unit exposures for respirable aerosols meet the 3-fold relative accuracy objective for GM_S and GSD_S and are close to this 3-fold objective for AM_S, AM_U, and $P95_U$ with the K factors of 3.30 to 3.33. Only the P95s has a fold relative accuracy (fRA) (8.18) that is significantly greater than 3.
- At this time, no additional monitoring for the three ESS scenarios is required. Although some of the statistics, such as the $P95_S$, do not meet the accuracy objective, these statistics are not used as unit exposures.
- The statistical analysis (Section 2.4) provides evidence consistent with log-log-linearity with a slope of 1[1] between dermal exposure and pounds of active ingredient handled. An ideal result of the log-log-linearity test is an estimated slope between 0 and 1 with a confidence interval that includes 1 but not zero, indicating that independence between exposure and pounds of active ingredient (a slope of zero) is rejected and that log-log-linearity with a slope of 1 is not rejected. The results of this analysis as displayed in Table 8 in Section 2.4 indicate the following:
    - The confidence intervals for dermal, inhalation 8-hr Time Weighted Average (TWA) (respirable and total inhalable), and inhalation dose (respirable and total inhalable) slopes exclude 0 and include 1.
    - Thus, the "unit exposure" approach for the dermal, inhalation 8-hr TWA (respirable and total inhalable), and inhalation dose (respirable and total inhalable) is a reasonable approximation.
- There was an additional analysis in parsing out exposure based on the type of sprayer (backpack, cart, handheld); the results for this are shown in Appendix A. The UEs calculated for cart, backpack, and handheld sprayers are not reported separately as

[1] The statistical analysis of log-log-linearity tests whether the slope of log exposure against log a.i., is 1, which supports the use of the data in the "unit exposure" formats. We now refer to these analyses as the log-log-linearity analyses. In the Governing Document (AEATF, 2008) and in previous reviews of the AEATF II studies we have referred to these analyses as a "proportionality" analysis, but this has caused some confusion because the statistical models do not assume that the exposure is directly proportional to the amount of a.i. handled (AaiH), but instead assume that the logarithm of the exposure is linear in the logarithm of AaiH with a slope of 1, which is a related finding but a very different model, as explained in more detail in Appendix A. We have therefore changed the terminology from "proportionality" to "log-log-linearity with a slope of 1."

recommended UEs in Table 1 as only the cart met the K-factor (i.e., the sample size is too small to draw conclusions for each type of ESS sprayer by themselves).

- The statistical analyses reported here and in Appendix A are for exposure with all 18 MEs. In the Supplement to Appendix A, we explored what the analysis would be with 17 of the MEs as the dermal exposure for one of the MEs was believed to be a statistical outlier based on the QQ plots. The data set with all 18 MEs was used in this report because there was not an error in the analysis of that sample nor an error with the ME.

To assess the risks resulting from cleaning commercial and institutional spaces with an ESS, the EPA will combine appropriate unit exposure values with chemical-specific inputs (e.g., maximum labeled application rates, dermal absorption, toxicological endpoints of concern) and default inputs (e.g., gallons sprayed per day) in the standard pesticide handler exposure algorithm: Potential exposure = UE (mg/lb a.i. or (mg/m^3)/lb a.i.) x maximum label rate (% a.i. by weight) x number of gallons sprayed.

1.0 Background

The AEATF II is developing a database representing inhalation and dermal exposure during many antimicrobial handler scenarios. A scenario is defined as a pesticide handling task based on activity (e.g., application or mixing/loading) and equipment type (e.g., paint brush/roller, airless paint sprayer, ready-to-use wipes, bucket and rag/sponge, trigger pump sprayer, mopping, pressure treatment of wood, etc.). The AEATF II is monitoring residues on both inner and outer dosimeters, which will allow the EPA to estimate exposures to various clothing configurations (e.g., long pants, long-sleeved shirt or long pants, short-sleeved shirt or short pants, short-sleeved shirt). Hand exposure as well as inhalation exposures are also being monitored. Prior to conducting intentional exposure studies in humans, the protocols are submitted to and reviewed by the EPA. The EPA presents the protocol and its reviews to the HSRB. The EPA presented the AEATF-II hand wand sprayer protocol, including Scenario 2b: ESS sprayers, on July 22, 2020.

1.1 Electrostatic Sprayer (ESS) Scenario Defined

The ESS scenario in this study is defined as subjects, recruited from people experienced with using ESS employed as janitorial/cleaning services to hospitals or commercial spaces to sanitize/disinfect indoor surfaces as they normally would do. The study conditions were simulated/designed to mimic actual work conditions and the subject's own routines that cause them to interact with/be exposed to the a.i. based on their own experiences.

The mixing/loading of the concentrate was not performed by the subjects. The mixing/loading exposure data were developed in prior AEATF II studies. The reason behind this strategy is there are multiple types of antimicrobial formulations (e.g., liquids, powders, etc.).

Subjects from the janitorial/cleaner industry sanitized/disinfected hotel conference center/hotel rooms with one of the three types of ESS: backpack, handheld, and cart. Three different brands were used: Clorox Total 360 cart system, Victory brand sprayer, and EMist.

Subjects wore WBD underneath long-sleeved shirts, and long pants, and no gloves, a painter's cap[1], an inner hat dosimeter (two pieces of gauze stapled to the inside of the painter's cap), and two personal air samplers (each running at 2 liters per minute). The conditions under which the study participants handle and apply the pesticide as they are monitored are referred to as the scenario. Both inner and outer dosimeters were worn by the monitored study participants, and both inner and outer dosimeters were analyzed for residues. Hand samples were collected using a wash that was analyzed. Face and neck samples were collected using wipes that were analyzed for residues. Gloves were not required as long as the concentration was below of 860 PPM of total quats as per label registration (AEATF 2021, page 13).

1.2 Study Objective

The AEATF II's study objective is to monitor inhalation and dermal exposures to be used as inputs in exposure algorithms to predict future exposures to persons sanitizing/disinfecting indoor surfaces by ESS cleaning methods. Dermal and inhalation exposure monitoring was

[1] In the AEATF 2021 report, the painter's cap was called a ball cap.

conducted while study participants sanitized/disinfected various indoor surfaces utilizing three different types of ESS. These measured exposures will be used in pesticide exposure assessments as "unit exposures".

"Unit exposure" (UE) is defined as the expected external chemical exposure an individual may receive (i.e., "to-the-skin" or "in the breathing zone") per weight-unit of chemical handled. The UE approach is the default data format used in pesticide handler exposure assessments. Mathematically, UEs are expressed as "handler" exposure normalized by the amount of active ingredient (a.i.) handled by participants in scenario-specific exposure studies (e.g., mg a.i. exposure/lb a.i. handled). EPA uses these UEs generically to estimate exposure for other chemicals having the same and/or different application rates.

Criteria for determining when a scenario is considered "complete" and operative have been developed (SAP 2007). As outlined in the AEATF II Governing Document (ACC 2011), the criteria are briefly summarized as follows:

- The AEATF II's objective for this study design is to be 95% confident that key statistics of normalized exposure are accurate within 3-fold. Specifically, the upper and lower 95% confidence limits should be no more than 3-fold (K=3) higher or lower than the estimates for each of the geometric mean, arithmetic mean, and 95th percentile unit exposures. To meet this objective, AEATF II proposed an experimental design with 18 monitoring events (MEs) for "professional/commercial" employed subjects cleaning/sanitizing hard surfaces.

1.3 Protocol Modifications, Amendments, and Deviations

1.3.1 Protocol Modifications Based on EPA and HSRB Reviews

The EPA and the HSRB recommended science-based changes to the ESS protocol during the review (EPA 2020 and HSRB 2020). The review comments and AEATF II responses are summarized in Table 2a for the EPA comments and Table 2b for the HSRB comments.

Table 2a. EPA Science Review and AEATF II Responses.

EPA Issue Raised	AEATF Response	EPA Comments
1. The researcher needs to make sure that the electrostatic sprayers are "turned on" (for the sprayers that have such an option) so that they are operating during the monitoring event (some sprayers will still spray when the electrostatic option is turned off, some sprayers do not have an option to be sprayed without the electrostatic function).	This was addressed as detailed in the AEATF report, "*A researcher will make sure that the electrostatic function on the sprayers is turned on (for those that have this separate from the on/off spray trigger) when the subject is ready to spray (AEATF 2021, page 203)*."	No further comment

Table 2a. EPA Science Review and AEATF II Responses.		
EPA Issue Raised	**AEATF Response**	**EPA Comments**
2. Researchers need to specify how much experience is needed for the subjects using the electrostatic sprayers (the design document notes that subjects need to be experienced in using this type of equipment but no criteria for how much experience is provided (months?, years?).	Was not added	The EPA agreed with the HSRB's recommendation on this topic, which was addressed by the AEATF. See #7 in Table 2b, below.
3. The protocol notes that the subjects will not be provided instructions on how to use the electrostatic spray equipment. Instead, "*In case a subject is not familiar with the specific brands and models of sprayers available for use in the study, the equipment user guides will be available.*" (ESS Addendum:10-11). Nonetheless, if subjects specifically ask the researchers about the operation of the equipment, what type of instructions, other than the user guides will be provided (e.g., user guides might be insufficient to safely operate the ESS if it is a model unfamiliar to the subject)?	This was addressed in the following, "*If the observer or other member of the research team sees someone misusing the sprayer or applying in a manner that is inconsistent with the product label, the Study Director or the Field PI should be notified and they will intervene and correct the subject... If there are questions about the operation of the electrostatic sprayers, the Study Director and Field Principal Investigator will be able to provide help (AEATF 2021, page 207).*"	ME 14 needed further clarifications on proper ESS spraying technique and how to use Nisus DSV sanitizer, after further instructing made modifications to their technique (AEATF 2021, pages 33-34).
4. The researcher should clarify the instructions to be given to the subjects to ensure that the target volumes are (approximately) met in each scenario, e.g., spray until the tank is empty, or spray a certain number of loads.	This was addressed in the following, "*The amount of spray solution and how many spray loads were to be sprayed was explained to the subject (AEATF 2021, page 31).*"	No further comments.
5. The increase in the total quat concentration above 400 ppm (as noted in AEATF 2020) in any of the scenarios that involve food contact surfaces (e.g., Scenario 3b) now need to be subsequently rinsed with a potable water rinse (PWR) per label directions.	All concentrations were below 400 ppm of quats so not incorporated	No further comment
6. The AEATF II has demonstrated in many previous studies using ADBAC as the surrogate test compound that for the inhalation samplers, aerosols and not vapors are collected in the OVS samplers (as one would expect with such a low VP chemical). EPA would accept if the AEATF II wants to combine the glass filters with the two adsorbent sections when analyzing the OVS tubes.	This was addressed in the following, "*The OVS tubes contain a glass fiber filter followed by two beds of XAD-2 sorbent in one glass tube. The filter is designed to trap aerosols and particles while the two-section sorbent beds will adsorb vapors. This allows for aerosols and vapors to be collected simultaneously (AEATF 2021, Pag209).*"	No further comment.

Table 2a. EPA Science Review and AEATF II Responses.		
EPA Issue Raised	**AEATF Response**	**EPA Comments**
7. The study is designed to incorporate diversity and it captures many sources of variation in exposure from hand-wand spraying activities (e.g., different types of sprayers, different spray pressures, different spray volumes, different environments, different PPE, different workers, etc.); however, not all plausible sources of exposure variation have been accounted for in the design (e.g., mushroom houses, etc.). Therefore, the study captures a sufficient range of exposure conditions, but is not likely to cover the full range of variation that is expected to exist.	None needed	No further comment as this is a limitation of all AEATF II studies.

Table 2b. HSRB Review and AEATF II Responses.		
HSRB Recommendation	**AEATF Responses**	**EPA Comments**
1. With respect to monitoring, the subject should be instructed to avoid eating during the activity. Should eating during the activity be allowed, the protocol should be specific as to how to account for loss due to this activity (e.g., similar to the description of rest room use by the participant).	This was addressed in the following, "*Before starting the ME, the subjects were informed of the following administrative and safety points:…• You cannot eat or smoke during the monitoring (AEATF 2021, page 31).*"	Since no eating is allowed, no further comment
2. The Board recommends that an assessment that the assumptions of ANOVA are met be conducted: • The dependent variable should be approximately normally distributed for each category of the independent variable, which can be checked using the skewness and kurtosis; • The homogeneity of variances is satisfied, which can be checked by using the Levene test. If the p value is greater than 0.05, this assumption is validated; • There should be no substantial outliers.	Not Applicable	Since the ANOVA analyses compared geometric means, the ANOVA assumption is log-normality rather than normality. The lognormality assumption was evaluated using empirical quantile plots and Shapiro-Wilks normality tests. Because of low statistical power, Levene's test and other tests for homogeneity of variances are often not recommended. In the statistical review we used Welch's ANOVA (that does not require homogeneity of variances) as well as standard ANOVA. In the statistical review we used the probability plots to identify a potential outlier – the analyses after removing the potential outlier are presented in the Supplement.

Table 2b. HSRB Review and AEATF II Responses.		
HSRB Recommendation	**AEATF Responses**	**EPA Comments**
3. The Board recommends that an assessment that the assumptions of linear regression are met be conducted: • There needs to be a linear relationship between the dependent and independent variables, which can be checked using a scatterplot; • There should be no substantial outliers; • The data should be approximately normally distributed, which can be checked using the skew-ness and kurtosis and a normal probability plot (i.e., a Normal P-P Plot); • The data should show homo-scedasticity, which can be checked by inspection of a plot of the unstandardized or standardized residual values against the unstandardized or standardized predicted values.	Not Applicable	Scatterplots and regression lines are presented to evaluate the linear relationship. Quantile plots (normal probability plots) of the studentized residuals were used to check for potential outliers and evaluate normality. As one way to evaluate homoscedasticity, we also examined plots of the studentized residuals against potential explanatory variables, although those plots did not show interesting patterns and so are not presented in the statistical review.

Table 2b. HSRB Review and AEATF II Responses.		
HSRB Recommendation	**AEATF Responses**	**EPA Comments**
4. On page 6 of the EPA review, the EPA states that "…the adequacy of the sample sizes of completed studies will be revisited," indicating that a post-hoc power analysis will be done. Post-hoc power analysis should be done to inform future studies. This should be clarified in the EPA Science Review.	Not Applicable	Several statisticians recommend against using power calculations using data from a completed study (post-hoc or retrospective power) because the calculations provide no more information than the p-value calculated from the observed data and lead to misleading conclusions. See Hoenig and Helsey (2001)[2] for a good exposition of this issue. In this case, the p-values for the slope are functions of the confidence intervals. Thus, the post-hoc power calculation does not provide additional insights beyond the calculated confidence intervals. At the October 2021 HSRB meeting, EPA and HSRB agreed that the Post-hoc power analysis is no longer needed to be presented (USEPA 2021, page 14).
5. On page 15 of the EPA review, the EPA states that "…the results of those analyses will not be stratified by group…. unless useful patterns are found." An example should be added to clarify that follow-up comparisons may be considered if differences are found in the scenarios. Alternatively, the statement "unless useful patterns are found" can be stricken to not infer that additional analyses will be conducted until something statistically significant arises (p-hacking).	Not Applicable	Comment acknowledged. The main type of analysis that was conducted was between the different sprayer types as was identified in page 15 of the review, "*For scenario 2b, we will use analysis of variance to compare the geometric means between the hand-held, backpack, and cart-mounted sprayers, but otherwise we will not stratify the analyses of scenario 2b by the sprayer type unless useful patterns are found (USEPA 2020, page 15).*" To address the possibility of group differences and look for useful patterns, the statistical review includes some stratified analyses. There was a supplemental analysis because of the potential of a point being an outlier that is detailed in the supplemental to Appendix A.

[2] Hornig, J. M. and Helsey, D.M. (2001). The abuse of power: The pervasive fallacy of power calculations in data analysis. *The American Statistician*, 55:19-24.

Table 2b. HSRB Review and AEATF II Responses.		
HSRB Recommendation	**AEATF Responses**	**EPA Comments**
6. Address what will be done if the subject wants to drink/eat/take a break with respect to sample collection and making sure that residues are not lost; what will be done if the subject wants to wipe their face with their hand or forearm? How will this affect exposure?	This was addressed in the AEATF report, "*Subjects will be instructed to take breaks at their discretion and will be given a bottle of water or sports drink if requested. Subjects will be allowed to hold and drink from the bottle provided to them. There is a potential to transfer residues from the subject's hands to the beverage bottle; however, the impact is likely to be minimal and this represents typical behavior. AEATF II will have drinks available. A chair covered in plastic will be available if the subject wants to sit down to rest and/or drink. 11. An interim hand wash sample will be collected if a subject needs to use the toilet during the monitoring event. No eating or smoking will be allowed during the monitoring. 12. Subjects will be allowed to wipe sweat from their forehead with their hand or arm and/or scratch/rub their face or other body parts. These are normal activities that could occur while working and therefore such activities will not be prohibited. However, this activity will be noted in the observation records so that any unusual residues might be explained (AEATF 2021, page 204).*"	No subjects took bathroom or food breaks. A few subjects did take water breaks as follows: ME 7 "*[ME 7] stopped for water - took off glasses and hat…[ME 13]After spraying for slightly over an hour, he took a short break and removed his safety glasses, respirator, and hat; he drank some water and wiped his face with his sleeve and wiped his hands on his pants. When he put his hat back on, he touched the hat inner dosimeter…;[ME 16] little over an hour into the monitoring event, the subject took a water break, removing his hat and mask(AEATF 2021, pages 403, 409, & 412).*"

Table 2b. HSRB Review and AEATF II Responses.		
HSRB Recommendation	**AEATF Responses**	**EPA Comments**
7. Make an effort to recruit participants with familiarity using the electrostatic sprayer, note the level of participant's experience in the study report, and consider as a covariate in the analyses.	"*For the occupational indoor ESS spraying (Scenario 2b): … Have occupational experience using an electrostatic sprayer to sanitize /disinfect indoor surfaces." (AEATF 2021, page 167)* *From the consent form: "We're asking you to participate in a research study because you are using an electrostatic sprayer at least once a month to sanitize or disinfect indoor surfaces as part of your job" (AEATF 2021, page 365)*	Efforts to recruit subjects with familiarity was made. One subject had 1 month of experience and the remaining 17 subjects had at least two months experience with a ESS as displayed in Table 5 (AEATF 2021, page 90). Adding the level of experience as a covariate might ultimately lead to problems in implementing requirements based on the level of experience. The data does not show any clear effects of the level of experience on exposure, especially because the level of experience varied with the sprayer type.

1.3.2 Protocol Modifications Based on EPA and HSRB Reviews

AEATF (2021) (page 79) lists 3 minor protocol amendments to the larger study that included the ESS subset. None of these protocol amendments affected the ESS study and were approved after the completion of the ESS study.

1.3.3 Protocol, Method, and SOP Deviations

Six protocol, and five standard operating procedure (SOP) deviations were noted in the study (study report pages 79 and 80).

The six protocol deviations include:

1. The changing of the time for the pre-exposure ambient air sampling;
2. All samples were analyzed for DDAC because of background levels of C14-ADBAC found in multiple matrices as was previously encountered in AEATF studies such as immersion, dip, and soak (IDS);
3. The direction of air flow was not mapped due to the rate at which people moved through rooms; field fortifications were not analyzed prior to being sent into the field but after; and shoes were removed outside of the cleaning area; and OVS tubes and polyvinyl chloride (PVC) filters were prepared using the test substance diluted in water not DDAC reference standard in acetonitrile;
4. Texting was done instead of telephone calls to remind some subjects of monitoring appointments;
5. Sometimes only one pre-ambient air sample was collected; and
6. Post-application ambient air sampling was shifted by 3 minutes after one post-ME.

The five SOP deviations include:

1. The shelf-life of the water isopropyl mixture was changed from 48 hours to 4 days;
2. Dermal face/neck wipes were done with 4-ply gauze pads instead of 8/12-ply gauze;
3. Inner hat dosimeters were removed with gloved hands and not tweezers as the tweezers kept tearing the gauze;
4. Fortifying of PVC filters were done outside of the PPI cassettes and placed back in before doing the recovery testing; and
5. Heat index was measured on-site with a Krestrel heat stress instrument instead of National Oceanic and Atmospheric Administration (NOAA) Heat Index chart.

For a detailed description of each of the deviations, the reader is referred to the study report. EPA accepts the study author's conclusion that these deviations did not adversely affect the outcome of the study. Although switching the active ingredient appears to be a major deviation, the active ingredient included (i.e., DDAC) was already part of the pesticide formulation being monitored and was assessed during the protocol review by EPA and the HSRB (and has existing analytical methods as it has been used by the HSRB in previous studies).

1.4 Material & Methods

The following is a summary of the key field aspects of the study.

- ***Study Location:*** The ESS study was conducted indoors at the Avanti Palms Resort and Conference Center in Orlando, FL. This included the conference center/conference rooms, guest rooms, and rest rooms. Test site schematics and photos of the site/rooms are in Appendix D starting on page 387 of the study report.

- ***Substance Tested:*** The product applied and monitored in the study was the Maquat® 5.5-M quaternary ammonium antimicrobial pesticide, EPA Reg. No. 10324-80; the commercial version procured for the study was DSV by Nisus Corporation EPA REG. 10324-80-64405. This product contains the following active ingredients:
    - Alkyl (50% C_{14}, 40% C_{12}, 10% C_{16}) Dimethyl Benzyl Ammonium Chloride.....2.200%
    - Octyl Decyl Dimethyl Ammonium Chloride.....1.650%
    - Didecyl Dimethyl Ammonium Chloride.....0.825%
    - Dioctyl Dimethyl Ammonium Chloride..... 0.825%

  The test substance in DSV used in the study was didecyl dimethyl ammonium chloride (DDAC). *"The specific quaternary ammonium compound analyzed in the study samples was DDAC (didecyl dimethyl ammonium chloride) which makes up nominally 0.83% of the concentrate formulation.*" (AEATF 2021, page 20).

- ***Test System:*** The study was designed to monitor exposures to subjects cleaning (i.e., sanitizing/disinfecting) surfaces within the ESS scenario while varying concentrations of the a.i.(s)/volume and the type of ESS utilized. Thus, the total amount of active ingredient handled (AaiH) was also varied. The test system for the ESS scenario was setup so that subjects sprayed the ESS onto horizontal and vertical surfaces (e.g.,

countertops, tables, etc.) in the conference rooms, public rest rooms, hotel guest rooms, and meeting rooms. Specifics of the sites and equipment are as follows:

- Ballrooms ~7 ft x ~24 ft to 80 x 64 ft; with round and rectangular tables and plastic chairs or rows of tables/chairs in a classroom/theater set up to spray
- Public restrooms, 12 x 36 to 16 x 43 ft; with stalls, urinals, and sinks to spray
- Meeting rooms, 29 x 43 ft; with round tables, chairs, AC units, and a small kitchenette to spray
- Hotel guest rooms, 29 x 14.2 ft; with beds, wall unit A/C, desk, tv, and bathrooms to spray
- Subjects were asked what brand and type of ESS sprayer they used and were provided them; an exception was that four Victory backpack users were asked to use EMist backpacks instead. With the four subjects switching backpack types, this was seen as enough diversity of sprayer types and brands. Subjects were also allowed to use attachments based on what they normally would use from the following list:
    - 1-gallon Clorox Total 360 electrostatic cart sprayer (Clorox T360) which sprays 46 micron droplets
    - 1-gallon Cordless Backpack EM360^{TM} electrostatic disinfectant sprayer (Emist BP) which sprays 75 micron droplets
    - 1-gallon Cordless Roller Cart EM360^{TM} electrostatic disinfectant sprayer (Emist Cart) which sprays 75 micron droplets
    - 34 fl oz VP200ES Professional Cordless Electrostatic Handheld Sprayer (Victory HH)
    - 2.25 gal VP300ES Professional Cordless Electrostatic Backpack Sprayer (Victory BP)

    For both for the VP series ESS, there were the following two options for droplet size:
        - 40 micron droplet
        - 80 micron droplet

    In addition, there was the option of a 12 inch wand extension

Figures 1 - 6 below illustrate the test systems, including equipment types and cleaning (sanitizing procedures).

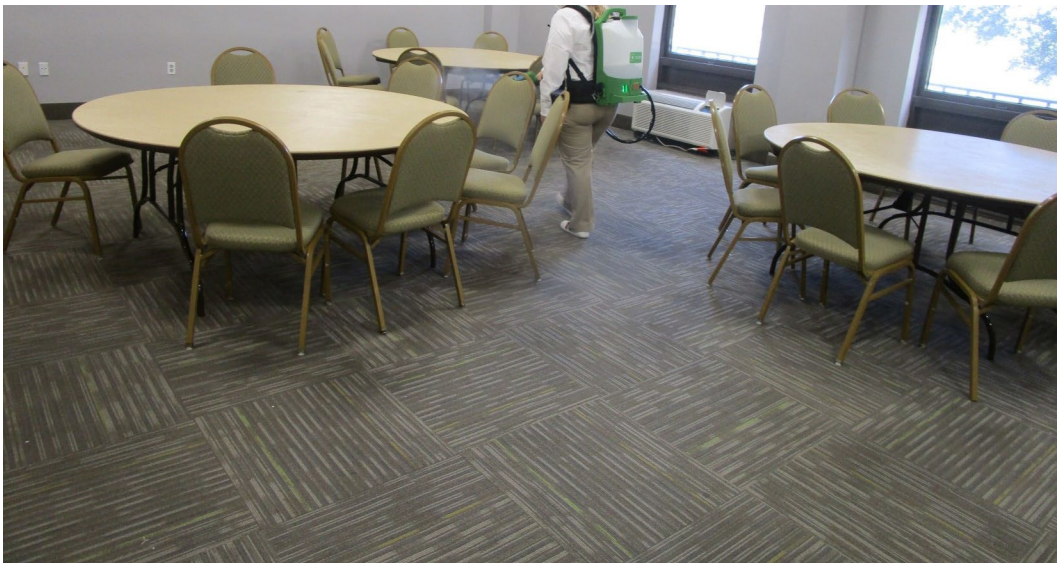


Figure 1. Subject sanitizing meeting room with Victory Backpack with Wand Extension.

Figure 2. Subject sanitizing conference room with meeting room with Victory Handheld – with wand extension EMist Backpack.

Figure 3. Subject sanitizing kitchenette with the EMist Backpack

Figure 4. Subject sanitizing with the EMist Roller Cart

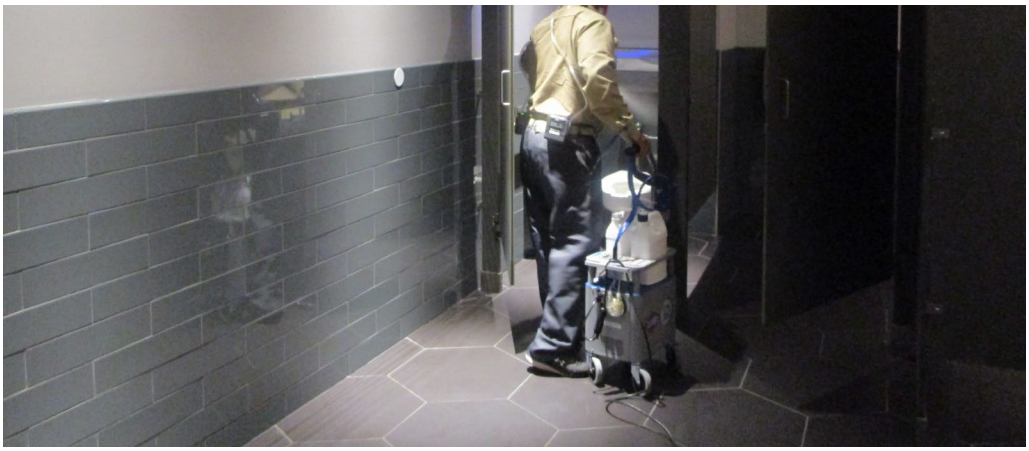


Figure 5. Subject sanitizing bathroom with the Clorox Total 360

Figure 6. Hotel bedroom

- ***Sample Size:*** The study consisted of 18 monitoring events (ME) with three using handheld sprayers, eight using backpack sprayers, and seven using cart sprayers. Each ME is a different subject. The 18 MEs in this study generated a total of ~900 samples of individual dosimeters, pre- and post- indoor air concentrations, and quality assurance/ quality control (QA/QC) samples.

- ***Duration:*** The sampling times ranged from 15 to 102 minutes; the average time for 0.5, 1, 2 gallons applied are 26, 58, and 80 minutes respectively (AEATF 2021, page 57). A summary of the individual ME start/stop sampling times is also reported in the study report alongside the durations.

- ***Concentration of Active Ingredient, DDAC (ppm):*** The concentrations in terms of total quat were 215 ppm, 430 ppm, and 860 ppm. The concentrations in terms of DDAC were 36.3 ppm, 72.7 ppm, and 145 ppm. The specific DDAC concentration for each ME is reported on page 98 of the AEATF II study report.

- ***Surface Area Sanitized/Disinfected:*** For the ESS scenario, the subjects sprayed surfaces *"…as they normally would; they were not told which surfaces should be sprayed or how wet to make the surface... The location where the subject started spraying was varied so that not all subjects started spraying in the same room. Additionally, whether the subject sprayed meeting rooms first followed by guest rooms or vice-versa was varied to minimize any bias that may occur if subjects got tired towards the end of their work period or gained efficiencies in their spraying technique."* (AEATF 2021, page 32). The square feet of rooms sprayed for the MEs in the 0.5-gallon group ranged from 2,071 to 7,316 ft^2. In the 1-gallon group, the square feet of the rooms sprayed ranged from 6,180 to 19,698 ft^2. In the 2-gallon group, the square feet of the rooms sprayed ranged from 4,142 to 40,434 ft^2. (AEATF 2021, page 95).

- ***Cleaning (Sanitizing/Disinfecting) Procedures***: For the ESS scenarios, researchers added the a.i. to the treatment solution, not the subjects (mixer/loader exposure was monitored in previous AEATF II studies). The subjects were *"…asked what type and brand of sprayer they used. With four exceptions, subjects used the same type and brand of electrostatic sprayer in the study that they had experience with… Subjects spraying volumes that exceeded the capacity of the… sprayer were asked to stop spraying when they ran out of solution, and a researcher would add more solution to the tank/reservoir. Subjects assigned to spray 2 gallons of solution with the Victory backpack sprayers had their choice of having the entire 2 gallons placed into the tank at once or spraying just one gallon at a time; they all requested it be filled with 2 gallons. Subjects using the Victory sprayers were told that they could use the 12-inch wand extension if they wanted to; they were also told to select either the red nozzle (40 microns) or the green nozzle (80 microns)… Subjects assigned to spray 2 gallons with the Clorox Total 360 cart sprayers were responsible for unscrewing the dispensing cap on the empty 1- gallon jug, replacing it with a regular cap, and putting the dispensing cap onto the full jug... Subjects typically started spraying at the far end of the room, working their way from the back to the front and ending up at the door to exit…. surface area than others… All subjects sprayed the tables and chairs … set up in the meeting rooms along with door handles…. In the guest rooms, subjects sprayed almost all surfaces such as the lamps, TVs, AC units, tub/shower combo, chairs, and desks."* (AEATF 2021, page 32-33).

- ***Environmental Conditions*****:** Environmental conditions (humidity and indoor temperatures) are reported on page 26 of the study report. Indoor temperatures for the scenario ranged from 62.4 to 76.9 F and the humidity indoors ranged from 53.9 to 78.9%. The ventilation rate ranged from 2.68 to 11.97 air changes per hour (ACH) for the ballrooms and 9.97 to 11.67 ACH for meeting rooms. The ventilation rate was not measured for the bathrooms and was measured in only one guestroom which had a ventilation rate of 6.6 ACH (AEATF 2021, page 26). The ventilation rate was for the total amount of air supplied to each room; these were calculated by measuring the air

flow at each supply diffuser with a Balometer® Capture Hood, summing the airflow for each room and dividing by the room volume. The return air flow was also measured at each return vent and summed for each room. The air flow direction relative to the subjects for was not meaningful as the subjects moved around the room (or to other rooms) as they sanitized/disinfected surfaces.

2.0 Results

2.1 Sample Analysis Methods QA/QC

Method Validation. In this ESS study, because DDAC already has validated methods for most of the matrices, method try-outs were done instead to demonstrate proficiency (AEATF 2021, page 59). These matrices are as follows: inner and outer WBDs, OVS tubes, hand wash solutions, and gauze. For the method try-outs, triplicate samples were spiked at each of the three sample concentrations (AEATF 2021, page 59). The results for the method-try out validations for DDAC range from 79.4±6.1% (mean ± standard deviation) for the high-level fortification of the face/neck wipe to 99.0±4.02% for low-level fortification for OVS tube (AEATF 2021, Table 13 page 99).

Three matrices had full method validations: painters caps and PVC filters as there were none for DDAC and for inner WDS as the limit of quantification was lowered from the validated method. For the method validations, seven samples were spiked at each of the three sample concentrations (AEATF 2021, page 59). The results for the method validations for DDAC range from 78.3±3.5% (mean ± standard deviation) for the high-level fortification of the painters cap to 94.1±7.47% for high-level fortification for inner WBD (AEATF 2021, Table 14 page 100).

The DDAC Limit of Quantification (LOQ) for the various matrices was: OVS tubes 10 ng/sample, PVC filter 1.0 ng/sample, neck/face wipe 0.05 µg/sample, painters cap 1.0 µg/sample, inner hat dosimeter 0.05 µg/sample, outer WBD sections 20 µg/section, inner WBD sections 1 µg/section, and hand wash 0.2 µg/sample (AEATF 2021, page 46). The LOD was set at 30% of the LOQ as per the AEATF governing SOP 9B.3 (AEATF, 2014); although a concentration can be quantified below the LOD, there is enough uncertainty around the concentration that it can't be distinguished from background. The LODs were 3 ng/sample, 0.3 ng/sample, 0.015 µg/sample, 0.3 µg/sample, 0.015 µg/sample, 6 µg/section, 0.3 µg/section, 0.06 µg/sample for the OVS tubes, PVC filters, face/neck wipes, painters cap, inner hat dosimeter, outer WDB sections, inner WBD sections and hand wash samples, respectively (AEATF 2021, page 46).

Controls. The pre-study analytical work detected C14-ADBAC in several matrices including the OVS tubes; these results of the pre-study analytical work are not included in the report. The analyzed active ingredient was switched to DDAC as this quat was also present in the test substance. All subsequent analytical results reported in this document are DDAC concentrations.

During method tryout, only one of the DDAC unfortified control matrix samples for outer WBDs had measurable concentrations of DDAC. The measured concentration of 5.26 µg DDAC was

less than 30% of the LOQ of 20 µg, so it was seen as acceptable. All other unfortified control samples were below the method detection limit (LOD) (AEATF 2021, page 59). The results of the matrix samples indicated there was not a concern for background contamination as was seen in C14-ADBAC.

The results of the unfortified field and laboratory control samples (blanks) for the study are described below. Three DDAC field control samples for PVC filters, which contained 1.62 ng from fortification event 1, 1.07 ng from fortification event 2, and 1.36 ng from fortification event 2, are slightly above the LOQ of 1 ng (AEATF 2021, pages 60 and 61). For each of the three fortification events, three control samples were prepared (AEATF 2021, pages 39 and 40). The results were seen as acceptable for the PVC filters; all other field control samples were below the LOQ with most below the LOD (AEATF 2021, pages 60 and 61). The results did not indicate ambient contamination of concern of impacting the results because DDAC concentrations were above the LOQ only for PVC filters and only 1/3 of the control samples of PVC filters were above the LOQ with one event having no samples above the LOQ. One out of nine inner WBD DDAC laboratory control samples had detectable residues of DDAC (69.5 µg compared to the LOQ of 20 µg). This may be due to in-lab contamination as the lab spike at 50 µg was over 141%, outside the normal acceptability of 120%. The other two spiked samples collected co-currently were within acceptable ranges; all other co-current lab spikes for inner WBD (nine samples were collected in total at each of the three fortification levels) and all other concurrent lab-spikes for other matrixes were within EPA acceptable targets (AEATF 2021, page 60).

Laboratory Recoveries. The concurrent laboratory recovery samples for DDAC were fortified at levels expected in the exposure study including one level at the LOQ. All except the gauze wipes had three concentration levels; the gauze wipes had four (AEATF 2021, page 60). One concurrent laboratory control sample of the inner WBD out of nine analyzed had detectable levels of DDAC; this was possibly due to in-lab contamination as two of the WBD lab spikes had higher than anticipated recoveries. The results of the laboratory recoveries are provided in AEATF (2021) Tables 15 to 21, pages 101-107. All concurrent laboratory recovery averages were less than 100% except for PVC filters (AEATF 2021, page 60). The recoveries range from 86.4 $\pm$ 14.1% (n=12) for the gauze pads (n=12) to 92 $\pm$ 12.1% (n= 27) for inner dosimeters. These recoveries were used to adjust the results of the field samples.

Field Recoveries. The field recovery samples were transported, stored, and analyzed with the corresponding field (dosimeter) samples. Results of the field recoveries for DDAC are summarized in AEATF (2021) on pages 108-116, Tables 22-27. Since the average field recoveries were <100% and handled in the same manner as the actual field samples, they were used to correct the actual field exposure samples (AEATF 2021, Page 61). The field recoveries for DDAC averaged 96.0±11.9% (n=27) for the OVS tubes, 91.0±10.4% (n=27) for the PVC filters, 98.0±5.04% (n=18) for the painters caps, 94.2±4.99% (n=27) for the inner dosimeters, 91.6±13.3% (n=27) for the face/neck wipes, and 95.9±5.26% (n=27) for the hand wash solution (AEATF 2021, page 61).

2.2 Calculating Unit Exposures

The analyses of residues on the dosimeters worn by each individual subject allow for the estimation of exposure for various clothing configurations from long- to short-sleeved shirts and long- to short-pants. The results of these various clothing configurations are available in Appendix A. These other clothing configurations include short sleeve shirts, long pants, along with wearing a hat. For brevity and usefulness (i.e., the majority of the dermal exposure is to the hands while the other body parts round-out when values are reported to 3-significant figures in Table 1) only the following clothing configuration is reported in the main body of this review:

(1) "Long-Long, no hat, no gloves Dermal" = long pants, long-sleeved shirt, no hat, no gloves

Dermal Unit Exposure. As discussed in the protocol, dermal exposure was measured using 100 % cotton inner and 35% cotton/ 65% polyester outer whole-body dosimeters (WBD), along with a cotton painter cap and two gauze pads as an inner hat dosimeter. The inner WBDs and inner hat dosimeter were worn underneath normal work clothing (i.e., long-sleeved shirt, long pants and a painters cap). The normal work clothing worn over the inner WBDs and inner hat dosimeter were also analyzed and reported as outer dosimeters. Dermal exposures monitoring techniques also included hand washes and face/neck wipes. The inner and outer WBDs were sectioned and analyzed by body part (i.e., upper and lower arms, front and rear torso, and upper and lower legs). Samples were adjusted, as appropriate, according to recovery results from the field recovery samples for their respective matrix (i.e., the field recoveries were used to correct the actual field monitoring samples since the recoveries were less than 100%).

Samples for the hands were collected by, *"washing and rinsing the subjects' hands with a total of 500 mL of a 50:50 (v/v) solution of distilled water (purchased) and isopropyl alcohol (catalog number A41520 from Fisher Scientific) over a metal bowl. Subjects held their hands over a stainless-steel bowl while a researcher slowly poured approximately 400 ml IPA/water over their hands while they were being rubbed together. The subject then immersed their hands in the wash solution in the bowl and lightly scrubbed their hands (front and back) in the solution for about 30 seconds. Finally, the researcher rinsed the subject's hands over the bowl with the remaining approximately 100 mL of solution. Hand wash samples were poured into 1-liter labeled clear glass jars with Teflon®-lined lids (AEATF 2021, page 36).*" Face/neck wipes were collected, *"two rayon/polyester gauze pads (Band-Aid brand Tru-Absorb sterile gauze sponges, 4-ply, 4 inch by 4 inch), each moistened with 4 mL of the water/IPA solution described above, were used to wipe the subjects face and neck (front and back) sequentially. The two gauze pads were placed together into a labeled clear glass jar with a Teflon®-lined lid. with two rayon/polyester gauze pads and 4 ml of isopropyl alcohol/water (AEATF 2021, page 36)."*

Hand wash removal efficiency studies were previously conducted by the AEATF II and reviewed by EPA and used in other AEATF II scenarios (e.g., USEPA 2010, USEPA 2012). These same two studies were used in this study to correct hand and face/neck samples. *"A study to measure the removal efficiency of DDAC (CAS 7173-51-5) from skin using a washing technique showed an average recovery of 90.3% DDAC (Boatwright 2007). A similar study was conducted with the structurally related compound alkyl dimethyl benzyl ammonium as the saccharinate salt (ADBAS; CAS 39387-42-3) using a wipe technique rather than a wash*

technique resulting in an average recovery of 89% (Boatwright, 2008). Based on these studies, a 90% dermal removal efficiency correction factor is used to adjust the DDAC hand-wash residues while a 89% correction factor is used to adjust the face/neck wipe residues." (AEATF 2021, pages 51-52)

One final adjustment factor was used for the face/neck samples to correct for the area of the face covered by the safety glasses. A correction factor of 1.43 (as per AEATF SOP 9.K.0, Section 2.2.3) was used to correct the face/neck residue values (AEATF 2021, page 52). Dermal samples were not adjusted for background levels of DDAC.

Total dermal exposure is calculated by summing exposure across all body parts for each individual monitored. The following WBD sections are summed to calculate the clothing configuration of long pants, long-sleeved shirts no hat (Long-Long, no hat, no gloves) plus face/neck wash, head exposure, and hand wash:

- inner lower arms,
- inner upper arms,
- inner front and inner rear torso, and
- inner lower and inner upper legs.
- Painter cap and inner cap dosimeter

For short sleeve shirts and long pants, the configuration would be similar as for long-long except the inner and outer lower arm would be summed. For a hat scenario, it would be the same for long-long except it would not include the cap (i.e., just the inner cap dosimeter).

Dermal unit exposures (mg a.i.) are normalized by the pounds of product handled to yield units of mg/lbs a.i. handled. The dermal unit exposure (mg/lbs a.i. handled) is calculated by dividing the summed total exposure by the measured ppm a.i. concentration of the solution * the amount of solution sprayed * density of the spray solution.

Inhalation Exposure. Inhalation exposure was measured using two personal air sampling pumps. The inhalation sampling consisted of *"…two low-volume, SKC personal air-sampling pumps were attached to the subject's belt, one with an OSHA Versatile Sampler (OVS) air-sampling tube containing a glass filter and XAD-2 sorbent (SKC catalog number 226-30-16), and the other with a disposable Parallel Particle Impactor (PPI) (SKC Catalog # 225-385A) containing a 37 mm PVC filter (SKC #225-5-37) and 37 mm support pad (SKC # 225-27). The OVS tube is designed to capture total inhalable residue while the PPI is designed to trap respirable particles. Samplers were attached to the subject's collar, one on each side, in the subjects' breathing zone to determine subject's potential inhalation exposure to DDAC. The sampler intakes were positioned downward to simulate the nasal passage of the subject. The airflow of each pump was calibrated to a target airflow of 2.0 liters per minute prior to use and documented."* (AEATF 2021, page 30). Background levels of DDAC in the OVS tubes and PVC filters were below method detection and thus the background levels were not used to adjust any of the samples (AEATF 2021, page 59)

Inhalation unit exposures for the DDAC OVS sampling tubes (measuring total inhaled residues) are provided using the two following methods:

(1) Air concentration expressed as an 8-hour time weighted average (TWA) and normalized by AaiH (i.e., (mg/m^3)/lb a.i. handled) is calculated as the air concentration ((mg/m^3) / lb ai) * exposure duration (hours/day) / 8 (hours / day).
(2) Inhalation exposure (mg/lb a.i.) or dose is calculated as the air concentration ((mg/m^3) / lb a.i.) * breathing rate (1 m^3/hour) * exposure duration (hours/day)).

2.3 Dermal and Inhalation Exposure Results

Results. A summary of the individual and mean dermal and inhalation results is presented in Table 4. Both empirical means and the results of the lognormal simple random sample means are provided for comparison; the latter being the recommended values summarized in Table 1. Also shown for comparison to the total dermal exposure are the dermal results for the hand exposures only. These tables report the results for each individual subject along with empirical and lognormal simple random sampling method statistical summaries.

Appendix A to this memo provides statistical models to estimate the unit exposure summary statistics, including:

- Empirical simple random sampling model; and
- Lognormal simple random sampling model

The results of the lognormal simple random sampling model have been selected to best represent the summary statistics for the unit exposures (for summary results of recommended unit exposures see Table 1 above). The estimates using substitution of half the LOQ for non-detected values below the LOQ or below the LOD are recommended. For a detailed discussion of the lognormal simple random sampling model calculations and results the reader is referred to Appendix A, which includes quantile plots to compare normal and log-normal distributions for the unit exposures.

Appendix A also provides various alternative statistical models for estimating the exposure from the lbs a.i. handled instead of simply using the unit exposures multiplied by the lbs ai handled. The main model is a linear regression model for log exposure against the log of the lbs ai handled. Also included is the HSRB-recommended quadratic regression model regressing log exposure against log (lbs a.i. handled) and log (lbs a.i. handled) squared. Quantile and regression plots are used to evaluate the linear regression model. Additional models considered in Appendix A are log-log-logistic, three-parameter logistic, and gamma regression models recommended by the HSRB. Of these alternative regression models, the best-fitting models for most exposure routes considered in this report are either the linear or gamma models, based on the Akaike information criterion (AIC). Since the gamma model's AIC scores were not very different from the linear models and the linear models are much easier to implement, the linear models were selected. (For inhalation and respirable dose and 8-hr TWA, the difference in AIC scores were less than 2, suggesting either model is equally valid, based on a common rule-of-thumb. For long-long dermal no hat, the difference in AIC scores was only 6.5 which also shows that the two models are still reasonably close.

Study Observations

The ESS study includes the recorded individual participant activities by observers. Detailed observations recorded during each ME capturing the events that occurred during the painting activities can be viewed in the study report's Appendix E (pages 396 to 414). Although a review of these observations indicates some instances where the subjects were observed touching sprayed surfaces in addition to walking into the spray these types of exposures are expected based on the task and are not considered outliers in the data. The following observations are highlighted:

- ***ME1:*** Subject used hands to adjust pants and used elbows to open doors
- ***ME2:*** Subject tended to walk into spray and notified the observer that the spray solution dripped onto their hand.
- ***ME3:*** Subject would spray continuously while walking forward or backward.
- ***ME5:*** Subject would occasionally walk into spray.
- ***ME6:*** Spray mist was observed near the subject clothing and as a mist sheen when spraying the tub/toilet.
- ***ME7:*** Subject would frequently touch surfaces and items that were sprayed. Took a break for water and removed glasses and hat.
- ***ME8:*** Subject would occasionally walk into spray. Had to have ESS switched to another one as it was spraying large droplets instead of mist; new one did not have this issue.
- ***ME9:*** Spray had to reattach the siphon tube, after reconnecting subject used their hand in front of the sprayer to make sure solution was coming out. Knocked cart over, but no solution was spilled. Would occasionally come into contact with mist.
- ***ME10:*** Subject stated that their hand was wet from the way the spray came from the spray gun. Had to have battery replaced in the last ten minutes-during this time the air pumps had to be removed.
- ***ME11:*** Subject touched the end of spray gun and had some overspray on hand when spraying the inside of the control panel. Walked into the mist.
- ***ME12:*** Subject touched sprayed surfaces occasionally.
- ***ME13:*** Subjected walked forward into the spray mist. Ten minutes into observation it was noted that the tubing for the PPI was disconnected-was reconnected. Subject took a break for water and removed glasses, respirator, and hat.
- ***ME14:*** Subject sprayed the air about 8 feet above the surface and was told that the ESS is a surface sanitizer/disinfectant. The subject was spraying into the air and not on surfaces because they were trained to spray the air for COVID-19. In addition, when spraying in sweeping up and down motions lead to a spray falling on face and torso. The subject also touched previously sanitized surfaces.
- ***ME15:*** Spray mist was visible near pants when spraying; subject would also walk into the mist. 20 minutes before the end of the ME, the sprayer stopped working, tank was adjusted and spraying worked as normal.
- ***ME16:*** Occasionally the subject walked into the spray. Took a water break an hour into it and removed mask with hat.
- ***ME17:*** Subject made sure not to stand in the path of spray and not to touch sprayed surfaces.
- ***ME18:*** Spray seen on clothing and subject did not like that the solution dripped down the spray gun onto hand.

Impact of Non-detects. All the samples for hand, face/neck, and hat exposures as well as the PVC filters had detectable values. The outer lower arm for the WBD sampling had detectable residues for 17 of the 18 MEs; all other outer WBD/caps had measurable concentrations. The inner hat had 8 samples below the limit of quantification (LOQ). Most of the rest of the individual WBD for inner sectioned body parts were mostly above the LOQ (17 samples were below the LOQ out of 93 measured samples). Most of the OVS tubes had detectable residues where 1 sample was below the LOQ. Both dermal and inhalation exposure results were estimated using various methods of handling non-detects, including ½ the LOQ, substituting of the non-detects with the midpoint of lowest and highest value, maximum value, minimum value, and the maximum likelihood method for censored data.

There was minimal impact on the method that was utilized for heralding the non-detects for all exposure routes. This was evident with the minimal differences between estimated parameters and the alternative methods for handling non-detects (i.e., substituting the maximum and minimum LOQ values and censored data maximum likelihood (MLE)) as displayed in Appendix A (Table A29 pages 25-26).

Table 4. ESS: Summary of Dermal and Inhalation Unit Exposure Estimates.												
Monitoring Event (ME)	Sprayer Type[1]	Droplet Size (µm)	DDAC in Spray (ppm a.i.)	ME Duration (minutes)	Amount Sprayed (gallons)	Amount DDAC Handled (lb a.i.)	Dermal (mg/lb a.i.)		Inhalation (total inhalable)		Inhalation (respirable)	
							Total	Hands	Dose (mg/lb a.i.)	8-hr TWA (mg/m^3/lb a.i.)	Dose (mg/lb a.i.)	8-hr TWA (mg/m^3/lb a.i.)
1	Victory HH^W	80	36.3	30	0.48	0.000146	128	29	0.286	0.036	0.161	0.020
2	EMist BP	75	36.3	15	0.50	0.000151	621	535	1.734	0.217	0.111	0.014
3	Chlorox T360	46	36.3	25	0.50	0.000151	336	263	8.443	1.055	2.634	0.329
4	Victory HH	40	36.3	27	0.50	0.000151	628	385	1.848	0.231	0.141	0.018
5	Chlorox T360	46	36.3	33	0.50	0.000151	222	191	6.784	0.848	1.535	0.192
6	EMist Cart	75	36.3	24	0.50	0.000151	353	295	7.094	0.887	0.817	0.102
7	Victory BP	80	145	69	1.93	0.002334	795	749	9.747	1.218	2.693	0.337
8	Victory HH	40	72.7	69	1.00	0.000607	663	511	1.971	0.246	0.066	0.008
9	Chlorox T360	46	72.7	61	1.00	0.000607	430	304	10.229	1.279	2.805	0.351
10	EMist BP	75	72.7	42	1.00	0.000607	703	678	0.974	0.122	0.096	0.012
11	Chlorox T360	46	72.7	93	0.99	0.000602	694	519	9.325	1.166	1.559	0.195
12	Victory BP	40	72.7	48	0.99	0.000599	725	609	4.104	0.513	0.218	0.027
13	Chlorox T360	46	72.7	89	1.86	0.002250	279	205	7.040	0.880	1.271	0.159
14	Victory BP^W	40	145	35	0.64	0.000774	1012	588	3.720	0.465	0.059	0.007
15	EMist BP	75	145	99	2.00	0.002420	1063	982	0.787	0.098	0.038	0.005
16	Chlorox T360	46	145	102	2.00	0.002420	377	264	15.939	1.992	4.209	0.526
17	Victory BP^W	80	145	56	1.93	0.002340	37	18	0.848	0.106	0.051	0.006
18	EMist BP	75	145	64	2.00	0.002420	833	801	1.114	0.139	0.084	0.011
AM_S	N/A	N/A	N/A	54.5	1.13	0.001049	550	440	5.110	0.639	1.030	0.129
SD_S	N/A	N/A	N/A	27.9	0.63	0.000979	294	267	4.422	0.553	1.280	0.160
AM_U	N/A	N/A	N/A	55.6	1.14	0.001188	621	560	6.012	0.751	1.395	0.174
SD_U	N/A	N/A	N/A	34.0	0.73	0.001997	620	819	9.846	1.231	5.346	0.668

1. HH = Hand Held, BP = Backpack, W = Wand Extension Used

Formulas for Table 4.

Let X_i be the i^{th} AaiH or unit exposure value and let $Y_i = \ln(X_i)$.

Empirical Mean (AM_S)= $\overline{X} = \sum_{i=1}^{18} X_i / 18$

Empirical SD (SD_S) = $S_X = \sqrt{\sum_{i=1}^{18} \left(X_i - \overline{X}\right)^2 / 17}$.

Suppose X is lognormally distributed, so that Y = ln(X) is normally distributed with a population mean μ and a population variance σ^2.

Lognormal Simple Random Sample Mean (AM_U) = Estimated population mean of X = Estimate of

$\exp(\mu + \frac{1}{2}\sigma^2) = \exp(\overline{Y} + \frac{1}{2} S_Y{}^2)$ where $\overline{Y} = \sum_{i=1}^{18} Y_i / 18$ and $S_Y = \sqrt{\sum_{i=1}^{18} \left(Y_i - \overline{Y}\right)^2 / 17}$.

Lognormal Simple Random Sample SD (SD_U) = Estimated population standard deviation of X = Estimate of

$\exp(\mu + \frac{1}{2}\sigma^2) \sqrt{\exp(\sigma^2) - 1} = \exp(\overline{Y} + \frac{1}{2} S_Y{}^2) \sqrt{\exp(S_Y{}^2) - 1}$.

2.4 Evaluation of Scenario Benchmark Objective

Benchmark Objective. The data from the study has been analyzed to see if the ESS scenario meets the AEATF II objective of a relative 3-fold accuracy (i.e., K = 3). These analyses used the SAS code originally developed by the Agricultural Handler Exposure Task Force (AHETF) and independently confirmed by the EPA OPP Health Effects Division (HED) (and now modified by the EPA OPP AD). Appendix A (starting page 7) provides the detailed benchmark analysis which is summarized as follows:

Benchmark Objective: fold Relative Accuracy (fRA)

The benchmark objective for AEATF II scenarios is for select statistics – the geometric mean (GM), the arithmetic mean (AM), and the 95th percentile (P95) – to be accurate within 3-fold with 95% confidence (i.e., "fold relative accuracy" also expressed as "K-factor"). EPA has analyzed the data using various statistical techniques to evaluate this benchmark. First, to characterize the unit exposures (also referred to as "normalized exposure"), normal and lognormal quantile plots of dermal and inhalation UEs are provided in Appendix A (Figures A1 to A22 for empirical quantile plots) to illustrate that in general the lognormal distribution is a better fit than the normal distribution for the normalized exposure (albeit for dermal, the normal distribution had better fits for dermal, the lognormal distribution was also acceptable and is required for the assumptions of the UE). Overall, these plots support the assumed lognormal distributions for the normalized exposure. Note: all logarithms defined in this review are natural logarithms.

Next, EPA calculated estimates of the GM, AM and P95 based on two different calculation methods:

- Empirical estimates; and
- Assuming a lognormal distribution and a simple random sample (SRS)

The 95% confidence limits for each of these estimates were obtained by generating 10,000 parametric bootstrap samples from the fitted lognormal distribution. Then, the fRA for each was determined as the 95th percentile of the maximum of the two ratios of the sample statistic to the parameter, after the parameter is replaced by its estimated value. The results are shown for: long pants, long sleeved shirts, no gloves (Long-long) in Table 5 (Appendix A pages 30 to 31); Table 6 for the inhalation exposure total inhalable dose and 8-hr TWA (Appendix A pages 33 to 34); and Table 7 for the inhalation exposure respirable dose and 8-hr TWA (Appendix A pages 35 to 37). Appendix A also presents fRA values calculated using a non-parametric bootstrap approach, with generally similar results. The results indicate that for the dermal unit exposure and the inhalation total inhalable dose/8-hr TWA under consideration, the ESS study meets the 3-fold relative accuracy objective for all but the 95% confidence limit for the empirical simple random sampling model (i.e., P95s in Table 5 and Table 6 below). The inhalation respirable dose and 8-hr TWA unit exposures meet the 3-fold relative accuracy objective for the geometric mean and limit; all others exceeded the 3-fold relative accuracy (i.e., GMs and GSD). The arithmetic means and limit in addition to the 95% mean were only marginally over with k-fold factors less or equal to 3.3, but more than 3 (i.e., AM_S, AM_U, and $P95_U$ in Table 7).

Table 5: Results of Primary Benchmark Analysis for the ESS Scenario Dermal.			
Statistic	**Dermal Exposure (Long-Long, no hat, no gloves)**		
	Unit Exposure Estimate (mg/lb a.i.)	**95% CI**	**fRA**
GM_S	439.3	301-652.1	1.47
GSD_S	2.30	1.74 to 3.05	1.32
GM_S = geometric mean assuming SRS = "exp(average of 18 ln(UE)) values" GSD_S = geometric standard deviation assuming SRS = "exp(standard deviation of 18 ln(UE)) values"			
AM_S	550.0	391.6 to 974.3	1.64
AM_U	620.7	401.7 to 992.3	1.57
AM_S = average of 18 unit exposures AM_U = arithmetic mean based on $GM_S = GM_S * \exp\{0.5*(\ln(GSD_S)^2\}$			
$P95_S$	1,063.3	938.0 to 5,259.1	**4.18**
$P95_U$	1,724.8	944.6 to 3,126.6	1.82
$P95_S = 95^{th}$ percentile (i.e., estimated as the maximum unit exposure from the 18 unit exposures) $P95_U = 95^{th}$ percentile based on $GM_S = GM_S * GSD_S^{1.645}$			

fRA (i.e. k) values that are above 3 are highlighted in bold font.

Table 6: Results of Primary Benchmark Analysis for the ESS Total Inhalable Inhalation Exposure						
Statistic	**Inhalation Exposure (Total Inhalable, Dose)**			**Inhalation Exposure (Total Inhalable, 8-hr TWA)**		
	Unit Exposure Estimate (mg/lb a.i.)	**95% CI**	**fRA**	**Unit Exposure Estimate (mg/m^3/lb a.i.)**	**95% CI**	**fRA**
GM_S	3.13	1.87 to 5.39	1.70	0.392	0.233 to 0.674	1.70
GSD_S	3.13	2.14 to 4.61	1.47	3.13	2.14 to 4.61	1.47
GM_S = geometric mean assuming SRS = "exp(average of 18 ln(UE)) values" GSD_S = geometric standard deviation assuming SRS = "exp(standard deviation of 18 ln(UE)) values"						
AM_S	5.11	2.96 to 11.9	2.06	0.639	0.370 to 1.49	2.06
AM_U	6.01	3.13 to 12.4	1.99	0.751	0.391 to 1.55	1.99
AM_S = average of 18 unit exposures AM_U = arithmetic mean based on $GM_S = GM_S * \exp\{0.5*(\ln(GSD_S)^2\}$						
$P95_S$	15.9	8.88 to 94.7	**4.71**	1.99	1.11 to 11.8	**4.71**
$P95_U$	20.5	8.96 to 46.4	2.27	2.56	1.12 to 5.80	2.27
$P95_S = 95^{th}$ percentile (i.e., estimated as the maximum unit exposure from the 18 unit exposures) $P95_U = 95^{th}$ percentile based on $GM_S = GM_S * GSD_S^{1.645}$						

fRA (i.e. k) values that are above 3 are highlighted in bold font.

Table 7: Results of Primary Benchmark Analysis for the ESS Respirable Inhalation Exposure.						
Statistic	Inhalation Exposure (Respirable, Dose)			Inhalation Exposure (Respirable, 8-hr TWA)		
	Unit Exposure Estimate (mg/lb a.i.)	95% CI	fRA	Unit Exposure Estimate (mg/m^3/lb a.i.)	95% CI	fRA
GM_S	0.352	0.166 to 0.775	2.16	0.044	0.021 to 0.097	2.16
GSD_S	5.26	3.03 to 9.23	1.75	5.26	3.03 to 9.23	1.75
GM_S = geometric mean assuming SRS = "exp(average of 18 ln(UE)) values" GSD_S = geometric standard deviation assuming SRS = "exp(standard deviation of 18 ln(UE)) values"						
AM_S	1.03	0.395 to 4.20	**3.32**	0.129	0.049 to 0.525	**3.32**
AM_U	1.40	0.458 to 5.18	**3.33**	0.174	0.057 to 0.647	**3.33**
AM_S = average of 18 unit exposures AM_U = arithmetic mean based on $GM_S = GM_S * \exp\{0.5*(\ln(GSD_S)^2\}$						
$P95_S$	4.21	1.60 to 49.9	**8.48**	0.526	0.200 to 6.24	**8.48**
$P95_U$	5.40	1.62 to 17.7	**3.30**	0.674	0.203 to 2.21	**3.30**
$P95_S$ = 95th percentile (i.e., estimated as the maximum unit exposure from the 18 unit exposures) $P95_U$ = 95th percentile based on $GM_S = GM_S * GSD_S^{1.645}$						

fRA (i.e. k) values that are above 3 are highlighted in bold font.

An additional analysis was included that tried to separate exposure based on what type of sprayer was used (i.e., backpack, cart, handheld ESS). The results of this analysis, including model estimates as was done for all data and k-factors, are included in Appendix A, Tables A30-A40. Cart type sprayers actually had a K-factor less than 3; however for backpacks, the K-factor was too high. There were not enough degrees of freedom to draw meaningful statistics from the handheld sprayers.

Presumption of Log-log-linearity With Slope 1. EPA evaluated the presumption that the mean exposure is a multiple of the amount of active ingredient handled (AaiH or a.i.). In the AEATF II's Governing Document and in statistical reviews of some of the earlier AEATF II studies, this presumption has been referred to as "proportionality", but we are now referring to this analysis as a "log-log-linearity" analysis to clarify that the statistical models do not assume that the exposure is directly proportional to either the amount of active ingredient handled. If the log-log-linear model has a slope of 1, then the arithmetic mean exposure will be a multiple of the amount of active ingredient handled. The statistical test compares the slope of 1 with a slope of 0, where 0 corresponds to complete independence between exposure and the amount of active ingredients handled.

To evaluate the relationship for this scenario EPA performed regression analysis of log(exposure) against log(AaiH) to determine if the slope of this log-log-linear model is not significantly different than 1 – providing support for a "proportional" (an abbreviation for " log-log-linear with slope 1") relationship – or if the slope is not significantly different than 0 – providing support for an independent relationship. If the slope is positive, not zero and not 1, then the arithmetic mean exposure tends to increase with the AaiH but not proportionally, so that, for example, doubling the AaiH will not tend to double the exposure. If the slope confidence interval excludes both 1 and 0 but the slope is positive, then the statistical evidence rejects both proportionality and independence and shows that the exposure tends to increase with

the AaiH but not proportionally. Note: the slope for the dermal (or inhalation) exposure measures the change in log mg dermal (or inhalation) exposure for each unit change in log a.i. A slope of 1 implies that the log of the unit exposure (mg/lb a.i.) is equal to a constant plus a random error, so that the unit exposure has the same mean for any amount of a.i., and thus the mg dermal (or inhalation) exposure is proportional to the lb a.i.

The resulting regression slopes and confidence intervals for the dermal, inhalation 8-hr TWA (respirable and total inhalable), and inhalation dose (respirable and total inhalable) exposures to be used by EPA in our assessments are summarized in Table 8. A more detailed discussion and table of the slopes along with the other clothing scenarios or sprayer specific scenarios is presented in Appendix A (pages 55-64 cover all discussion and tables; for specific sprayer type tables the reader is referred to the following: backpack sprayer Table A46; cart Table A47; and handheld sprayer Table A48).

The confidence intervals for the slope exclude 0 and include 1 for dermal, inhalation 8-hr TWA (respirable and total inhalable), and inhalation dose (respirable and total inhalable). Thus, the assumption of independence was rejected and the assumption of log-log-linearity with slope 1 was supported (more precisely, did not reject proportionality (a slope of one)). Therefore, the "unit exposure" approach for the dermal, inhalation 8-hr TWA (respirable and total inhalable), and inhalation dose (respirable and total inhalable) is a reasonable approximation.

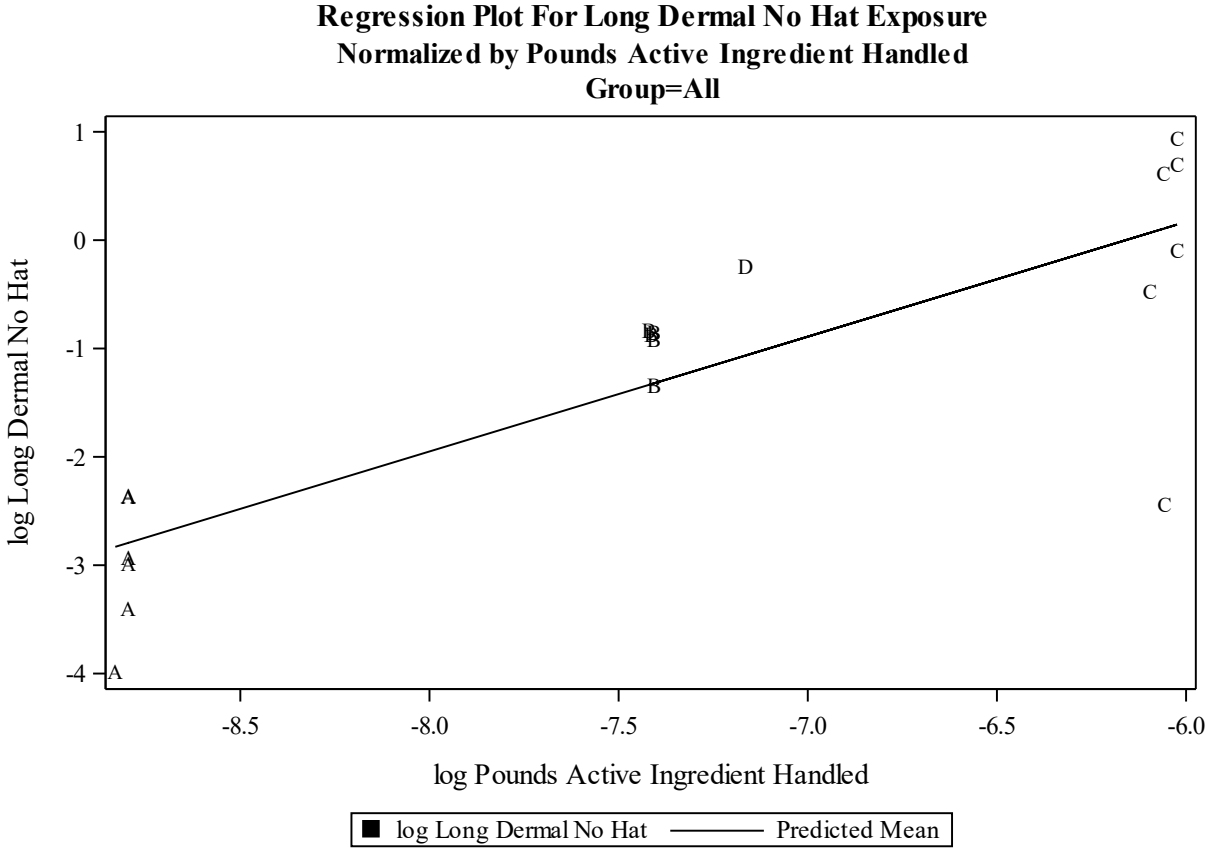
Table 8. 95 Percent Confidence Intervals for the Slope of Log Exposure (mg) versus Log Pounds of Active Ingredient for Dermal and Inhalation Exposures.

Scenario/Clothing	Slope	Confidence Interval	Appendix A
Dermal (Long-Long, no hat, no gloves)	1.06	0.68 – 1.44	Table A45 All Data Sub mid value
Inhalation (Total inhalable, dose)	1.05	0.53 – 1.57	Table A45 All Data Sub mid value
Inhalation (Total inhalable, 8-hour TWA)	1.05	0.53 – 1.57	Table A45 All Data Sub mid value
Inhalation (Respirable, dose)	0.9	0.14-1.66	Table A45 All Data Sub mid value
Inhalation (Respirable, 8-hour TWA)	0.9	0.14-1.66	Table A45 All Data Sub mid value

Figures 7 to 11 show the data and corresponding fitted regression models for the dermal and respirable and total inhalable 8-hour TWA exposure routes. The data points marked with the symbols: "A" are 0.5 gallons and 36.3 ppm of DDAC; "B" are 1 gallon and 72.7 ppm DDAC; "C" 2 gallons and 145 ppm; and "D" is the person that had the higher concentration but had to leave early so could only spray 0.75 gallons. Appendix A also presents probability plots of the residuals from these fitted regression models ((Figures A23 to A33, pages 64 to 77); these probability plots show that this simple log-log-linear regression model fits reasonably well except for the dermal which has a noticeable outlier, this was explored in the supplement to

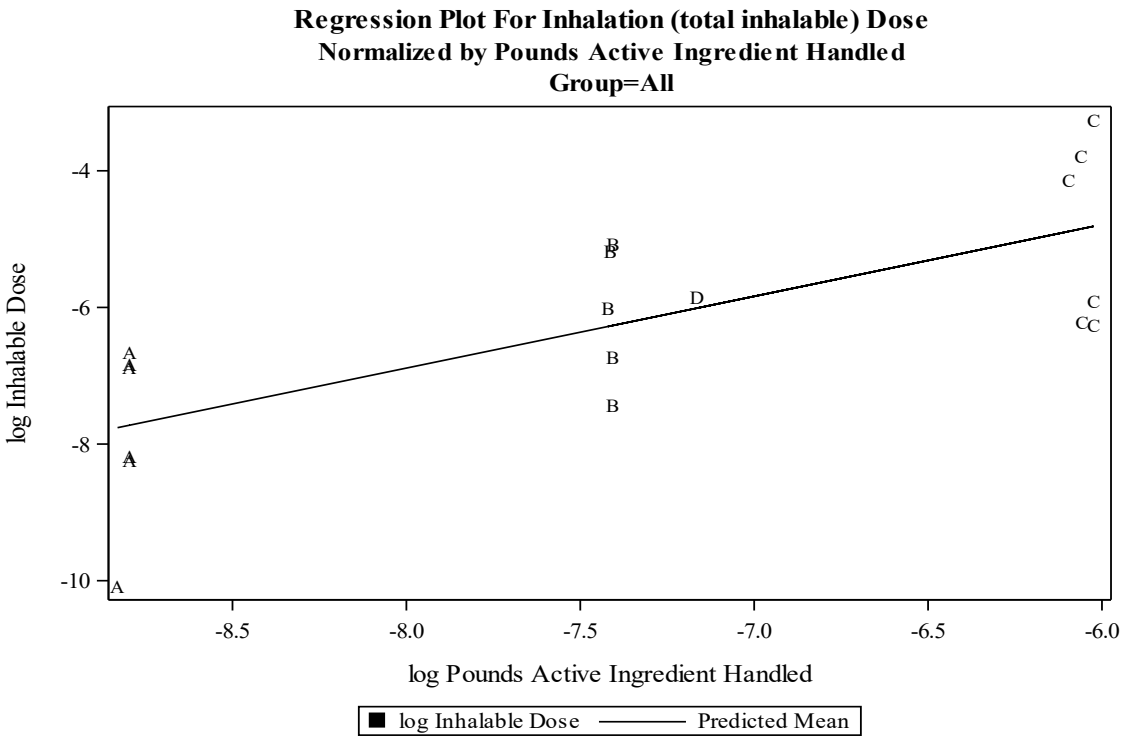
Appendix A, but the removal could not be justified based on laboratory or data monitoring errors so it was retained (Appendix A page 67).

Appendix A also includes the fitted regression models for the inhalation and dermal exposure routes (Appendix A pages 72 to 104 for all sprayer types combined, backpack sprayer, and cart sprayer- There were not enough samples to make meaningful regressions for handheld sprayers).



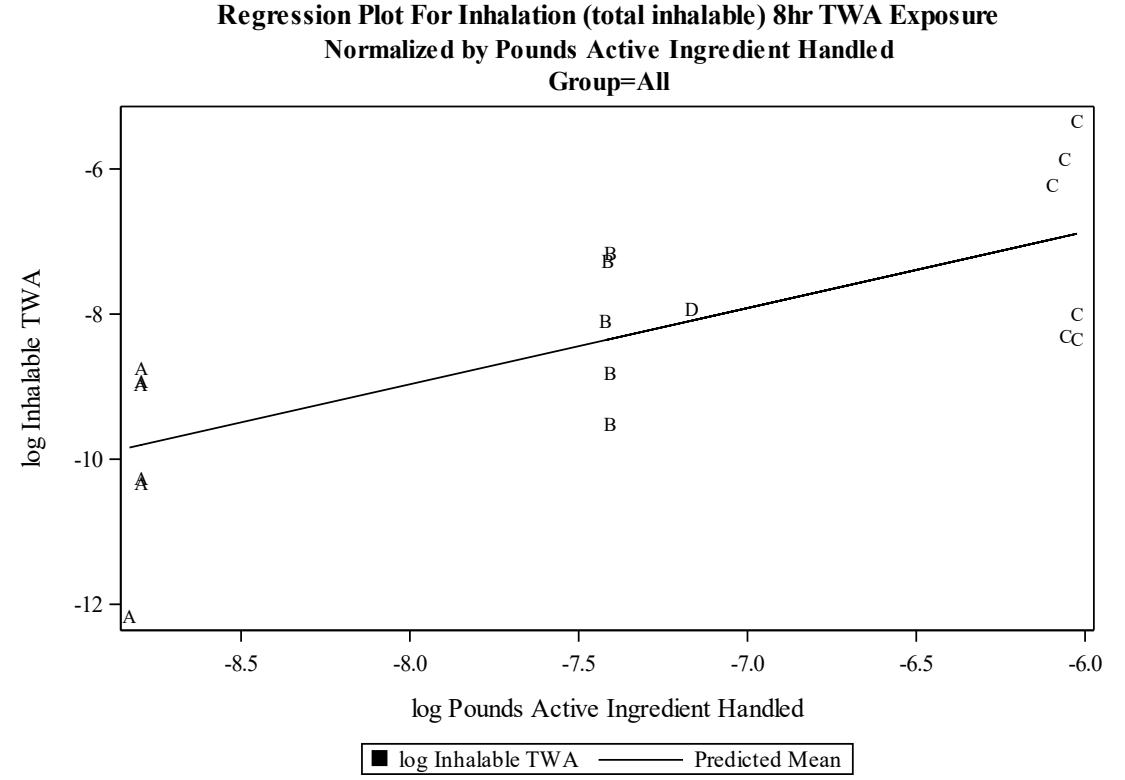
A = 0.5 gals 36.3 ppm, B = 1 gal 72.7 ppm, C = 2 gals 145 ppm, D = 0.75 gals 145 ppm

Figure 7. Regression plot for Long/Long, no hat, no gloves Dermal (mg)



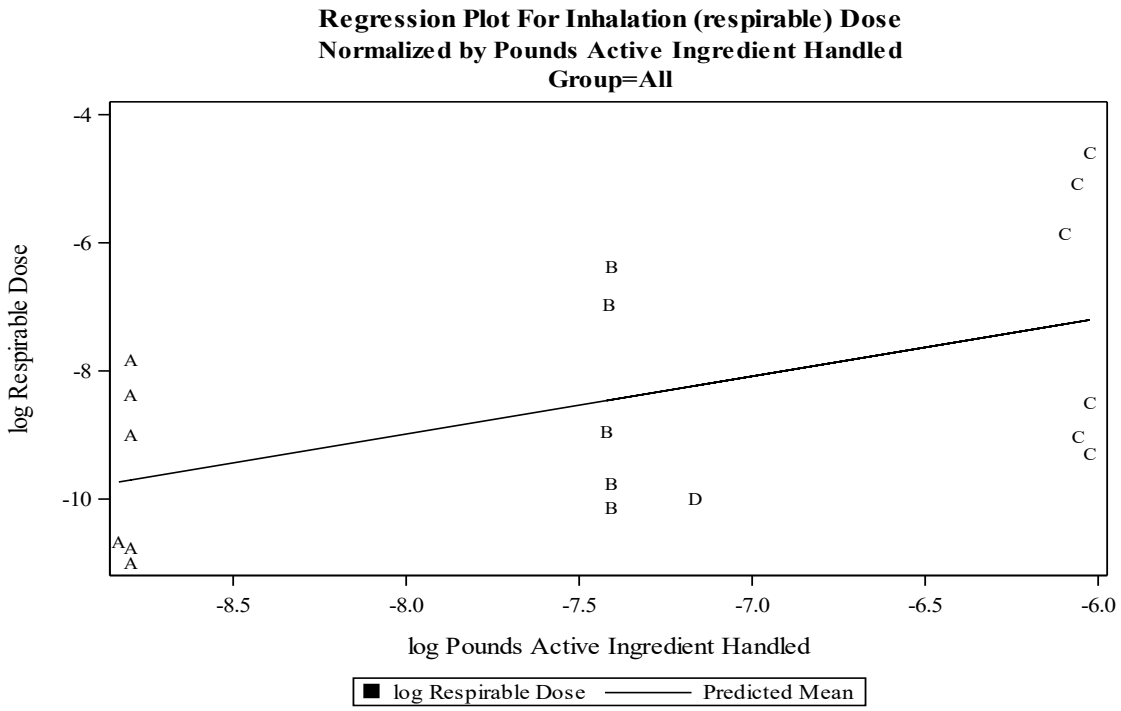
A = 0.5 gals 36.3 ppm, B = 1 gal 72.7 ppm, C = 2 gals 145 ppm, D = 0.75 gals 145 ppm

Figure 8. Regression plot for Inhalation (total inhalable) Dose Exposure (mg)



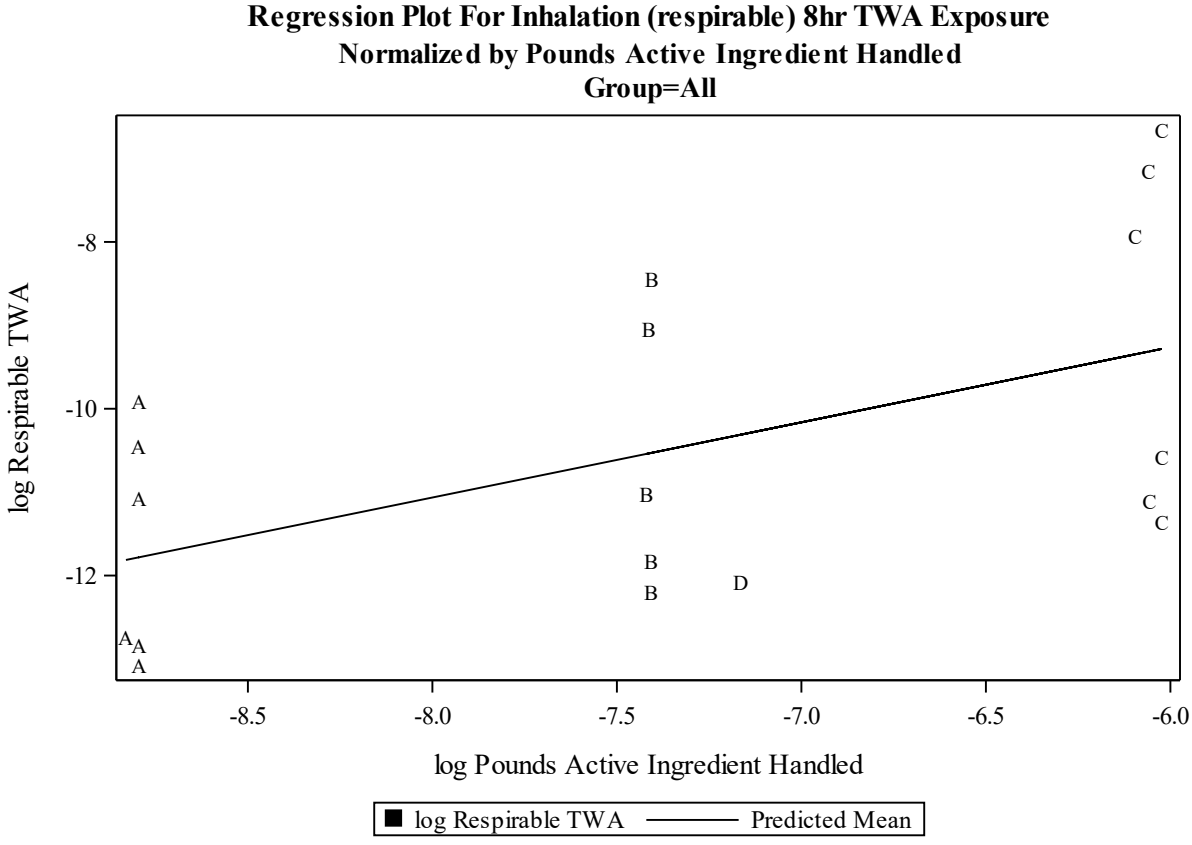
A = 0.5 gals 36.3 ppm, B = 1 gal 72.7 ppm, C = 2 gals 145 ppm, D = 0.75 gals 145 ppm

Figure 9. Regression plot for Inhalation (total inhalable) Time-Weighted Average Conc Exposure (mg).



A = 0.5 gals 36.3 ppm, B = 1 gal 72.7 ppm, C = 2 gals 145 ppm, D = 0.75 gals 145 ppm

Figure 10. Regression plot for Inhalation (respirable) Dose Exposure (mg)



A = 0.5 gals 36.3 ppm, B = 1 gal 72.7 ppm, C = 2 gals 145 ppm, D = 0.75 gals 145 ppm

Figure 11. Regression plot for Inhalation (respirable) Time-Weighted Average Conc Exposure (mg).

3.0 Discussion of Data Generalizations and Limitations

The regulatory need for a generic data base of pesticide handlers for antimicrobial pesticide products has been discussed previously (SAP 2007). The study design for the ESS scenarios incorporated random diversity selection where feasible. Such a study design requires a discussion of how the data can be generalized and the limitations of the results. The following items are provided to potential users of these data to characterize the results of this sampling effort:

(1) The study purposively selected sites in Orlando, FL as the study location. This selection criterion, rather than a random selection of sites across the country, limits to some degree the statistical generalizations of the data. Thus, we cannot determine whether these results provide unbiased estimates of exposure distributions from using ESS in locations other than Orlando, FL, and it is not possible to use these data to estimate the potential bias or geographic variability. To generalize these results to the whole country requires an assumption that the exposure distribution for these scenarios is independent of the geographic location. The statistical limitations of the purposive site selection are deemed acceptable by the Joint Regulatory Committee (JRC). It is reasonable to assume that the cleaning routines to use an ESS to sanitize/disinfect indoor surfaces in Orlando are not substantially different than spraying the same types of surfaces and equipment throughout the country. Given a limited set of resources for the overall AEATF II monitoring program, the assumption that sanitizing/disinfecting does not vary geographically was sufficiently reasonable to forgo the random site selection (of all buildings throughout the country) in favor of spending the limited resources to monitor additional distinctly different scenarios (e.g., open pouring liquids, trigger pump spray & wipe, painting, hand-held spray wands, etc.).

(2) The data generated in this study are acceptable to use as surrogate for assessing other chemicals considered to have low volatility (i.e., vapor pressures less than ~1E-4 mmHg @ 20ºC). This "rule-of-thumb" for the vapor pressure threshold is reviewed by EPA on a case-by-case basis, particularly for those antimicrobial pesticides with vapor pressures that are near to this threshold. For example, for those chemicals with vapor pressures of ~1E-4 mmHg, EPA reviews the available inhalation toxicity data to see if the toxicity studies were performed as a gas or with an aerosol.

(3) The small sample size by itself does not create statistical limitations since the confidence intervals for the summary statistics based on the primary statistical model were reasonably narrow (meeting better than the 3-fold relative accuracy goal, except in a few instances as discussed above).

More important is the fact that the original sets of subject participants, locations, and dates from which the subjects, and sampling dates were chosen were limited and hence might not be representative of all experienced ESS workers (i.e., custodians, janitors) living in Florida (e.g., those that had experience sanitizing surfaces with ESS that did not volunteer), buildings (e.g., office buildings, hospitals, schools, etc.), and time periods (e.g., summer versus winter, day versus night, etc.). In other words, the most significant limitation is that these data were not derived from a fully stratified random sample of MEs even though the statistical analyses made that assumption. At a minimum this increases the uncertainty of the estimates (so the calculated confidence intervals are too narrow) and there may also be some bias (e.g., study

participants not in the volunteer pool might be more or less prone to exposure than the selected group).

(4) In this study/scenario/review we evaluated the presumption of "proportionality" that the mean exposure is a positive multiple of the concentration of a.i. and duration of exposure (i.e., the mean exposure is proportional to the AaiH and the exposure tends to increase with increasing AaiH). Proportionality is evaluated by testing if the log-log-linear model has a slope of 1. The analyses of log-log-linearity then shows that dermal and inhalation exposure tends to increase proportionally with lbs a.i. handed. Data will continue to be collected by the AEATF II to add to the knowledge base of normalized exposures.

(5) In this study, an additional analysis was conducted to see if the different sprayer types would yield different UEs. As described in Section 2.4, analysis did provide useable UEs for the cart sprayer, however the backpack and hand-held sprayers did not have useable UEs (too high a k-factor and not enough samples for meaningful statistics). Breaking out a single UE for carts could be perceived as singling out that sprayer type if the results are lower or higher than for all the sprayers combined. At the same time, the EPA feels that the current UE that includes all sprayer types is a good surrogate for all current models. The EPA is open to having industry collect their own data for their sprayer type to be added to these data to increase the sample size for individual types of sprayers and providing that for a future analysis.

(6) As noted in Section 2.4 there was a single ME17 that could have been interpreted as an outlier for dermal, but not inhalation. Further investigation of this ME shows that the subject utilized the 12-inch wand extension and handled the high concentration, high volume. Two other MEs utilized this same wand extension as well. One ME sprayed a low concentration and low volume and it was not an outlier, however when looking at the raw numbers it was noticeably lower than other backpack sprayers. The effect may have not as been as pronounced due to the lower amount of lbs of a.i. handled. The third person, ME14, that used the 12-inch wand, medium volume and medium concentration, actually had one of the highest dermal exposures for the hat, possibly due to their application methods as noted in the AEATF II 2021 report. Because nothing was wrong with the laboratory analysis or out of the ordinary reported in the observations for this ME, and the fact that other MEs used the same set up without being an outlier, including this potential outlier helps increase the amount of variability within the UE to more accurately represent possible exposure to people using ESS. A supplemental Appendix A presents how the removal of this point impacts the UEs.

4.0 Conclusions

The EPA has reviewed the AEATF II ESS study and concludes that the AEATF II made the appropriate changes to the protocol proposed by the EPA and HSRB and has properly executed the study. The protocol deviations that occurred and were properly reported have not adversely impacted the reliability of these data. The EPA recommends that the inhalation and dermal UEs generated in this ESS study be used provided the data are used within the boundaries set forth in this review. The following is a summary of our conclusions:

- The AEATF II data for inhalation and dermal exposures represent reliable data for assessing ESS sanitizing of indoor surfaces. The AEATF II unit exposures summarized in Table 1 are recommended to be used for regulatory purposes.

- Estimates of the GM, AM, and P95 were shown to be accurate within 3-fold with 95% confidence (except in only a few instances). At this time, no additional monitoring for the ESS scenarios is required.

5.0 References

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Appendix A

Statistical Review of the AEATF II Electrostatic Sprayer Study

And

Supplement to Appendix A

(To be included as a separate electronic file)