ABSTRACT

BRYAN EDWARD RAMSTACK. Analysis of Respirator Cartridges and Filters as a Determination of Occupational Exposure. (Under the direction of Dr. PARKER C. REIST)

This research attempted to determine occupational exposure from the amount of contaminant deposited on respirator cartridges. The flowrate through the respirator was estimated by existing ergonomic and respiratory ventilation models. The respirator concentrations were compared with simultaneous breathing zone air samples. A respiration flow model was modified into 18 different variations depending on 1) the increase in oxygen required per increase in workload; 2) estimate of total ergonomic workload; and 3) the basal oxygen exceeded the calculated maximum possible flowrate. Of the 18 models only 5 were acceptable. Dust/mist respirator results were 1.5 to 2.2 times less than the breathing zone samples. Respirator cartridge organic vapor constituents were 1.0 to 2.5 times less than the charcoal tube values. The models appear to overestimate the actual flow, although factors such as mask leakage, faceshield blocking, sensitivity of filter pads to relative humidity, and differences in analytical sensitivities made quantitative conclusions unreliable. The results of organic vapor respirator cartridges did show countenance for this procedure in screening workplace exposures or estimating a respirator workplace protection factor.

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Introduction:

A worker's exposure to airborne workplace contaminants can be measured by several methods. As air sampling equipment technology has improved, personal sampling increasingly relies upon battery operated pumps or passive dosimeters. However, breathing zone samples do not evaluate the effectiveness of respiratory protection in areas requiring personal protective equipment to supplement traditional engineering controls. Furthermore, breathing zone sample results can vary by the type (passive vs. active), location and orientation of the collecting device.

In an article published in 1988, First [1] stated "Analysis of the respirator pad or chemical cartridge gives a good integrated sample of the air that would have reached the lungs, although the exact air volume can only be estimated." This research attempted to determine industrial airborne workplace concentrations based on the amount of contaminant deposited on respirator cartridges. The airborne concentrations were calculated by estimating the flowrate through the respirator with existing ergonomic and human ventilatory models. The calculated concentrations were compared with concurrent continuous breathing zone air samples to determine any statistical correlation. The goal of this research was to determine if the respirator cartridge analysis method could be used as a screening device for estimating workplace airborne concentrations.

Background:

The use of respirator pads to determine exposure to pesticides was described by Durham and Wolf [2] in 1962. Respiratory exposure was estimated by the amount of pesticide deposited on the filter pads of a properly fitted "single unit respirator and a modified plastic funnel" covering. The covering protected the respirator pad from direct spray. The stem of the funnel covering was plugged and two 12mm holes drilled 6mm apart midway between the base and the apex. During sampling, the holes were directed downward to simulate the aerodynamic effect of human nostrils. Durham and Wolf listed several previous studies comparing the results of respirator pad analysis to breathing zone air samples.

Measurements by Batchelor & Walker [3] during orchard spraying with parithion indicated the respiratory pad technique gave values 3 to 5 times greater (in mg/kg/day) than air sampling results. Durham and Wolfe [2] contended that the ratios of respiratory pad samples to air sampling results were actually "of the same order of magnitude" because Batchelor & Walker did not shield the respirator pads to prevent impingement of the parithion aerosol. Durham and Wolfe argued that about 75% of the apparent exposure on an unshielded respirator pad was actually due to impingement and therefore not representative of potential inhalable contaminates.

Further measurements of DDT by Wolfe [4] revealed the respirator pad method gave values about two times as high as breathing zone samples. Again, the author stated the results were "considered to be about the same order of magnitude."

This method continues to be utilized in agricultural pesticide sampling, e.g. see Winterlin, et. al [5] in a 1984 survey of strawberry harvesters in California. Winterlin's 28 liter per minute (lpm) "low flow" breathing zone results for captan and THPI (tetrahydrophtalimide) were 2 to 5 times the respirator pad values [assuming 10 lpm respiration rate as stated by the author; in micrograms per cubic meter].

The results of these studies question the validity of correlating respirator filter sampling to breathing zone air sampling. However, all of the above cited studies assumed a single worker breathing rate over the entire sampling period (8 lpm for Batchelor, et. al. [3] and Wolfe [4] versus 10 lpm for Winterlin, et al. [5]). This assumption was not well-founded if the workers used multiple body positions (i.e. sitting, standing, or walking) during the operation. It was also not logical if the physical workload varied during the sampling period. Using improvements in estimating the exact respiratory air volume of a worker, it was anticipated that the respirator filter cartridge analysis method would approximate the continuous breathing zone air sampling pump results.

Sampling Methods:

Sampling Location and Operations: Sampling was conducted at three separate industrial areas at Pope Air Force Base located in Fayatteville, North Carolina. The first area was a vehicle maintenance facility. Work at this facility included body work and spray painting on military cars, vans, and specialized vehicles. All spray painting was conducted in an enclosed auto spray paint booth. The paint booth ventilation system provided an average exhaust ventialtion of 212 cubic feet per minute per square foot of cross section (CFM/Ft^2). This facility was used for sampling painting operations for paint mist and organic vapors. Personnel used an air atomization method of spraying to apply a mixture of acrylic enamel, thinner and hardener (drier).

The second industrial area studied was an aircraft structual repair shop used for sanding and painting specialized military equipment such as aircraft engine housings and maintenance scaffolding. Operations were conducted in a waterfall paint booth which provided an average exhaust ventilation of 143.3 CFM/Ft^2. This facility was used for sampling sanding operations only. Sanding operations utilized a pneumatic orbital disk sander.

The last industrial area was a fiberglass repair shop. The personnel in this shop mended and sanded aircraft components. The shop included two large paint booths with exhaust flow rates of 505 CFM/Ft^2 and 488 CFM/Ft^2. One sanding operation was sampled from this shop. During this study personnel used a pneumatic orbital disk sander similar to that used in the sanding operations above.

The personnel in all areas wore cartridge-type respirators and were previously monitored through industrial hygiene and respiratory protection programs. The respirators worn during painting were half-face dual filter (American Optical) with organic vapor cartridges (R51A TC-23C-235) and dust/mist prefilter (R30 TC21C-144). The dust/mist filters were constructed of resin coated composite fibers. During sanding operations the same model of repirator was worn, but only the dust/mist filter was used.

Sampling Techniques & Analysis: Painting and sanding operations were sampled for total dust and mist particulates. Breathing zone dust samples were taken with 35 millimeter mixed cellulose ester filters (0.8 micrometer; matched weight) in an open face cassette. The sampling pumps (DuPont Alpha 1) were calibrated to a flowrate of 2.0 liters per minute (lpm). During sampling, the cassette filter was placed in the breathing zone of the subject by attachment to the coverall collar. The filter cassette was attached such that the filter was vertical (perpendicular to the floor) with the open face directed towards the front of a standing worker. The respirator samples were collected by installing new dust/mist filters over each respirator cartridge. The filters were attached over the organic vapor cartridges for painting operations. During sanding operations, the organic vapor cartridges were removed and the filters attached directly to the respirator. Both the membrane and respirator filters were analyzed by determining the pre-sampling versus post-sampling weight changes utilizing an analytical balance (Mettler 52L).

Initial sampling revealed the weight of the respirator filters were influenced by the relative humidity and the elapsed time at ambient laboratory conditions. Repeated weighting, over elapsed time, showed that the weight of a resin coated respirator filter changed over time until an equilibrium weight was achieved. The filter weight continued to change until elapsed time reached two hours. A plot of percent of total filter weight change (during elapsed time of two hours) versus elapsed time at ambient laboratory conditions revealed an inverse exponential curve (Figure 1). This figure indicated that 95% of the total weight gain/loss occurred within 1.5 hours. Therefore, all samples (pre-weight and post-weight) were analyzed after 1.5 hours of equilibration to ambient laboratory conditions.

In addition, four (4) blank respirator filters were repeatedly weighted over a period of several weeks at relative humidities ranging from 50% to 70%. Thirteen (13) sets of measurements were taken at eight (8) different relative humidities. A regression curve was calculated from these measurements to estimate the average percent change in filter weight versus relative humidity (Figure 2). The regression indicated that the percent change in respirator filter weight is determined by the relative humidity with the following equation:

Figure 1: % Filter Wt Change vs. Time

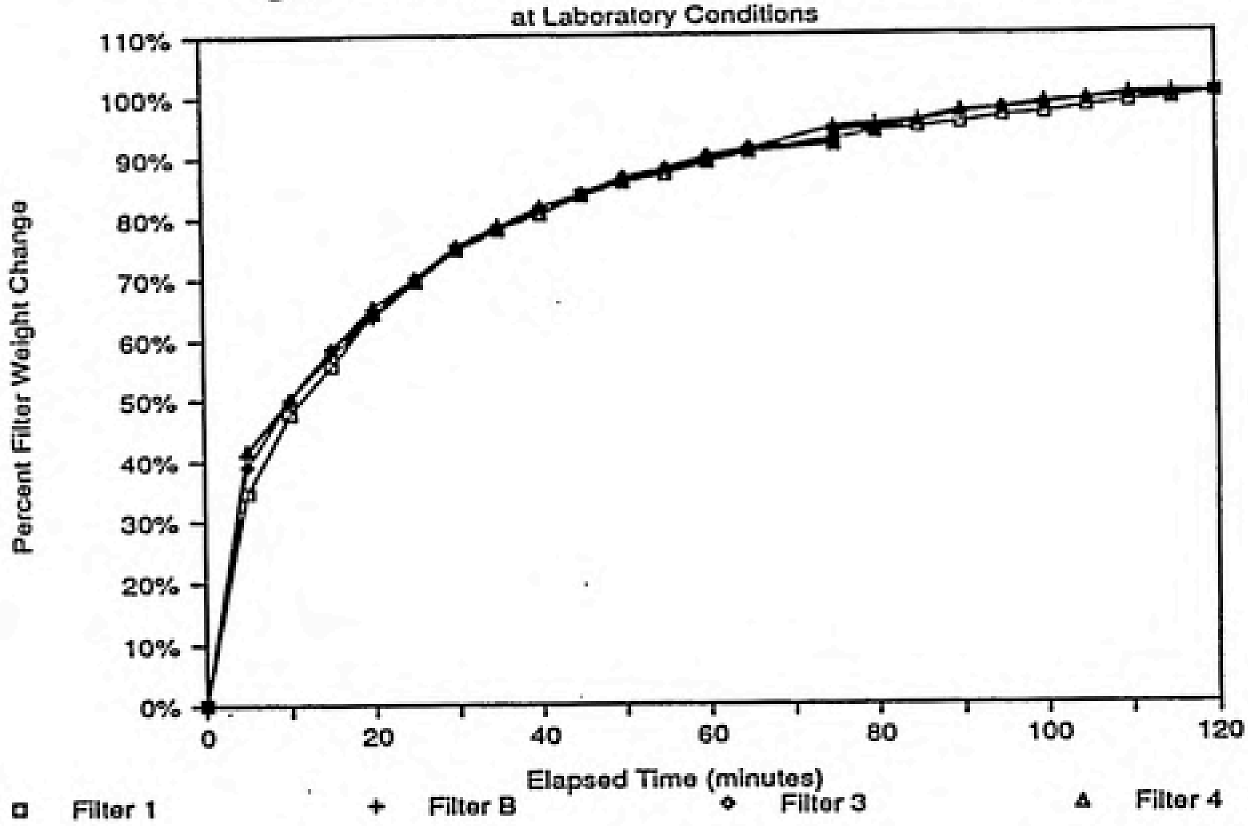
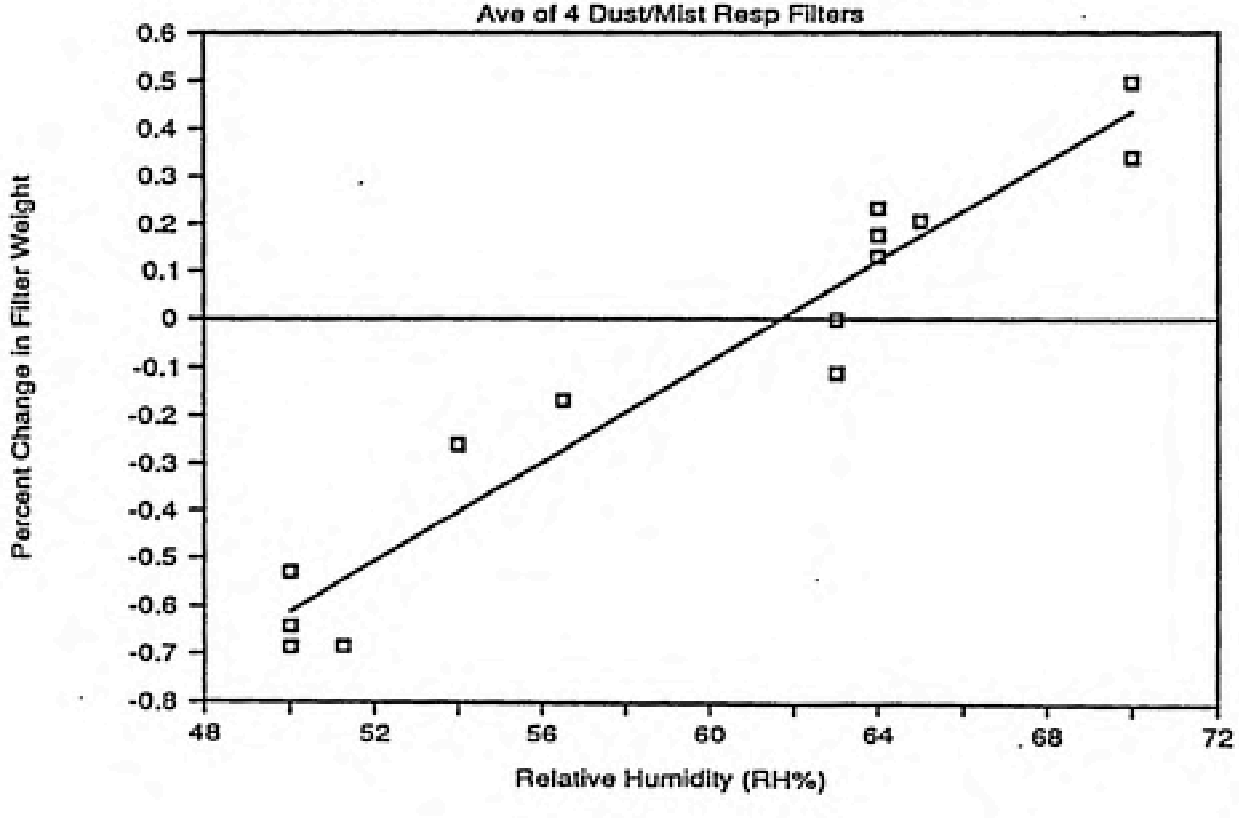


Fig 2: Filter Wt % Change vs RH %



$$\% \text{ change in filter wt} = [\ 0.05233 \times RH\%\ ] - 3.2273$$

The percent change in filter weight is relatively small (-0.7% to +0.5%) with respect to changes in relative humidity. However, it corresponds to corrections of up to 2.5 times the sample weight (Table 1). This is explained by the fact that the sample weights (2.1 mg to 27.1 mg) were only an average of 0.6 percent of the respirator filter weights (2296.18 mg to 2664.24 mg). The regression analysis was used to correct all respirator filter sampling results.

Three painting operations were sampled for detectable aromatic hydrocarbons. A list of analyzed hydrocarbons can be found in Table 2. The breathing zone samples of painting operations were obtained with large charcoal tubes (1 gram front portion, 0.25 grams rear portion) at a flow rate of 1.0 lpm. New organic vapor respirator cartridges were used for each sample. After each sample the charcoal tube was capped and respirator cartridges wrapped in foil. All samples were transported on ice to the laboratory, where they remained until analyzed. All organic vapor samples were analyzed on a Perkin Elmer 990 gas chromatograph and analyzer. Desorption efficiencies and blank analysis were determined for both the charcoal tube and respirator cartridge. The average weight of several blank organic vapor cartridges was approximately 52 grams of activated charcoal.

Table 1. Corrections to Dust/Mist Samples
Due to Changes in Laboratory Relative Humidity

Sample #	Uncorrected Resp Filter Sample Wt (mg)	Change to Samp Wt due to RH% (mg)	Weight Changed / Uncorrected Wt
1 Left Filter	21.2	-6.39	0.30
1 Right Filter	18.15	-6.39	0.35
2 Left Filter	13.29	-6.83	0.51
2 Right Filter	11.0	-6.83	0.62
3 Left Filter	5.87	+2.78	0.47
3 Right Filter	3.35	+2.78	0.83
4 Left Filter	8.35	-4.75	0.57
4 Right Filter	2.10	-5.17	2.46*
5 Left Filter	5.13	-1.88	0.37
5 Right Filter	9.65	-1.68	0.17
6 Left Filter	27.64	-1.75	0.06
6 Right Filter	21.13	-1.73	0.08
7 Left Filter	26.97	-1.81	0.07
7 Right Filter	27.10	-1.86	0.07

Respirator filter weights without samples ranged from:
2296.18 mg to 2664.24 mg

$$\frac{\text{Average sample wt} = 14.38\text{ mg}}{\text{Average filter wt} = 2480.0\text{ mg}} = 0.0058 \approx 0.6\%$$

* Note: Sample weight taken as zero.

Table 2. Volatile Aromatic Hydrocarbons Analyzed
During Painting Operations

Ethlyene Dichloride	n-Octane
n-Heptane	Toluene
Isopropanol	1,1,1-Trichloroethane
Methyl Ethyl Ketone	Trichloroethlyene
Methycyclohexane	m-Xylene
Methycyclopentane	o-Xylene
	p-Xylene

The respirator cartridges were removed from the freezer, immediately opened, and the charcoal transfered into a 500 ml beaker. The charcoal was thoroughly agitated for one minute. Then five one-gram samples (ten for organic vapor samples #4 and #5) were selected from the beaker. The beaker was agitated between each sample. The samples were weighted in Miniert screw cap reaction vials to +/- .0005 grams. The results of the five (or ten) grab samples were averaged for each chemical constituent and multiplied by 52.

The respirator and breathing zone results were compared by mass collected per volume of air sampled. This concentration was calculated by dividing the measured mass collected on the filters by the volume of air that flowed through the respirator or sampling pump. The volume of air flowing through the sampling pump was determined by multiplying the average flowrate (pre-operation calibration and post-operation calibration) by the pump operating time. The respirator volumetric flowrate was calculated by a model adapted from predictions of human respiration during exercise.

Respirator Airflow Estimates:

Previous respirator pad studies [2, 3, 4, 5] have shown that the assumption of constant worker respiration over the sampling period leads to inconsistent results. This research determined the amount of air flowing through the respirator filters by a predictive human respiration model adapted from Hansen, et al [6]. Hansen's study predicted a range of expected breathing performance in normal subjects during exercise. Measurements of the rate of oxygen uptake (Vol Rate O_2; lpm) and expired minute ventilation (Vol Rate Exp; lpm) found different predictive ratios of Vol Rate Exp/Vol Rate O_2 at progressive stages of exercise (Table 3).

Table 3. Predictive Ratios of Expired Minute Volume to Rate of Oxygen Uptake at Progessive Levels of Exercise*

Vol Rate Expired (BPTS) / Vol Rate O_2 Required =

		= 32.2 +/- 12.1 (At Rest)
"	"	= 28.5 +/- 8.1 (At 0 Watts)
"	"	= 26.5 +/- 4.4 (At AT**)
"	"	= 37.7 +/- 6.9 (At Maximum Exercise)

** AT = Aerobic Threshold of Oxygen Required or Consumed
= 0.56 x Maximum Vol Rate O_2 Required

Vol Rate O_2 (max) = [Weight(kg) x (50.75 - 0.372 x Age(yrs))]

* From Hansen, et. al. [6]

The ratios are necessary because it is impossible to predict with any degree of accuracy the volume of air expired during exercise. However, it is possible to predict the volumetric rate of oxygen uptake with quite good precision [7]. From Hansen's research, the rate of oxygen uptake with no workload was predicted by the equation: Vol Rate O_2 (0 Watts) = 5.89 x W + 140, where W is the subject's body weight in kilograms. A worker's maximum possible volumetric rate of oxygen uptake was also predicted by the equation: Vol Rate O_2 (max) = W x (50.72 - 0.372 x A), where A is the worker's age in years. From these predictions, Hansen et. al. could determine a worker's total volume of expired (or inspired) air, if the total rate of oxygen required during the task is known.

The rates of oxygen required during the sampled operations were calculated in three steps. The first step was to estimate the total work rate (power) necessary for the worker to perform the operation. The second step was to subtract the worker's basal metabolic rate from the total work rate to determine the actual physical work rate of the operation. The final step was to calculate the worker's increase in the rate of oxygen required due to task. Then this increase was added to the rate of oxygen required at zero work rate (0 watts). This yielded a total rate of oxygen required (lpm) per work rate (watt) for the operation.

Ergonomic Estimates of Total Energy Required: An estimate of the operation work rate was determined from three (3) ergonomic references. Krager and Hancock [8] list work rates for average workers at specific operations. For this research, using Krager and Hancock's list, both sanding and painting require a total work rate of 3400 calories per minute. Passmore and Durnin [9] also list work rates for average workers at specific operations. Both sanding and painting require 2000 calories per minute using Passmore and Durnin's list. Salvendy [10] does not list work rates by specific operations, but uses estimates based on a worker's position and movement. A copy of Salvendy's values are listed in Table 4. All of these work rates are tabulated for a standardized man of 70 kilograms weight, 175 cm height and 30 years old.

Table 4. Estimated Energy Expenditure*

Position of Worker (A)	Net Energy Expended (kcal/min)
Sitting	0.3
Kneeling	0.5
Crouching	0.5
Standing	0.6
Stooping	0.8

Type of Work (B)	Net Energy Expended (kcal/min)	
One Arm Work	Light	0.7 - 1.2
"	Medium	1.2 - 1.7
"	Heavy	1.7 - 2.2
Both Arms Work	Light	1.5 - 2.0
"	Medium	2.0 - 2.5
"	Heavy	2.5 - 3.0

Estimated Energy Expenditure (kcal/min) = A + B
Note: 1.0 kcal/min = 69.735 Watts
* From Salvendy, Table 3.5.4 [10]

Basal Metabolic Rate: Ergonomic estimates provide the total power (work rate) required for a person to perform an operation [8,9]. The worker's basal metabolic rate must be subtracted from the total energy to determine the actual physical work rate. In living organisms the total power required for any activity is the sum of that power necessary for the organism to sustain basic metabolism at rest (basal metabolic rate) plus the power required to perform the activity (physical work rate). Therefore, the actual rate of physical work for any operation is the estimated ergonomic rate minus the basal metabolic rate. In this research the basal metabolic rate was determined by three methods:

1) Calculate the rate of oxygen required at rest as follows: Vol Rate O_2 (rest;ml/min.) = Vol Rate O_2 (0 Watts) = (5.89 x Weight (kg)) + 140 [6]. The power required at rest was then calculated from the inverse of 9.3 (+/- 1.35) milliliters of oxygen per minute required per watt required [6].

2) Calculate the rate of oxygen required at rest as follows: Vol Rate O_2 (rest;ml/min.) = Vol Rate O_2 (0 Watts) = (5.89 x Weight (kg)) + 140 [6]. The rate of energy required at rest was then calculated from the inverse of 11.5 milliliters of oxygen per minute required or consumed per watt required [11].

3) From a table of standard values for calories per hour per square meter of body surface area at various ages by sex [12]. These values are listed in Table 5. The body surface area was calculated as follows: Surface Area (m^2) = 0.007184 x (Weight (kg)) $^{0.425}$ x (Height (cm))$^{0.725}$.

Table 5: Basal Metabolic Rate in Calories per Square Meter of Body Surface Area per Hour at Various Ages as of Last Birthday*

Listing for Males

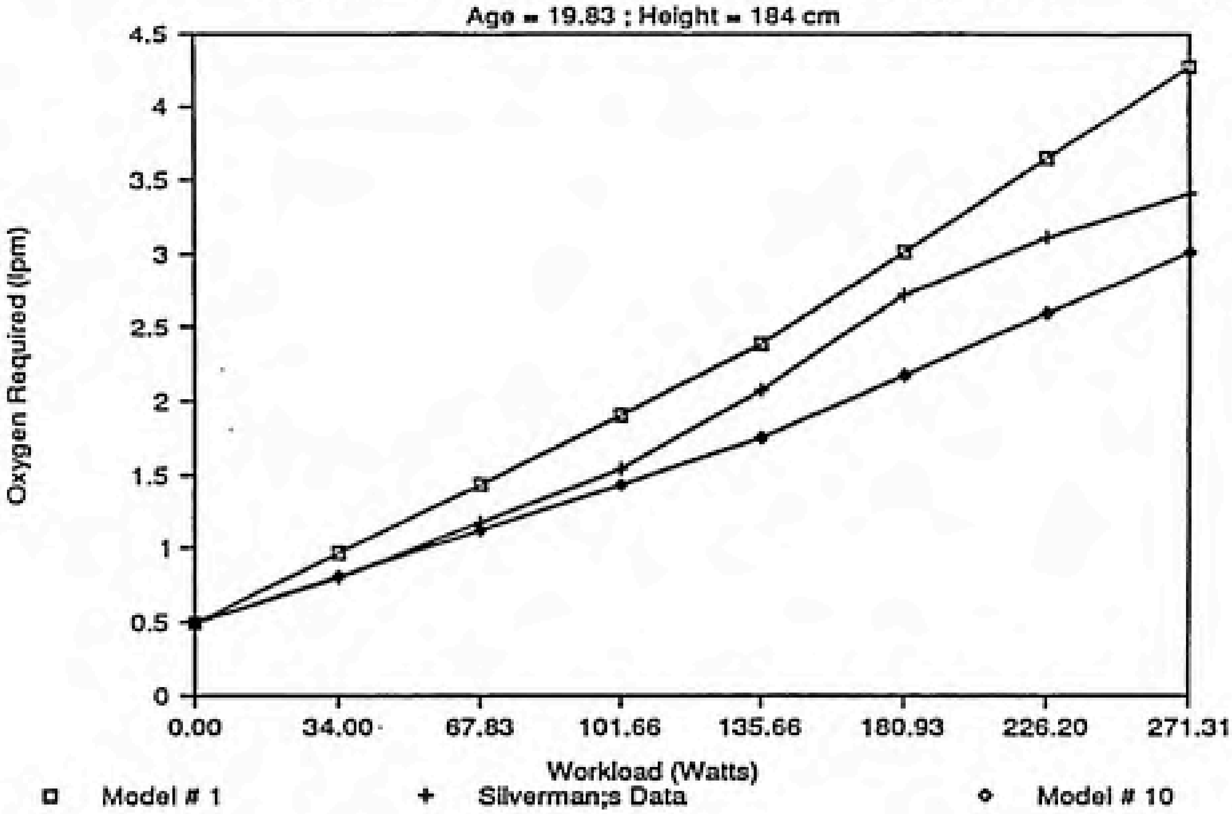
Age Last Birthday	Mean Value (Cal/m^2/hr)
19	42.32
19.5	42.00
20 - 21	41.43
22 - 23	40.82
24 - 27	40.24
28 - 29	39.81
30 - 34	39.34
35 - 39	38.68
40 - 44	38.00
45 - 49	37.37
50 - 54	36.73

* From Boothby, et. al. Table 4 [11].

Volumetric Rate of Oxygen Required Per Work Rate: With the actual physical rate known, the total rate of oxygen required per work rate was calculated from the rate of oxygen required at no work (0 Watts; see equation above) plus the increase in rate of oxygen uptake caused by the physical work rate. The increase in Vol Rate O_2 required per increase in work rate was determined from two (2) references. Hansen's [6] model assumed an increase of 9.3 (+/- 1.35) milliliters of oxygen per minute per increased watt of physical work rate (0.0093 lpm/watt). The Handbook of Respiration [11] assumed an increase of 13.94 milliliters of oxygen per minute per increased watt of physical work rate (0.01394 lpm/watt). Consequently, a worker's volumetric rate of oxygen (lpm of O_2), strictly due to the task, will be the power required by the task (watts) multiplied by the increase in Vol Rate O_2 per increase in work rate (lpm/watt). Finally, a worker's total volumetric rate of oxygen was calculated as the sum of the Vol Rate O_2 (0 Watts) plus the Vol Rate O_2 strictly due to the operation. To validate the calculation of total Vol Rate O_2 required during a task, these models were compared with published clinical data on ventilation rates with respiratory resistance at various workloads [13]. The models demonstrate excellent agreement as shown in Figure 3.

Total Volume of Air Expired: From the calculated total rate of oxygen required and the predicted ratios of Vol Rate Exp/Vol Rate O_2, the total volume of expired air was computed by knowing the duration of the task. Total volume of expired air = Total volmetric rate of oxygen X Vol rate expired/Vol rate O_2 X time of operation.

Figure 3: Workload vs. O2 Required



Combining these references and steps yielded eighteen (18) different models to estimate a worker's volume of air through a respirator. For this research it was assumed that the total expired volume equals the total inspired volume, even though the volume of inspired air is slightly larger than the volume expired [14]. This assumption was necessary because the volume of air through the respirator filter (or cartridge) will only include inspired air.

Another assumption was that no face seal leakage occurred during inhalation and therefore there was no penetration of the contaminant through the filter. Lastly, it should also be noted that none of these models consider increased worker breathing due to the resistance of increased respirator filter load. For the simplicity of the models and the short sampling times involved (maximum length was 2 hours), it was assumed that these factors were negligible.

Results and Discussion:

Operations sampled: There were seven dust/mist samples collected: four samples during sanding on painted metal, one sample while sanding on unpainted fiberglass, and two from spray painting procedures. In addition there were five organic vapor samples carried out during the spray painting operations. The subjects sampled were all males with ages ranging from 21 to 50 years (average = 26.3 years; standard deviation = 8.08 years). The lengths of operations sampled ranged from 20 to 120 minutes (average = 54.67 min; S.D. = 26.84 min). The seven dust/mist samples included four different individuals. The four sanding samples (#1, #2, #6, and #7) were all from the same person. The five organic vapor samples included three different individuals two of which were also included in the dust/mist samples (OV-#3 in dust/mist #3; OV-4 and OV-5 in dust/mist #4). In total, over the twelve samples, five (5) different individuals participated in the sampling. During all operations, except organic vapor samples #1 and #2, the respirators were worn during the entire breathing zone sampling period. During dust/mist samples #1, #2, #6 and #7, the subject also wore a full faceshield which partially blocked the respirator filters.

Observations of Operations: The sanding operations involved standing, sitting, stooping and kneeling, while the painting operations only involved standing and stooping (Appendix I). During organic vapor samples #1 and #2, the subject's respirator was removed each time the paint spray gun was refilled. However, the charcoal tube sampling pump was not shut off during refilling.

Refilling the spray paint gun was accomplished outside the paint spray booth on a table adjacent to a large open overhead doorway. The subject poured a mixture of paint, thinner and hardener into the paint spray-gun receptacle and agitated the mixture with a stick. The refilling operation lasted from 2 to 12 minutes. The paint spray gun would operate from 10 to 24 minutes between refills. For organic vapor sample #1, the paint spray gun was refilled seven (7) times for a total of 38 minutes. Organic vapor sample # 2 included four (4) refills for a total of 20 minutes. During the remaining organic vapor samples the worker was asked wear the respirator during paint spray gun refills.

General Trends of Raw Data: The weights of dust/mist sampling and organic vapor sampling may be found in Appendix II. Breathing zone samples during sanding operations measured from 0.47 to 5.29 milligrams (mg) of dust, while the respirator filters measured from 10.63 to 50.46 mg. The painting operations breathing zone mist samples ranged from 0.63 to 1.12 mg, while the respirator filters measured from 3.60 to 4.19 mg. There was no observable trend over the seven (7) samples between the ratio of respirator cartridge sample weight to breathing zone membrane filter sample weight. The ratios of the weights ranged from 3.7 to 25.3 and did not correspond to the length of sampling time.

Weight corrections for respirator filter pads by relative humidity ranged from -6.83 to +2.42 mg (Table 1). Weight corrections were not applied to the breathing zone dust/mist samples. In sample #4, the right cartridge respirator pad had a negative sample value when the weight correction was applied. In this case the sample value taken as 0 mg and the left respirator cartridge filter weight used for the total weight.

For all organic vapor samples the respirator cartridges measured more mass per constituent than the charcoal filter tube. There were no observable trends for the ratios of respirator cartridge constituent mass to charcoal tube constituent mass among or between samples (Table 6). However, for seven (7) constituents, 1,1,1-trichloroethane in OV Sample #1 (OV-1); isopropanol in OV Sample #2 (OV-2); m-xylene in OV Sample #3 (OV-3); isopentane, n-octane, and isopropanol in OV Sample #4 (OV-4); and n-hexane in OV Sample #5 (OV-5), the constituent was detected in the charcoal tube, but not in the respirator cartridges (first case). Three (3) constituents; methyl ethyl ketone and 1,1,1-trichloroethane in OV-3; and 1,1,1-trichloroethane in OV-5, were detected in the respirator cartridges, but not in the charcoal tube (second case). (See Appendix II).

Table 6: Ratios of Charcoal Tube to Respirator Organic Vapor Cartridge Sampling Results

Chemical	Samp # OV-1 BZ / Resp mg / mg	Samp # OV-2 BZ / Resp mg / mg	Samp # OV-3 BZ / Resp mg / mg	Samp # OV-4 BZ / Resp mg / mg	Samp # OV-5 BZ / Resp mg / mg
Methylcyclopentane	0.07	0.09	0.05	0.05	0.05
n-Heptane	0.09	0.10	0.05	0.06	0.03
Cyclohexane	0.02				
Methylcyclohexane	0.05	0.06	0.03	0.04	
n-Octane	0.05	0.06			0.03
Methyl Ethyl Ketone	0.16	0.07	0.00		0.04
Isopropanol			0.06		0.01
Trichloroethylene	0.07	0.08	0.03		0.05
Toluene	0.07	0.07	0.05	0.06	0.04
Ethlyene Dichloride	0.10	0.09	0.15		0.06
p-Xylene	0.07	0.06	0.04	0.06	0.04
m-Xylene	0.05	0.05			0.04
o-Xylene	0.06	0.05	0.04	0.08	0.03

Model #17 used for resp vol Chemical	Samp # OV-1 BZ / Resp mg/m^3 / mg/m^3 (note 1)	Samp # OV-2 BZ / Resp mg/m^3 / mg/m^3 (note 2)	Samp # OV-3 BZ / Resp mg/m^3 / mg/m^3	Samp # OV-4 BZ / Resp mg/m^3 / mg/m^3	Samp # OV-5 BZ / Resp mg/m^3 / mg/m^3
Methylcyclopentane	1.00	2.01	1.88	1.74	1.29
n-Heptane	1.19	2.37	2.41	2.19	1.18
Cyclohexane	0.22				
Methylcyclohexane	0.67	1.40	1.56	1.34	
n-Octane	0.75	1.51			1.18
Methyl Ethyl Ketone	2.27	1.64	0.00		1.32
Isopropanol			2.99		0.19
Trichloroethylene	0.99	2.07	1.49		1.60
Toluene	0.99	1.78	2.55	2.16	1.22
Ethlyene Dichloride	1.44	2.24	7.42		2.01
p-Xylene	0.92	1.39	2.17	2.34	1.35
m-Xylene	0.75	1.16			1.28
o-Xylene	0.81	1.13	1.79	2.80	2.94

Note 1: BZ result includes 38 minutes during refilling when respirator not worn.
Note 2: BZ result includes 20 minutes during refilling when respirator not worn.

The detection of some constituents in one method and not the other were probably caused by two different events. In the first case, the detection of constituents in the charcoal tube, but not in the respirator cartridge was probably caused by the greater analytical sensitivity of the charcoal tube. The constituents were detected in relatively low quantities in the charcoal tubes and thus may have been present in the respirator cartridges, but below detectable limits. The analytical detection limit of the respirator cartridges was over ten times (10x) higher (i.e. less sensitive) than the charcoal tubes. This was a consequence of the application of grab sampling from the total weights of charcoal in the respirator filter cartridges. In the charcoal tubes, the entire samples of activated charcoal were analyzed.

In the second case constituents were detected in the respirator cartridge but not in the charcoal tube. This was probably caused by contamination of the respirator cartridge samples. In both samples where this event occurred (OV-3 and OV-5) the respirator cartridges were stored in the laboratory the longest amount of time before analysis (up to 30 days). In addition, the constituents were detected in fairly low concentrations and with very poor precision. In two cases, methyl ethyl ketone in OV-3 and 1,1,1-trichloroethane in OV-5, the precision was so inadequate that the standard deviation of the analysis was greater than the actual amount detected.

Respirator Air Flow Models: The volume of air sampled through a worker's respirator was calculated from a model developed by

Hansen, et al. [6] and modified with respect to increased rate of oxygen required per increase in work rate (lpm/watt); the total work rate required for the operation (watts); and basal metabolic rate (watts). All 18 models were applied to each of the seven dust/mist samples (see Appendix III). Models were rejected if the required total volumetric rate of oxygen (lpm) for the operation exceed the subject's calculated maximum possible volumetric rate of oxygen. For models that calculated total work rate required based on the worker's position (i.e. standing, walking; models #4, #5, #6, #13, #14, and #15), any model was rejected even if only one subject position in one sample met this criteria. Of the 18 models only five (5) were acceptable for all the dust/mist samples. The acceptable models are annotated in Table 7.

To determine if the accepted models provided legitimate estimates of total inspired volume, the calculated rates of expiration were compared to published ventilatory patterns measured during exercise [5]. Published studies measured expired minute volumes of 20.0 (+/- 5.5) lpm up to 93.3 (+/- 23.0) lpm at various stages of exercise. The acceptable respirator air flow models from this research calculated an average expiration rate of 56.3, 46.4, 43.0, 37.0, and 55.0 lpm for models #8, #13, #16, #17, and #18, respectively. All of the models fall within a range of expiration rates that would indicate a moderate level of exercise, which was expected from operations such as sanding and painting.

Table 7: Acceptable Dust/Mist Sample Models

Model Number		Sample Subject Exceed Maximum Oxygen Flowrate	Sample #(s)Where Maximum O_2 Flow Is Exceeded
1	V11-E8-R11	YES	1,2,3,4,5,6,7
2	V11-E8-R6	YES	1,2,3,4,5,6,7
3	V11-E8-R12	YES	1,2,3,4,5,6,7
4	V11-E10-R11	YES	5
5	V11-E10-R6	YES	5
6	V11-E10-R12	YES	1,2, 5,6,7
7	V11-E9-R11	YES	5
8	V11-E9-R6	NO	none
9	V11-E9-R12	YES	5
10	V6-E8-R11	YES	5
11	V6-E8-R6	YES	5
12	V6-E8-R12	YES	1,2, 4,5, 7
13	V6-E10-R11	NO	none
14	V6-E10-R6	YES	5
15	V6-E10-R12	YES	1,2, 5,6,7
16	V6-E9-R11	NO	none
17	V6-E9-R6	NO	none
18	V6-E9-R12	NO	none

Model Codes:

Increased Volume Rate Oxygen Required Per
Increase in Actual Physical Work Rate:

Vol Rate O_2 (0 Watts) = (5.89*Wt(kg)+140)/1000 [lpm]
V11-XX-XX = From Reference 11: 0.01394 lpm O_2 required/watt
V6-XX-XX = From Reference 6: 0.0093 lpm O_2 required/watt

Ergonomic Estimate of Total Energy Required:

XX-E8-XX = From Reference 8: 3400 cal/min (238 Watts)
XX-E10-XX = From Reference 10: see Table 4.
XX-E9-XX = From Reference 9: 2000 cal/min (140 Watts)

Basal Metabolic Rate:

Vol Rate O2 (rest) = Vol Rate O_2 (0 Watts) [lpm]
XX-XX-R11 = From Reference 11: 71.74 watt/lpm O2 rest
XX-XX-R6 = From Reference 6: 107.53 watt/lpm O2 rest
XX-XX-R12 = From Reference 12: see Table 5.

Particle Sizing of Dust/Mist Samples: Particle sizing was conducted to distinguish discrepancies between initial sanding and painting sampling results. By comparing particle sizes with published data, it was possible to determined if the operations were representative of typical industrial processes. During dust/mist samples #2 (sanding) and #3 (painting), 5 and 10 minute samples were obtained for particle sizing. The samples were taken in the breathing zone of the subject during the operation with a membrane filter cassette (0.8 um matched weight). The sampling pump was calibrated to 2.0 lpm. The samples were optically sized with a porton graticule (Ernst Leitz Wetzler Binocular Microscope; 12.5x eyepiece, 10x object). The porton graticule was calibrated with a stage micrometer. The corresponding diameters of the porton numbers were determined by linear regression (Appendix V).

The results of sizing the 5 and 10 minute spray painting samples were identical. A count of 9 fields in each sample measured particle sizes ranging from 0.716 to 16.84 micrometers. The count median aerodymanic diameters (CMAD) were 0.716 microns and the mass median aerodynamic diameters (MMAD) were 5.44 microns. This result agrees with the results by Chan, et al. [15] who measured MMAD of 4.7 - 6.6 microns for conventional air-atomized paint spray guns.

Likewise, the results of the 5 and 10 minute sanding samples were identical. A count of 9 fields in each sample measured particle diameters from 3.74 to 76.0 microns, with a CMAD of 7.934 microns and MMAD of 52.1 microns. The approximate 10 fold increase in MMAD for sanding versus painting is anticipated because of the abrasive method in which particulates were generated during sanding.

Trends of Calculated Data for Dust/Mist Samples: For all of the acceptable models, the dust/mist breathing zone results were 1.5 to 2.2 times the respirator filter samples (See Appendix III). Respirator flowrate models #13 and #18 determined the respirator concentrations for all dust/mist operations less than the comparable breathing zone results. Only in samples #1 and #2 (sanding operations) with respirator flowrate models #8, #16 and #17 did the respirator filter results exceed the breathing zone values. Figures 4 - 8 show dust/mist sampling results by respirator filter versus breathing zone results for respirator flow rate models #8, #13, #16, #17 and # 18, respectively. Linear regression (with a zero intercept) of all dust/mist sample results produced coefficients of 2.22 (model #8), 1.79 (model #13), 1.57 (model #16), 1.47 (model #17), and 1.89 (model #18) for breathing zone (BZ) versus respirator filter pad (RFP) results (i.e. BZ = coefficient X RFP).

There were several reasons why the respirator filter pad results could be less than the breathing zone values. One possibility was a poor fitting respirator. In this research, one of the assumptions necessary to model airflow through a respirator was no respirator face seal leakage during inhalation. However, after one painting sample there was irrefutable physical evidence of mask leakage. Paint spots were visible around the subject's nose where the respirator should have provided a tight seal. If the respirator

Figure 4: Dust/Mist BZ vs. Resp Results

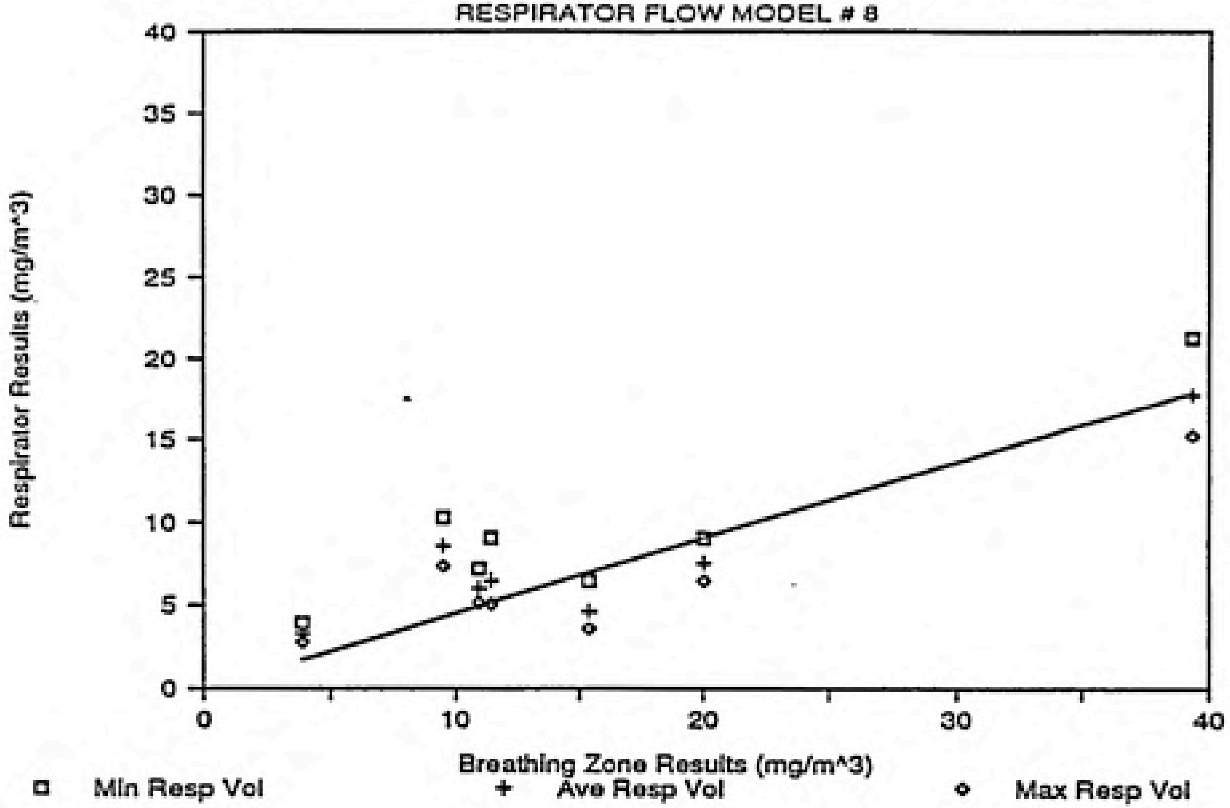


Figure 5: Dust/Mist BZ vs. Resp Results

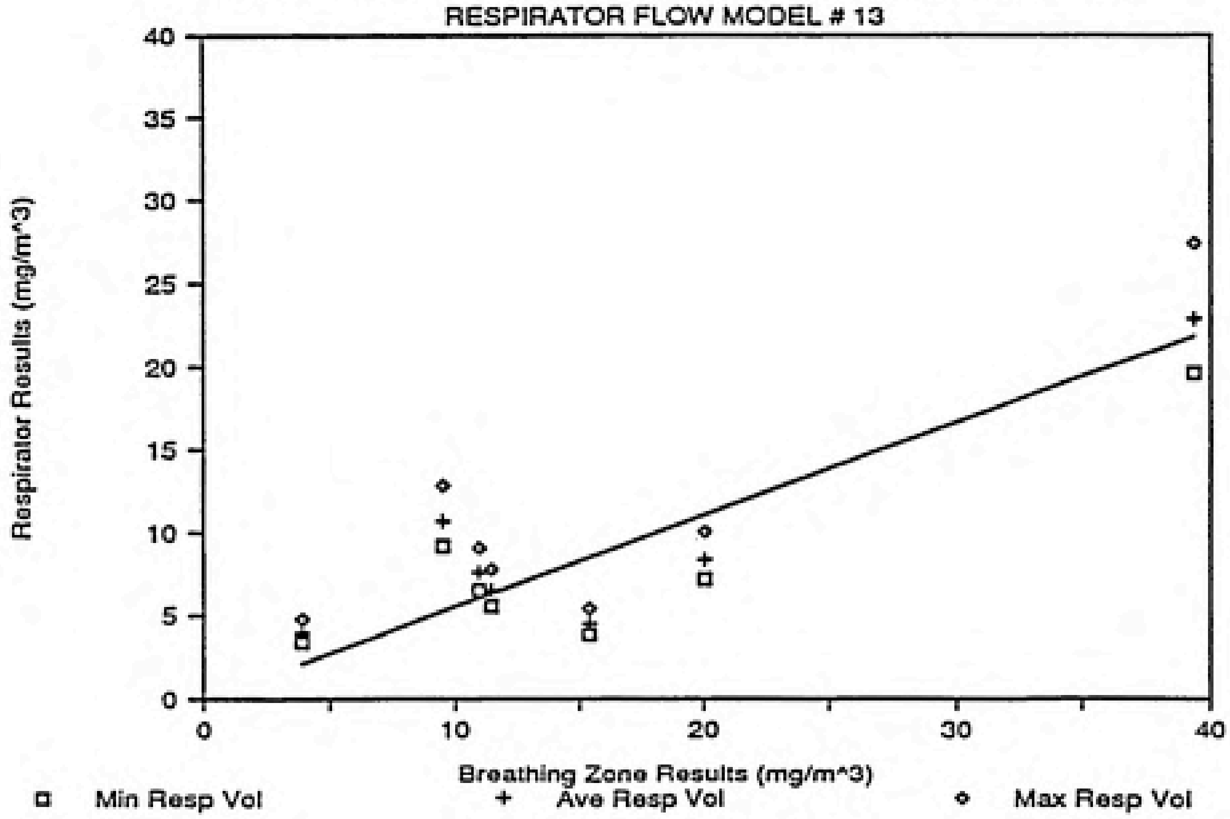


Figure 6: Dust/Mist BZ vs. Resp Results

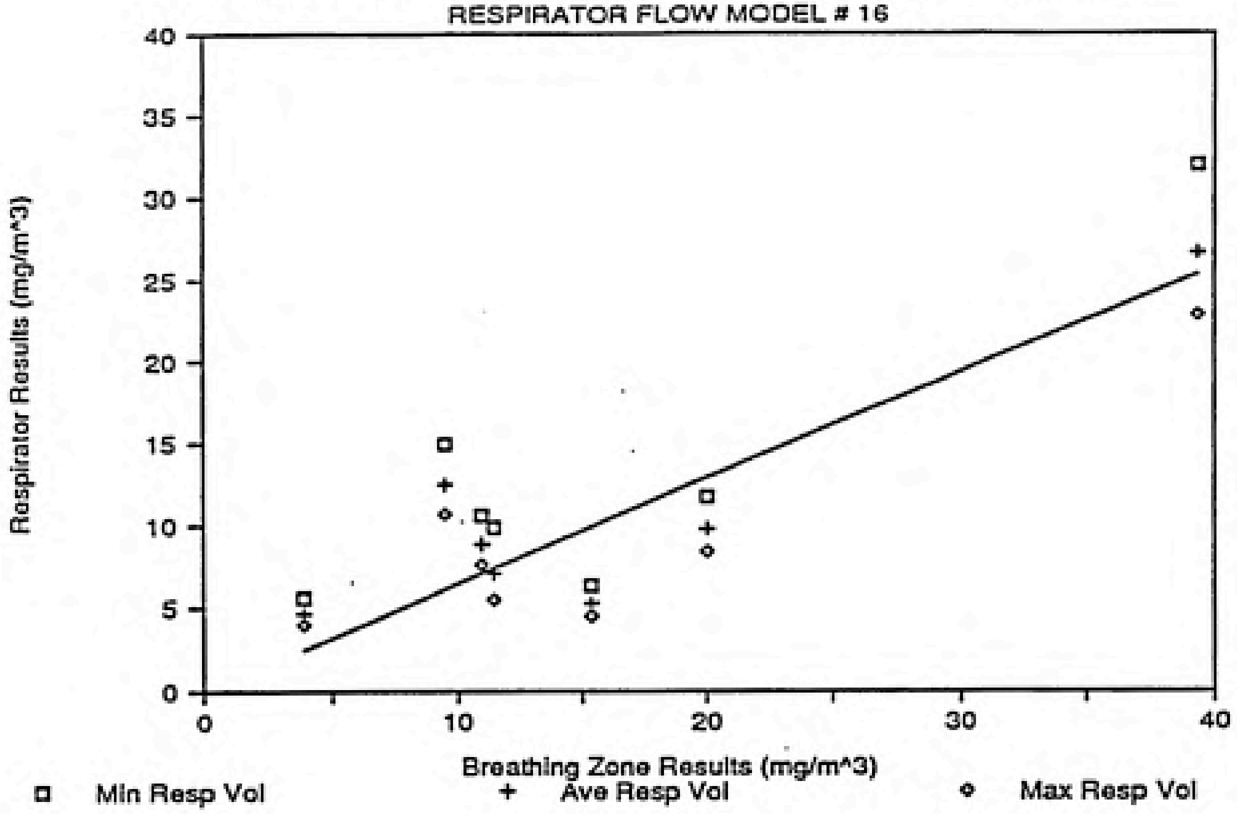


Figure 7: Dust/Mist BZ vs. Resp Results

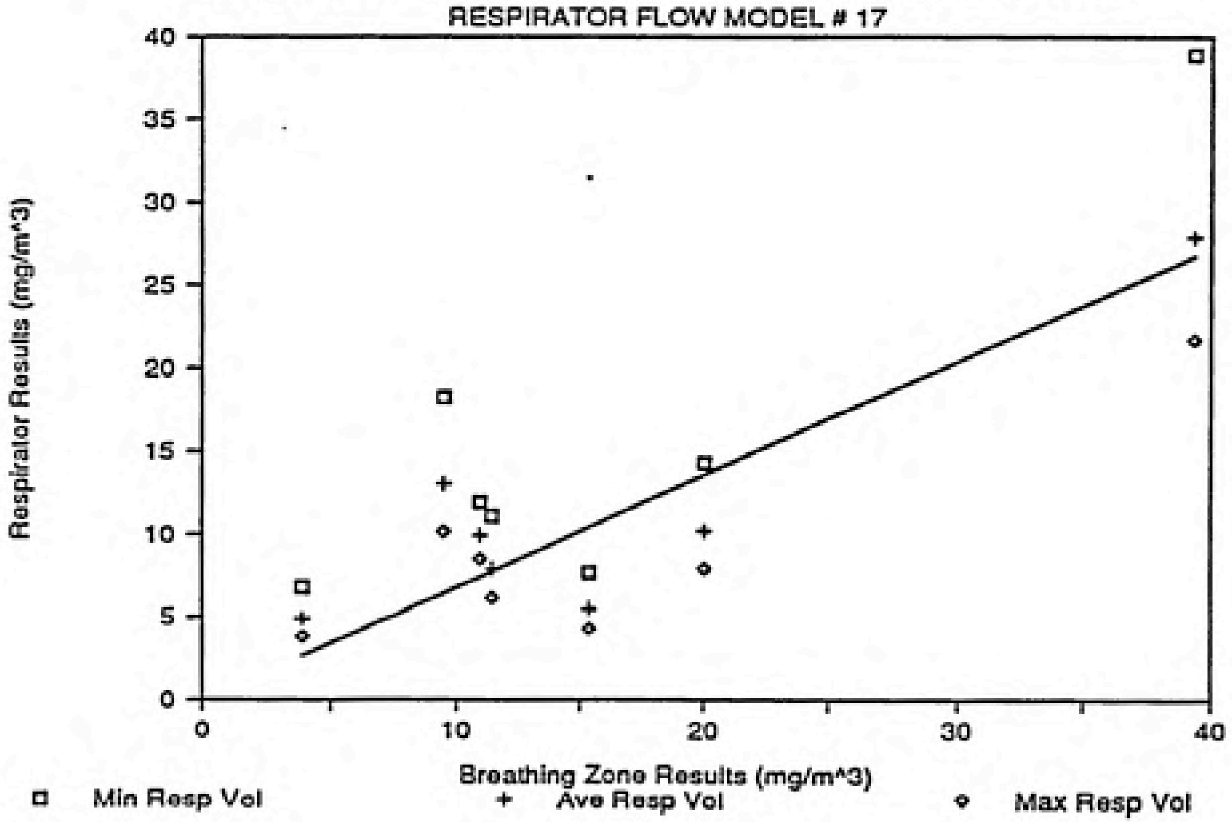
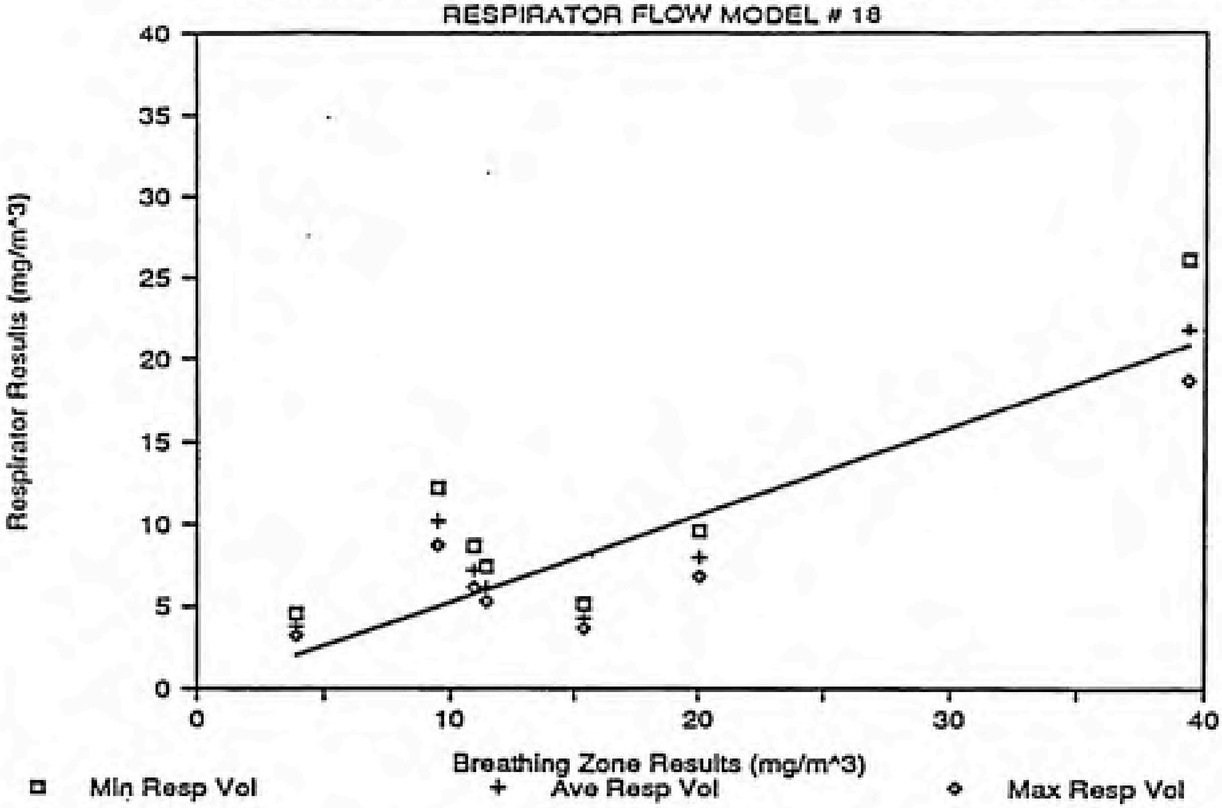


Figure 8: Dust/Mist BZ vs. Resp Results



fit were deficient, the flow of air through the filter pads would be diminished, thus decreasing the amount of paint mist deposited on the filter.

Another possibility was the influence of the faceshield blocking the respirator filters, but not the breathing zone cassette filters, for samples #1, #2, #6, and #7. The faceshield would impede the impaction of large particles onto the respirator pads. This is significant because of the relatively large particle sizes (MMAD 52 um) of the sanding dust. However, the effect of the faceshield would make the respirator pads more representative of the true breathing zone concentration. The cassette filter sample, being outside the faceshield, would overestimate the particulate concentration susceptible to inhalation. This was analogous to studies that indicated the concentrations of welding fumes outside a welders helmet were 3.3 - 15 times the concentration inside the helmet [16].

A third possiblity for discrepancies were errors in determining the sample weights deposited on the respirator filter pads. The corrections to respirator filter weight due to changes in relative humidity in the laboratory (Table 1) were based on limited data (4 filters @ 14 days). Because comparatively minute variations in relative humidity corresponded in several samples (#2 and #4) to large deductions in sample weight, small errors in the relative humidity correction factor lead to significant differences in the amount of sample detected.

Additional factors that would have effected this difference were loss of sample during storage/transport and errors in analytical balance measurements. However, these additional factors are considered negligible.

Statistical Analysis for Dust/Mist Samples: The breathing zone and respirator cartridge sampling results were compared using a Paired Student-t test protocol (MYSTAT Ver 2.0, Copyright (c) 1988, Systat Inc., Evanston, Il). The analysis determined if there was a significant difference between the sampling means of the respirator filter concentrations versus the breathing zone sampling pump concentrations for the dust/mist sample. All five of the acceptable respirator airflow models (average flowrates) were employed for the comparison. Because the models provided a range of possible respirator flowrates, the lower limits of this range (mimimum flow rates) were also used to calculate resprator filter concentrations. The minimum flowrate concentrations were then compared to the breathing zone results.

The results of paired student-t tests are listed in Table 8. Of the five (5) acceptable respirator flow rate models, only model #17 maintained no significant difference (95% confidence level) between the breathing zone and respirator filter values for dust/mist samples. For minimum flow rate values of acceptable respirator models, all of the models have no significant difference between the breathing zone and respirator filter pad results. This outcome suggests that the respirator flow rate models overestimated the actual worker inspiration rates. However, operational differences such as the faceshield covering during sanding and leaks around the edge of the respirator during painting interfered with quantifying this difference.

Trends of Calculated Data for Organic Vapor Samples: Respirator airflow model #17 was the only model to show no significant differences between the respirator and breathing zone dust/mist concentrations. Therefore, all of the respirator cartridge sampling results utilized this model for calculating workplace concentrations. The organic vapor sampling results indicated the breathing zone charcoal tube constituents were 1.5 to

Table 8: Paired Student-t Test Results

Average	Breathing Zone Versus	Mean Difference	Std. Dev. Difference	T Value	P Value
	" " ALL DUST / MIST SAMPLES " "				
	Model #8	6.650	6.585	2.636	0.030
Average	Model #13	8.376	7.384	3.001	0.038
Flow	Model #16	5.123	6.034	2.246	0.045
Rate	Model #17	4.449	5.965	1.973	0.088*
	Model #18	7.019	6.770	2.743	0.027
	Model #8	4.723	5.954	2.099	0.081*
Minimum	Model #13	6.189	6.834	2.396	0.054*
Flow	Model #16	2.801	5.574	1.330	0.232*
Rate	Model #17	0.227	5.439	0.110	0.916*
	Model #18	5.271	6.121	2.279	0.063*
	" " ALL DETECTED ORGANIC VAPOR CONSTITUENTS " "				
Ave	OV-1 (all)	0.571	2.792	0.678	0.513*
Flow	OV-2 (all)	3.655	4.004	3.028	0.013
Rate**	OV-3 (all)	2.746	3.914	2.219	0.054*
	OV-4 (all)	2.613	4.800	1.440	0.200*
	OV-5 (all)	0.616	8.141	0.251	0.807*
	" " SPECIFIC ORGANIC VAPOR CONSTITUENTS " "				
	Methylcyclo-pentane	0.286	0.267	2.397	0.075*
Ave	n-Heptane	1.396	1.396	2.281	0.085*
Flow	Toluene	7.434	5.421	3.066	0.037
Rate**	p-Xylene	0.806	0.638	2.826	0.048
	o-Xylene	0.348	0.619	1.257	0.277*

Note: OV = organic vapor (volatile aromatic hydrocarbons) samples (all constituents; See Table 5)

* = No statistically significant difference at 95% confidence level

** = Using Respirator Flow Model # 17

2.5 times greater than the respirator cartridge constituents. There was a general trend in the ratios of respirator cartridge to charcoal tube (breathing zone) results within and between samples. Within a sample the ratios were fairly constant among the constituents, allowing for confidence limits due to the analytical procedure. The ratios were about 1.0, 1.75, 2.7, 2.1 and 1.5 for samples OV-1, OV-2, OV-3, OV-4, and OV-5, respectively, with confidence allowances. However, OV-1 and OV-2 involved breathing zone charcoal tube sampling while the worker refilled the paint gun and did not wear the respirator. To correct for this discrepancy, the exposures to the charcoal tube during the refill operations were assumed to be zero and the concentration adjusted by subtracting the duration of the refill operations (38 minutes in OV-1; 20 minutes in OV-2) from the total sampling time. The adjusted ratios of breathing zone charcoal tube concentrations to respirator cartridge concentrations were 1.7 (OV-1) and 3.0 (OV-2). Disregarding the results of OV-1 and OV-2 because of the inconsistencies in exposure measurements, the ratios of charcoal tube to respirator cartridge concentrations were fairly uniform approximately 2.0.

Figures 9 through 13 display the respirator cartridges results versus charcoal tube (breathing zone) results for all the organic vapor constituents detected. From linear regression (with intercept at zero) the coefficient of charcoal tube to respirator cartridge constituents were 1.06 (OV-1), 1.71 (OV-2), 1.94 (OV-3), 1.43 (OV-4), and 0.59 (OV-5). Figures 14 - 18 exhibit comparisons of individual constituent results for methylcyclopentane, n-heptane,

Figure 9: Organic Vapor Sample # 1

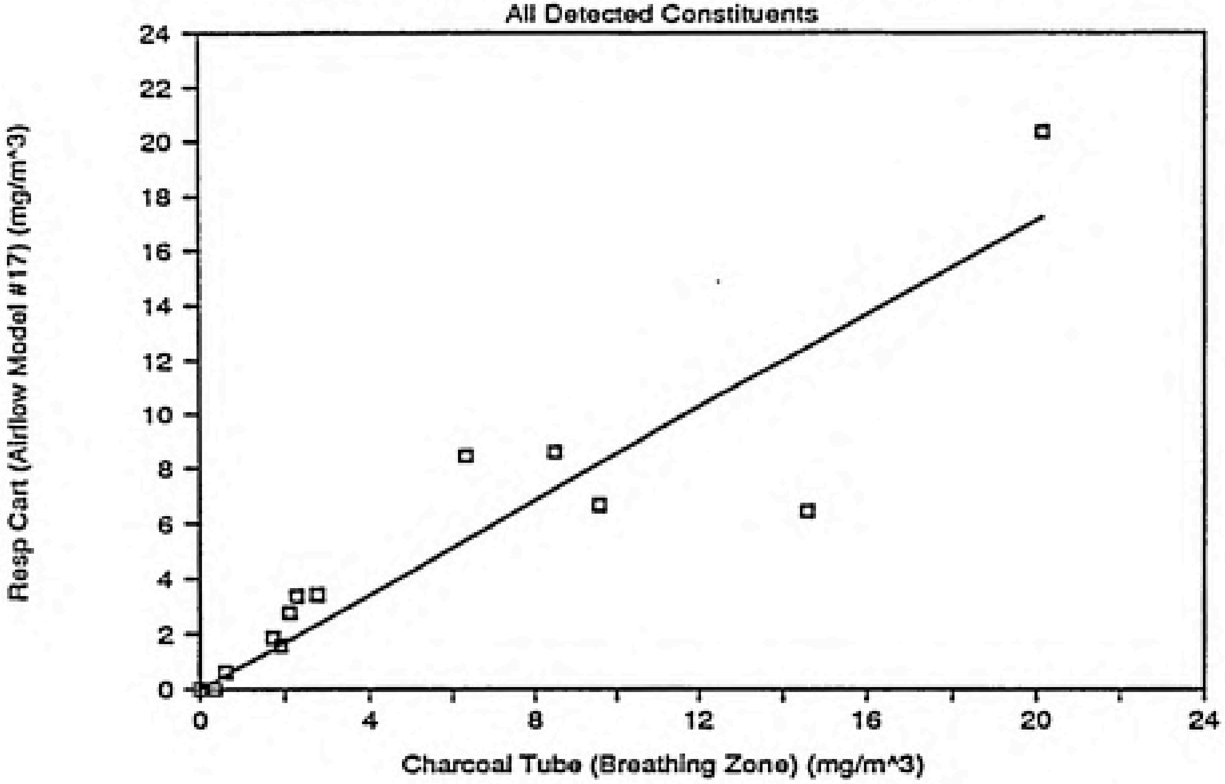


Figure 10: Organic Vapor Sample # 2

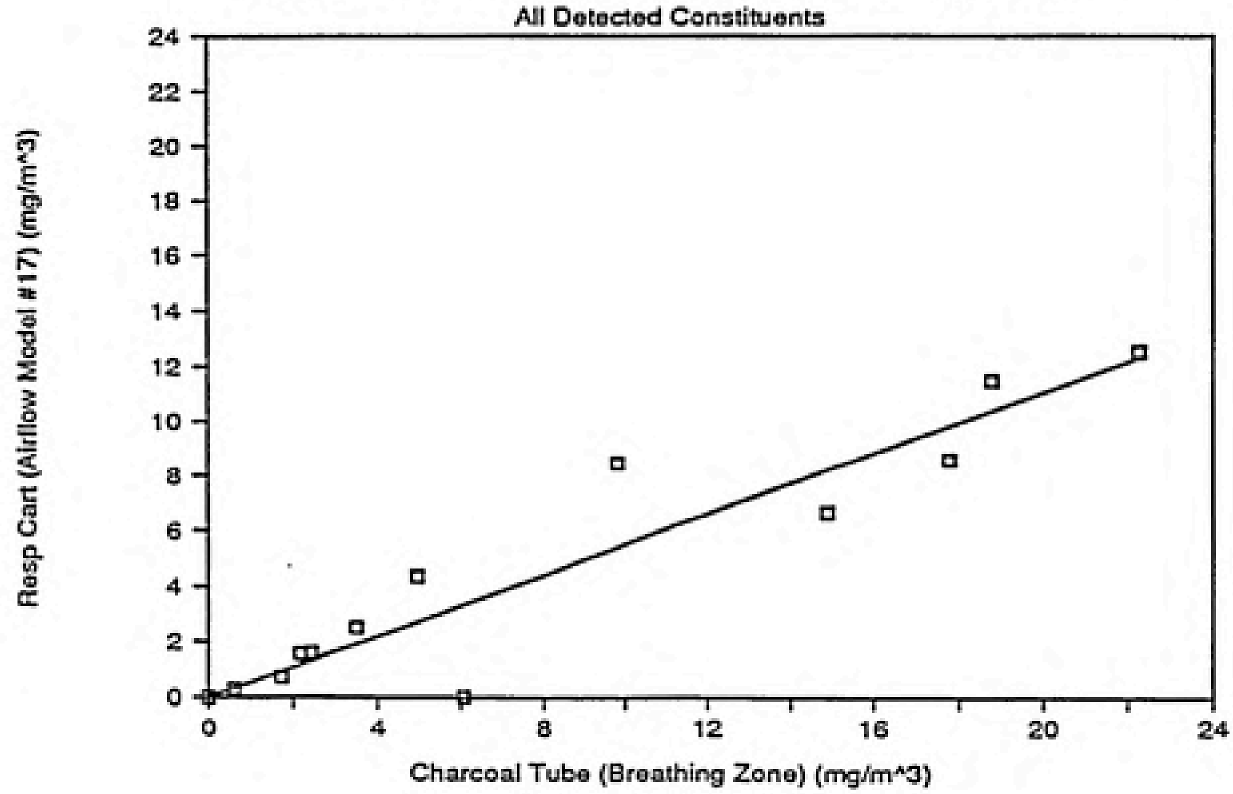


Figure 11: Organic Vapor Sample # 3

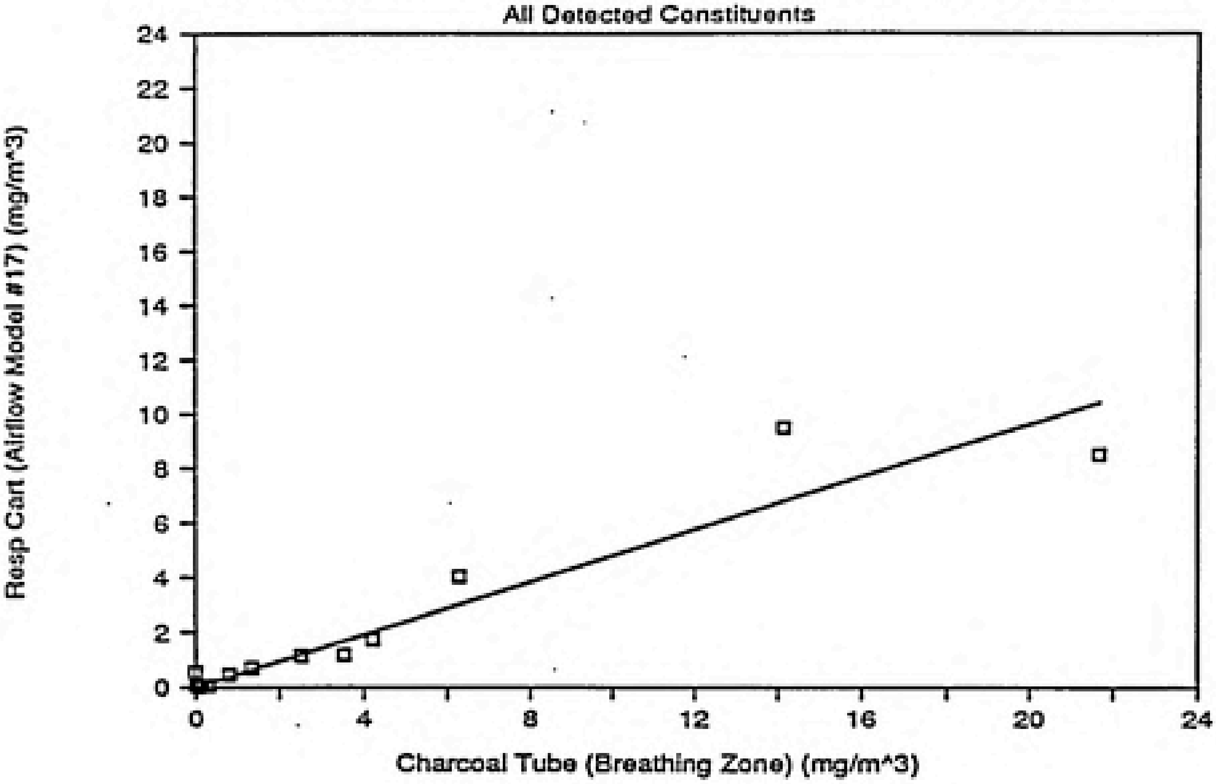


Figure 12: Organic Vapor Sample # 4

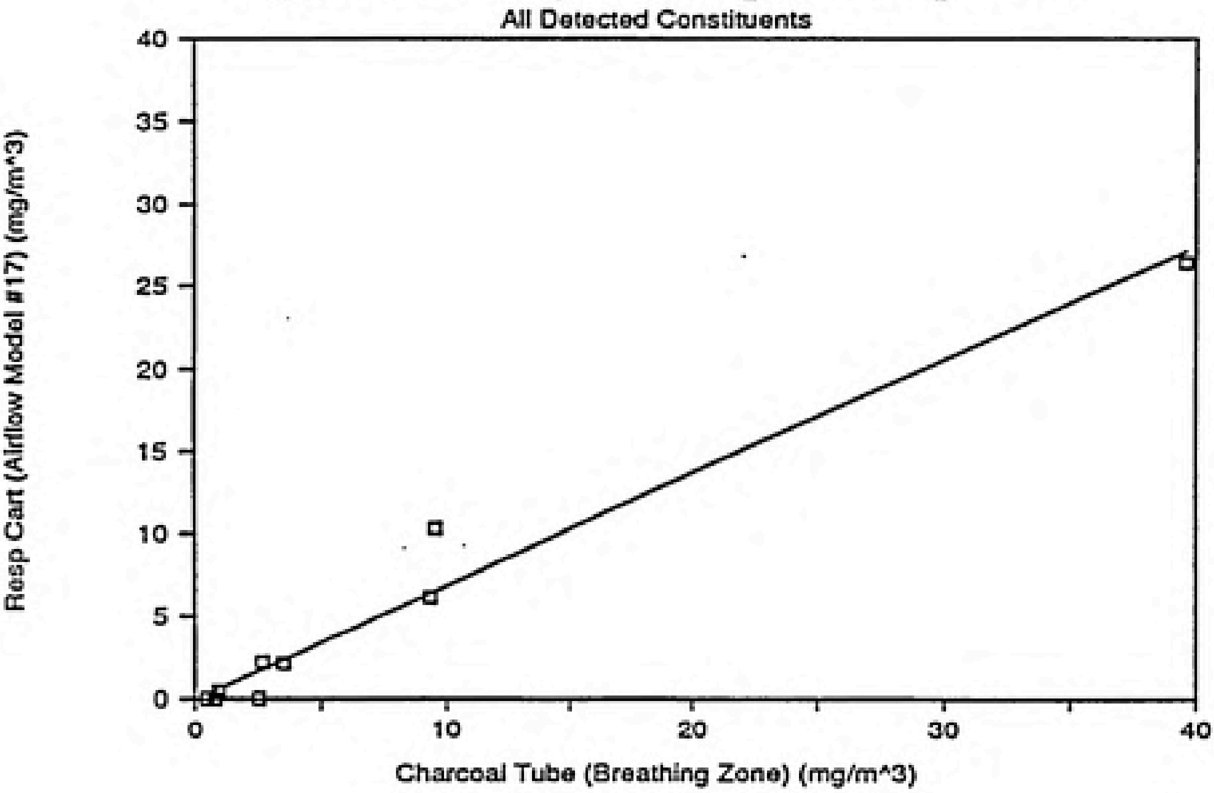


Figure 13: Organic Vapor Sample # 5

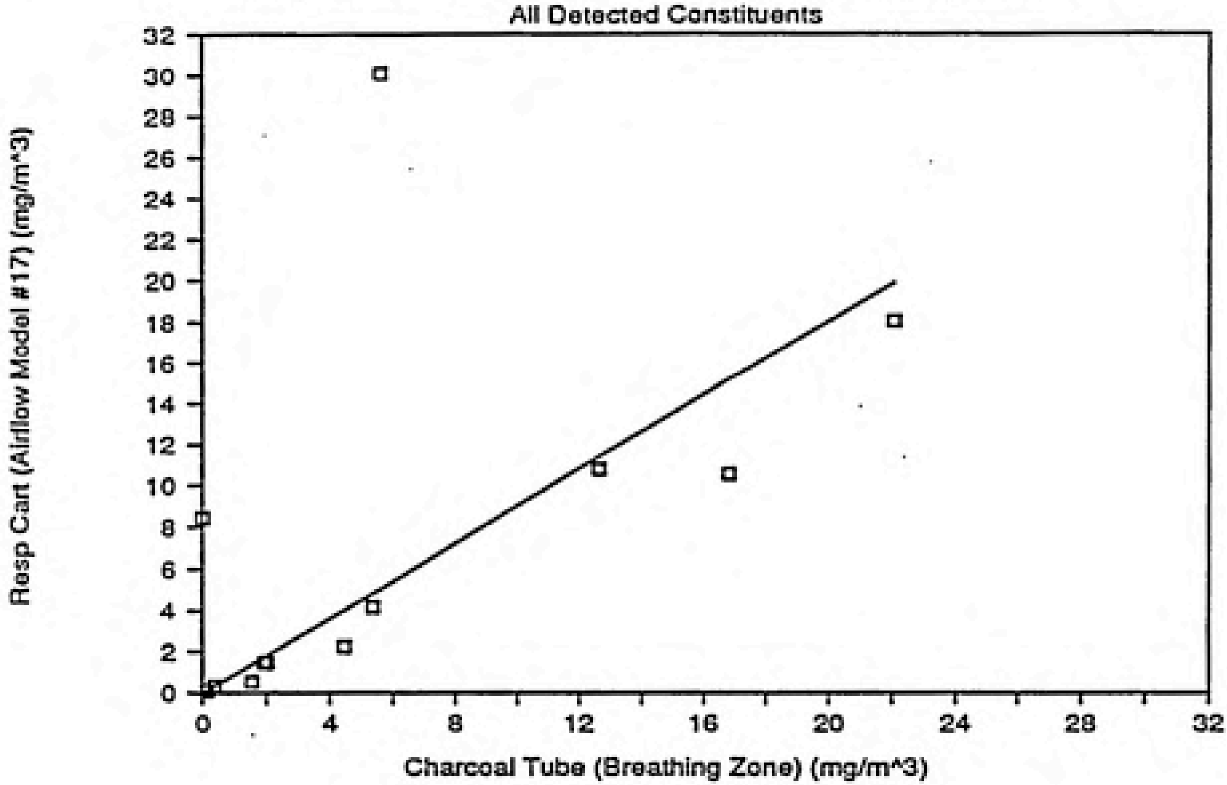


Figure 14: Organic Vapor Sample Results

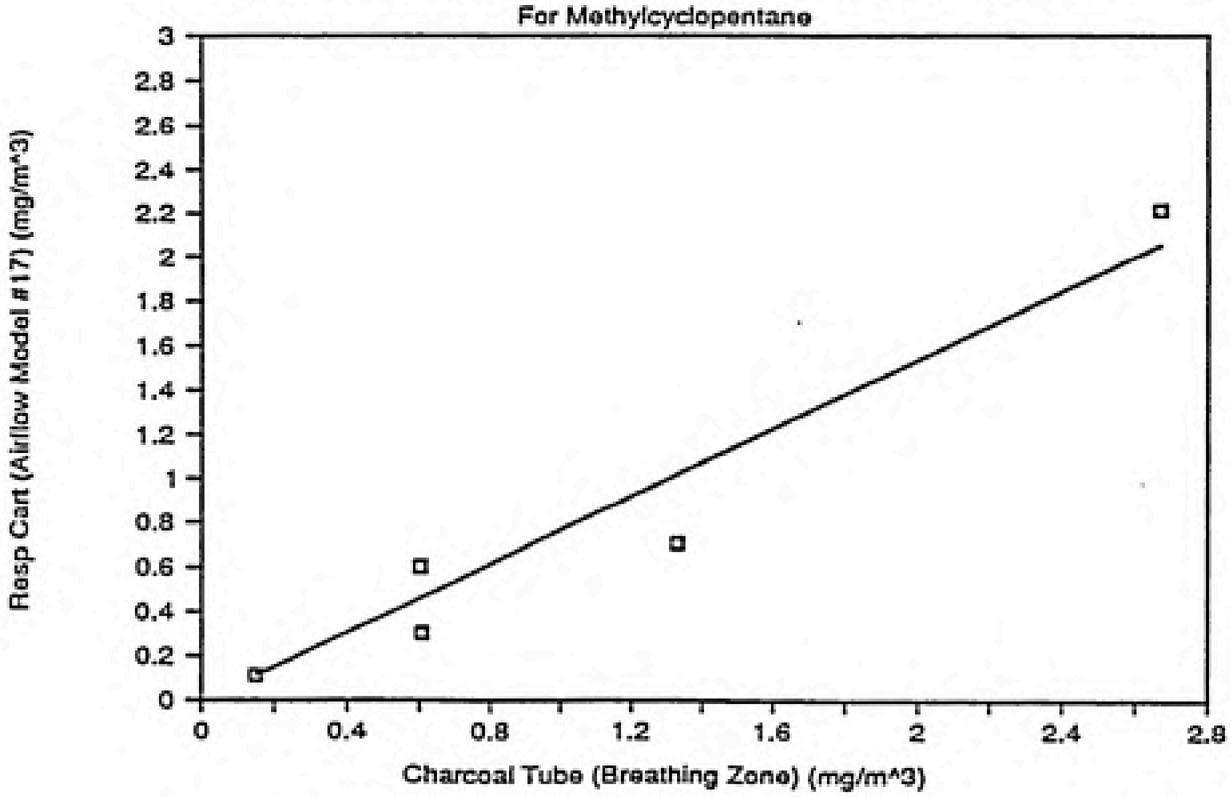


Figure 15: Organic Vapor Sample Results

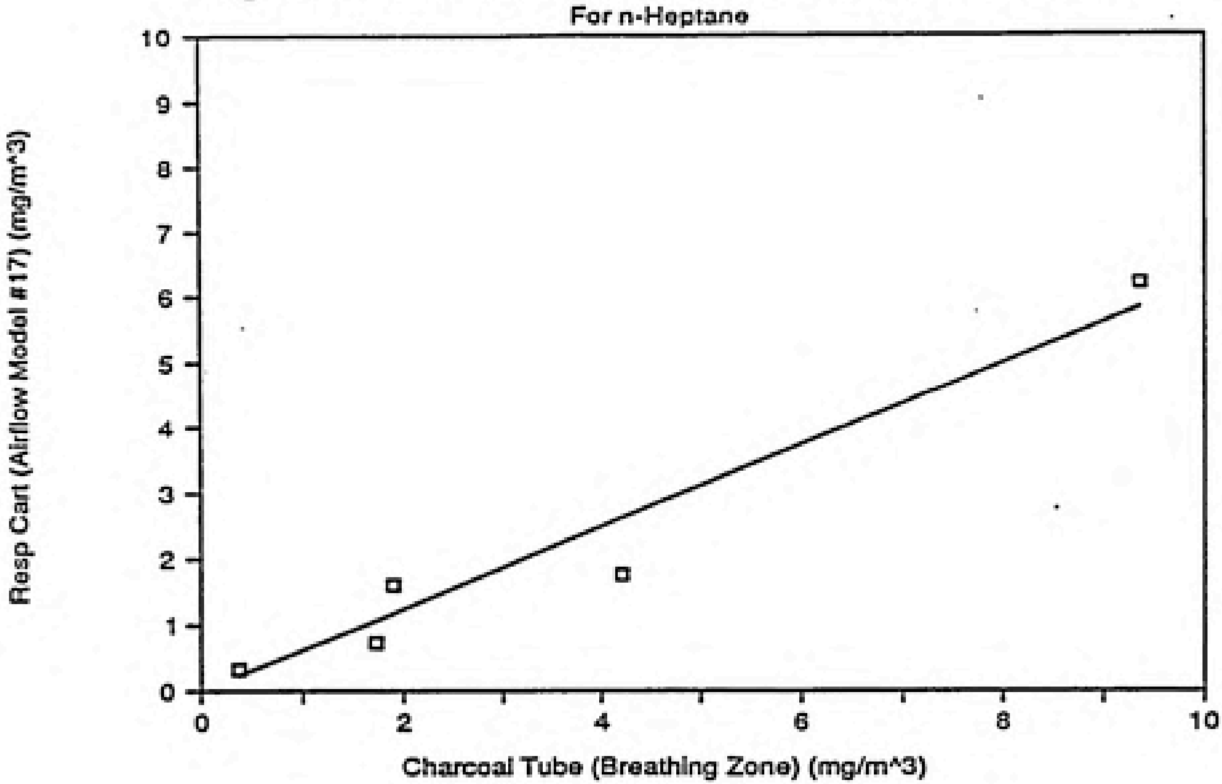


Figure 16: Organic Vapor Sample Results

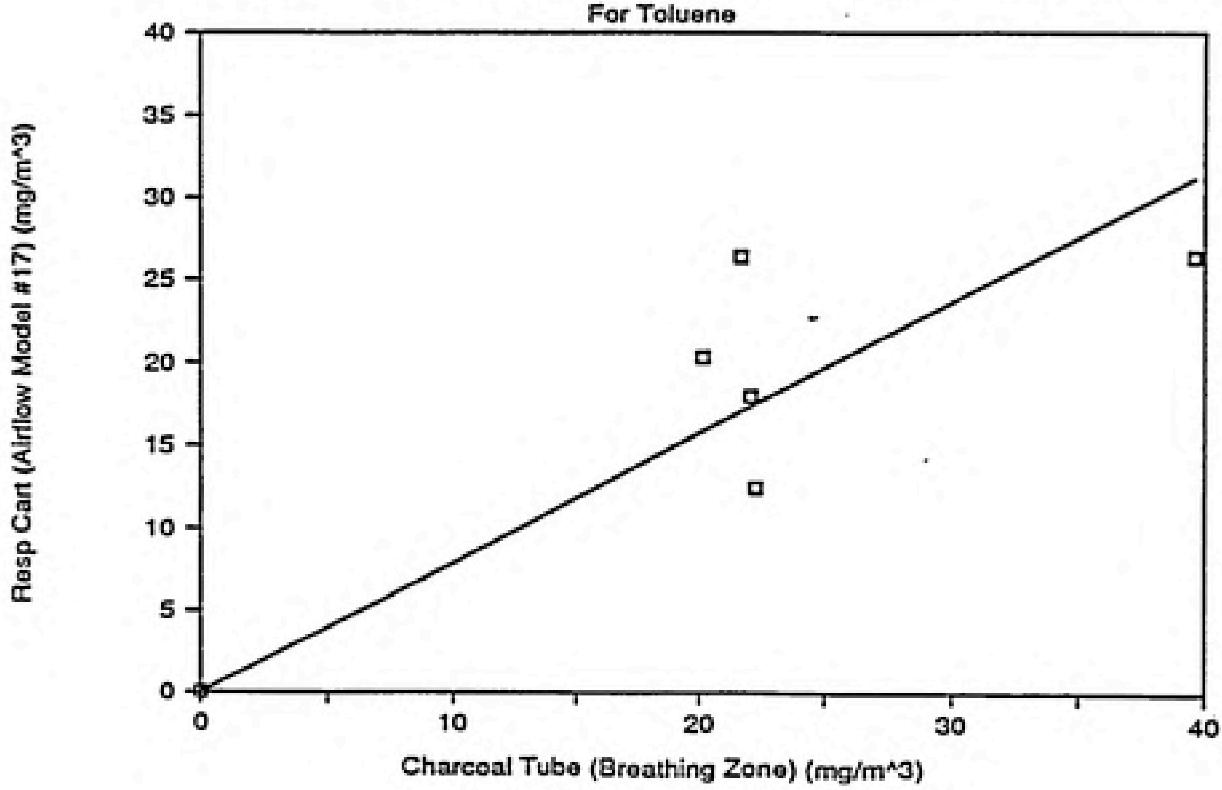


Figure 17: Organic Vapor Sample Results

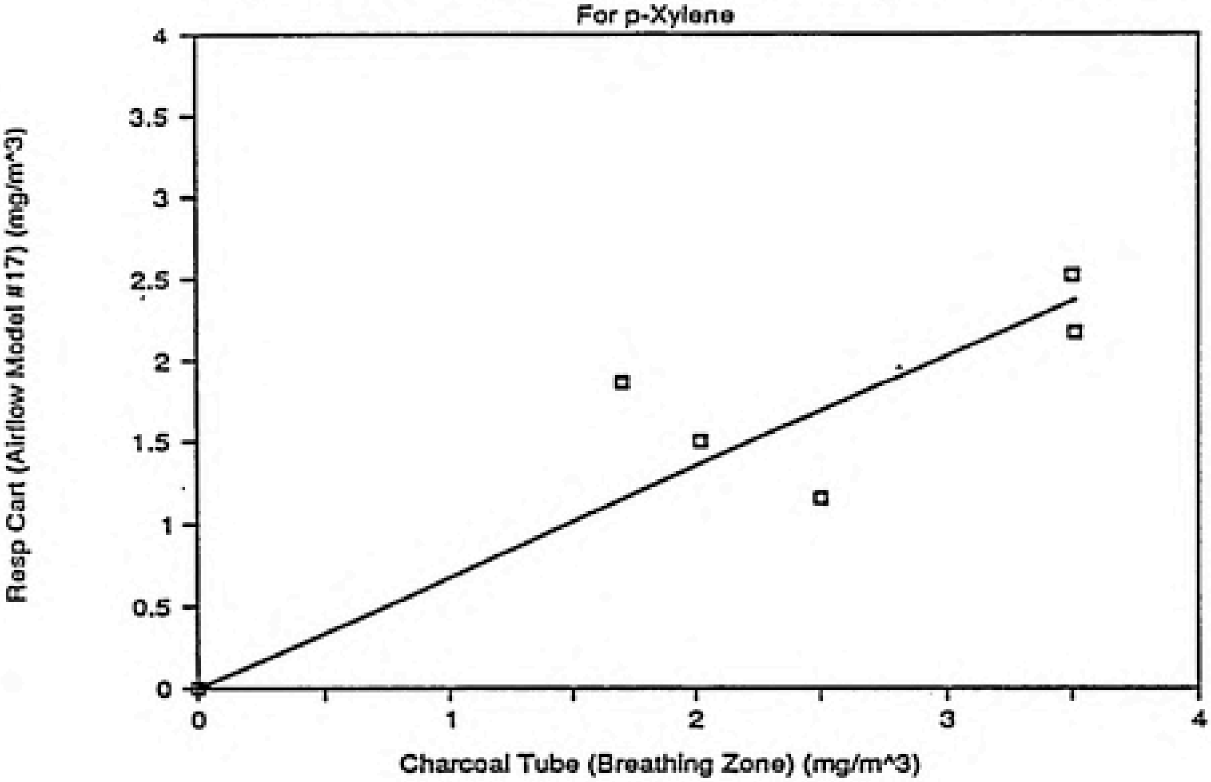
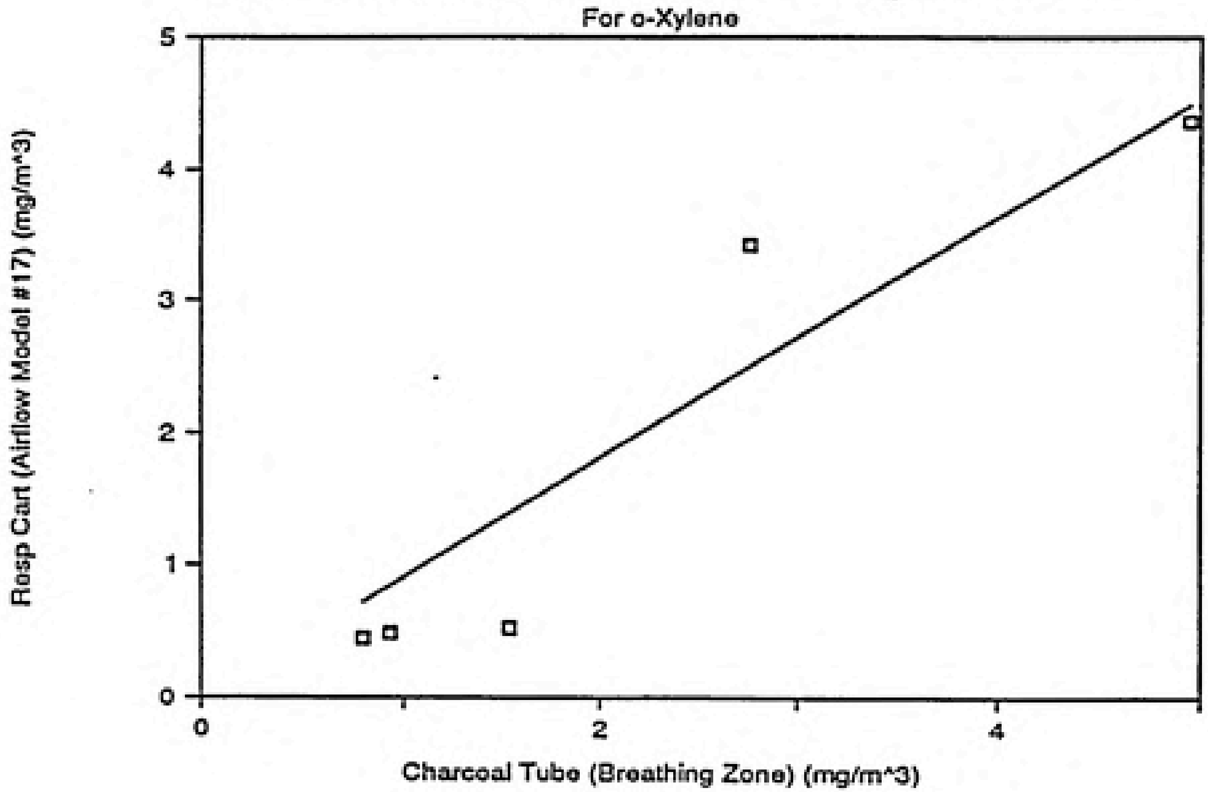


Figure 18: Organic Vapor Sample Results



toluene, p-xylene and o-xylene. Calculated linear regression coefficients for individual constituents were 1.30 (methylcyclopentane), 1.61 (n-heptane), 1.27 (toluene), 1.48 (p-xylene), and 1.10 (o-xylene).

One possible reason why the charcoal tube results were greater than the respirator cartridges was the poor fitting respirators. The affect is identical to the explanation of the discrepancy in dust/mist samples. A consequence of this incident was the implication that the respirator protection factor1 (PF) would actually be reduced to 2.0, instead of the assumed value of PF=10 for half-mask dual cartridge respirators.

Statistical Analysis for Organic Vapor Samples: The organic vapor results were compared statistically by all non-zero constituents in each sample and five (5) individual constituents among samples (Table 8). For four (4) of the five (5) of the volatile aromatic hydrocarbon samples, except OV-2, there was no significant difference (95% confidence level) between the charcoal tube breathing zone results and the respirator cartridges when all of the constituents were compared. For indvidual constituents, three of the five, methylcyclohexane, h-heptane, and o-xylene, demonstrated no significant differences between the charcoal tubes

1. The respirator protection factor is defined as the concentration outside the respirator divided by the concentration inside the resprirator [17]. PF = Conc (out) / Conc (in).

and the respirator filter catridges. These outcomes signified that this method would be viable for workplace exposure screening samples or estimating a resprirator workplace protection factor.

Conclusion:

It has been suggested that industrial airborne workplace concentrations can be calculated based on the amount of contaminant deposited on respirator cartridges and estimating the flowrate through the respirator with ergonomic and respiratory ventilation models.

The physiological models used in this research appear to overestimate the actual flow, although several factors such as respirator mask leakage, sensitivity of resin coated filter pads to relative humidity, and differences in analytical sensitivities between the methods made quantitative conclusions unreliable. However, the results of the organic vapor respirator cartridges did show countenance for this procedure in screening workplace exposures or estimating a resprirator workplace protection factor [17, 18].

Further studies should be conducted to validate this method. Additional studies might include more subjects and operations and probably include qualitative fit testing immediatly before and after (and possibly during) the sampling.

Further studies may indicate that, like biological exposure indicies [18], respirator cartridge analysis methods are inconsistant to charcoal tube sampling because too many factors influence the results. However, if the purpose of workplace sampling is to determine the potential employee exposure, then the affect of factors such as faceshields would make the respirator pad analysis more representative of the true breathing zone concentration.

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Appendix I

Operation Observations by Sample

Sample # 1

Dust/Mist Sample # 1

Subject Info:

Height: 182.88 cm
Weight: 81.64 kg
Age: 25 yrs
Sex: M

Operation: Pneumatic disk sanding inside paint booth

Breathing Zone Sampling Info:

Time Pump (on/off) 0959/1054
Total Sampling Time: 55 min
Flowrate (on/off;lpm) 2.04/1.97
Total Volume Sampled (liters) = 111
Membrane Filter Wt (post/pre or matched): 0.04992/0.04887

Respirator Sampling Info:

Left Filter Weights (Post/Pre): 2.66993/2.64878
Right Filter Weights (Post/Pre): 2.41849/2.40034

note: 2.0 hrs @ room temp; No post incubation before weighting
Blank correction is + 0.00639 grams/filter
Open face filter cartridges (no filter covers).

Observation:

Elapsed Time hr:min	Position of subject	Position Time (min)	Respirator (on/off)
0:00 - 0:02	standing (prep)	2	on
0:02 - 0:35	standing	33	on
0:35 - 0:43	kneeling	8	on
0:43 - 0:45	sitting	2	on
0:45 - 0:48	standing	3	on
0:48 - 0:51	kneeling	3	on
0:51 - 0:55	standing	4	on

Ergonomic note:

Operation required two arm movement.

Total Respirator Time On = 55 min

Time Resp on Kneeling = 11 min
Time Resp on Standing = 42 min
Time Resp on Sitting = 2 min

Sample # 2

Dust/Mist Sample # 2

Subject Info:

Operation: Pneumatic disk sanding inside paint booth

Height: 182.88 cm
Weight: 81.64 kg
Age: 25 yrs
Sex: M

Breathing Zone Sampling Info:

Time Pump (on/off) 1207/1306
Total Sampling Time: 59 min
Flowrate (on/off;lpm) 2.05/2.05
Total Volume Sampled (liters) = 121
Membrane Filter Wt (post/pre or matched): 0.04937/0.04890

Respirator Sampling Info:

Left Filter Weights (Post/Pre): 2.69486/2.68157
Right Filter Weights (Post/Pre): 2.48315/2.47215

note: 2.0 hrs @ room temp; No post incubation before weighting
Blank correction is + 0.00683 grams/filter
Open face filter cartridges (no filter covers).

Observation:

Elapsed Time hr:min	Position of subject	Position Time (min)	Respirator (on/off)
0:00 - 0:02	standing (prep)	2	on
0:02 - 0:26	standing	24	on
0:26 - 0:28	kneeling	2	on
0:28 - 0:59	standing	31	on

Ergonomic note:

Operation required two arm movement.

Total Respirator Time On = 59 min

Time Resp on Kneeling = 2 min
Time Resp on Standing = 57 min

Sample # 3

Dust/Mist Sample # 3

Operation: Spray Painting

Subject Info:

Height: 180.34 cm
Weight: 88.45 kg
Age: 26 yrs
Sex: M

Breathing Zone Sampling Info:

Time Pump (on/off) 0840/0928
Total Sampling Time: 48 min
Flowrate (on/off;lpm) 2.04/2.04
Total Volume Sampled (liters) = 98
Membrane Filter Wt (post/pre or matched): 0.04912/0.04800

Respirator Sampling Info:

Left Filter Weights (Post/Pre): 2.54415/2.53828
Right Filter Weights (Post/Pre): 2.29953/2.29618

note: 1.5 hrs @ room temp; No post incubation before weighting
Blank correction is -0.002775 grams/filter

Observation:

Elapsed Time	Position of subject	Position Time (min)	Respirator (on/off)
0:00 - 0:07	stooping	7	on
0:07 - 0:24	standing	17	on
0:24 - 0:29	stand(refill)	5	on
0:29 - 0:35	standing	6	on
0:35 - 0:38	stand(fix gun)	3	on
0:38 - 0:48	standing	10	on

Total Respirator Time On = 48 min

Time Resp On Standing = 41 min
Time Resp On Stooping = 7 min

Sample # 4

Dust/Mist Sample # 4

Operation: Spray Painting

Subject Info:

Height: 187.96 cm
Weight: 104.33 kg
Age: 21 yrs
Sex: M

Breathing Zone Sampling Info:

Time Pump (on/off) 0909/0929
Total Sampling Time: 20 min
Flowrate (on/off;lpm) 2.05/2.05
Total Volume Sampled (liters) = 41
Membrane Filter Wt (post/pre or matched): 0.04869/0.04805

Respirator Sampling Info:

Left Filter Weights (Post/Pre): 2.46325/2.45490
Right Filter Weights (Post/Pre): 2.67680/2.66742

note: 1.5 hrs @ room temp; No post incubation before weighting
Weight Correction is 1.001934 * Pre Weight

Observation:

Elapsed Time	Position of subject	Position Time (min)	Respirator (on/off)
0:00 - 0:08	standing	8	on
0:08 - 0:10	stand(refill)	2	on
0:10 - 0:20	standing	10	on

Total Respirator Time On = 20 min

Time Resp On Standing = 20 min

Sample # 5:

Dust/Mist Sample # 5

Operation: Sanding Fiberglass

Subject Info:

Height: 182.88 cm
Weight: 134.26 kg
Age: 50 yrs
Sex: M

Breathing Zone Sampling Info:

Time Pump (on/off) 0817/0851
Total Sampling Time: 34 min
Flowrate (on/off;lpm) 2.05/2.05
Total Volume Sampled (liters) = 70
Membrane Filter Wt (post/pre or matched): 0.04870/0.04796

Respirator Sampling Info:

Left Filter Weights (Post/Pre): 2.66937/2.66424
Right Filter Weights (Post/Pre): 2.38855/2.37890

note: 1.5 hrs @ room temp; No post incubation before weighting
Weight correction is 1.000705 * Pre Wt

Observation:

Elapsed Time	Position of subject	Position Time (min)	Respirator (on/off)
0:00 - 0:22	standing	22	on
0:22 - 0:30	stitting	8	on
0:30 - 0:34	standing	4	on

Total Respirator Time On = 34 min

Time Resp On Standing = 26 min
Time Resp On Sitting = 8 min

Sample # 6

Dust/Mist Sample # 6

Operation: Sanding Painted Metal with Pneumatic Orbital Sander

Subject Info:

Height: 182.88 cm
Weight: 81.64 kg
Age: 25 yrs
Sex: M

Breathing Zone Sampling Info:

Time Pump (on/off) 1020/1039+1210/1351
Total Sampling Time: 120 min
Flowrate (on/off;lpm) 2.2/2.2
Total Volume Sampled (liters) = 264
Membrane Filter Wt (post/pre or matched): 0.05325/0.04796

Respirator Sampling Info:

Left Filter Weights (Post/Pre): 2.50365/2.47601
Right Filter Weights (Post/Pre): 2.47465/2.45352

note: 1.5 hrs @ room temp; No post incubation before weighting
Weight Correction is 1.000705 * Pre Wt

Observation:

Elapsed Time	Position of subject	Position Time (min)	Respirator (on/off)
0:00 - 0:19	sitting	19	on
0:19 - 0:28	standing	9	on
0:28 - 0:35	stooping	7	on
0:35 - 0:42	standing	7	on
0:42 - 0:44	stooping	2	on
0:44 - 0:60	sitting	16	on
0:60 - 1:15	stooping	13	on
1:15 - 1:17	sitting	2	on
1:17 - 1:41	standing	26	on
1:41 - 1:45	kneeling	5	on
1:45 - 1:49	stooping	4	on
1:49 - 1:51	kneeling	2	on
1:51 - 2:00	standing	8	on

Total Respirator Time On = 120 min

Time Resp On Standing = 50 min
Time Resp On Sitting = 18 min
Time Resp On Kneeling = 7 min
Time Resp on Stooping = 26 min

Sample # 7

Dust/Mist Sample # 7

Subject Info:

Height: 182.88 cm
Weight: 81.64 kg
Age: 25 yrs
Sex: M

Operation: Sanding Pneumatic Orbital

Breathing Zone Sampling Info:

Time Pump (on/off) 1408/1457
Total Sampling Time: 49 min
Flowrate (on/off;lpm) 2.2/2.2
Total Volume Sampled (liters) = 108
Membrane Filter Wt (post/pre or matched): 0.05222/0.04798

Respirator Sampling Info:

Left Filter Weights (Post/Pre): 2.59421/2.56724
Right Filter Weights (Post/Pre): 2.66179/2.63469

note: 1.5 hrs @ room temp; No post incubation before weighting
Weight Correction is 1.000705 * Pre Wt

Observation:

Elapsed Time	Position of subject	Position Time (min)	Respirator (on/off)
0:00 - 0:04	sitting	4	on
0:04 - 0:24	kneeling	20	on
0:24 - 0:25	standing	1	on
0:25 - 0:27	sitting	2	on
0:27 - 0:49	standing	22	on

Total Respirator Time On = 49 min

Time Resp On Standing = 23 min
Time Resp On Sitting = 6 min
Time ResP On Kneeling = 20 min

Note: Two persons were sanding during this sampling.

Sample # OV-1

Organic Vapor Sample # 1

Operation: Spray painting tanker truck inside waterfall paint booth

Breathing Zone Sampling Info:

Time Pump (on/off) 1242/1510
Total Sampling Time: 158 min
Flowrate (on/off;lpm) 1.05/0.97
Total Volume Sampled (liters) = 159.58

Subject Information:

Height: 180.34 cm
Weight: 77.11 kg
Age: 22 yrs
Sex: M

Observation:

Elapsed Time	Position of subject	Position Time (min)	Respirator (on/off)
0:00 - 0:14	stooping	14	on
0:14 - 0:19	refill spray gun	5	off
0:19 - 0:22	stooping	3	on
0:22 - 0:25	standing	3	on
0:25 - 0:31	stooping	6	on
0:31 - 0:43	refill spray gun	12	off
0:43 - 0:46	standing	3	on
0:46 - 0:56	stooping	10	on
0:56 - 0:59	refill spray gun	3	off
0:59 - 1:04	stooping	5	on
1:04 - 1:10	standing	6	on
1:10 - 1:19	refill spray gun	9	off
1:19 - 1:31	standing	12	on
1:31 - 1:34	refill spray gun	3	off
1:34 - 1:46	standing	12	on
1:46 - 1:50	refill spray gun	4	off
1:50 - 1:59	standing	9	on
1:59 - 2:01	refill spray gun	2	off
2:01 - 2:12	standing	11	on

Ergonomic note:

Operation required one arm movement.

Total Respirator Time On = 94 min

Time Resp on Standing = 56 min
Time Resp on Stooping = 38 min

Sample # OV-2

Organic Vapor Sample # 2

Operation: Spray painting tanker truck inside waterfall paint booth

Breathing Zone Sampling Info:

Subject Information:

Height: 180.34 cm
Weight: 63.45 kg
Age: 22 yrs
Sex: M

Time Pump (on/off) 0827/1004
Total Sampling Time: 97 min
Flowrate (on/off;lpm) 1.05/1.00
Total Volume Sampled (liters) = 99.425

Observation:

Elapsed Time	Position of subject	Position Time (min)	Respirator (on/off)
0:00 - 0:04	standing	4	on
0:04 - 0:06	stooping	2	on
0:06 - 0:16	standing	10	on
0:16 - 0:23	refill spray gun	7	off
0:23 - 0:33	standing	10	on
0:33 - 0:37	refill spray gun	4	off
0:37 - 0:46	standing	9	on
0:46 - 0:49	refill spray gun	3	off
0:49 - 0:50	stooping	1	on
0:50 - 0:59	standing	9	on
0:59 - 1:02	refill spray gun	3	off
1:02 - 1:13	standing	11	on

Ergonomic note:

Operation required one arm movement.

Total Respirator Time On = 56 min

Time Resp on Standing = 53 min
Time Resp on Stooping = 3 min

Sample # OV-3

Organic Vapor Sample # 3

Subject Information:

Height: 180.34 cm
Weight: 88.45 kg
Age: 26 yrs
Sex: M

Operation: Spray Painting

Breathing Zone Sampling Info:

Time Pump (on/off) 0840/0928
Total Sampling Time: 48 min
Flowrate (on/off;lpm) 1.05/0.92
Total Volume Sampled (liters) = 47.28

Observation:

Elapsed Time	Position of subject	Position Time (min)	Respirator (on/off)
0:00 - 0:07	stooping	7	on
0:07 - 0:24	standing	17	on
0:24 - 0:29	stand(refill)	5	on
0:29 - 0:35	standing	6	on
0:35 - 0:38	stand(fix gun)	3	on
0:38 - 0:48	standing	10	on

Total Respirator Time On = 48 min

Time Resp On Standing = 41 min
Time Resp On Stooping = 7 min

Sample # OV-4

Organic Vapor Sample # 4

Operation: Spray Painting Gray Primer
in Paint Booth

Subject Information:

Height: 187.96 cm
Weight: 104.33 kg
Age: 21 yrs
Sex: M

Breathing Zone Sampling Info:

Time Pump (on/off) 0909/0929
Total Sampling Time: 20 min
Flowrate (on/off;lpm) 1.05/1.05
Total Volume Sampled (liters) = 21

Observation:

Elapsed Time	Position of subject	Position Time (min)	Respirator (on/off)
0:00 - 0:08	standing	8	on
0:08 - 0:10	stand(refill)	2	on
0:10 - 0:20	standing	10	on

Total Respirator Time On = 20 min
Time Resp On Standing = 20 min

Sample #   OV-5

Organic Vapor Sample # 5

Operation: Spray Painting Gray Primer
in Paint Booth

Subject Information:

Height: 187.96 cm
Weight: 104.33 kg
Age: 21 yrs
Sex: M

Breathing Zone Sampling Info:

Time Pump (on/off) 0910/1001
Total Sampling Time: 51 min
Flowrate (on/off;lpm) 1.04/1.04
Total Volume Sampled (liters) = 53.04

Observation:

Elapsed Time	Position of subject	Position Time (min)	Respirator (on/off)
0:00 - 0:20	standing	20	on
0:20 - 0:22	stand(refill)	2	on
0:22 - 0:36	standing	15	on
0:36 - 0:38	stand(refill)	2	on
0:38 - 0:51	standing	13	on

Total Respirator Time On = 51 min
Time Resp On Standing = 51 min

Appendix II

Dust/Mist and Organic Vapor Sampling Results by Weight

Appendix II: Dust/mist Sampling Results by Weight

Sample #	1	2	3	4	5	6	7
Operation	Sand	Sand	Paint	Paint	Sand	Sand	Sand
BZ Result mg/m^3	9.50	3.89	11.44	15.37	10.94	20.04	39.33
Sex	M	M	M	M	M		
Height cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Age years	25	25	26	21	50	25.00	25.00
Time of Work min	55	59	48	20	33	120.00	49.00
BZ Sample Wt final	0.04992	0.04937	0.04912	0.04867	0.04870	0.05325	0.05222
BZ Sample Wt begin	0.04887	0.04890	0.04800	0.04804	0.04796	0.04796	0.04798
BZ Sample wt mg	1.05	0.47	1.12	0.63	0.74	5.29	4.24
BZ flow lpm	2.01	2.05	2.04	2.05	2.05	2.20	2.20
BZ Sample Vol m^3	0.111	0.121	0.098	0.041	0.068	0.264	0.108
RH% at Post Wt				65	63	63	63
Left Cart Wt final	2.66993	2.69486	2.54415	2.46325	2.66937	2.50365	2.59421
Left Cart Wt Begin	2.64878	2.68157	2.53828	2.45490	2.66424	2.47601	2.56724
Resp Filter Corr mg	-6.39	-6.83	2.42	-4.27	-1.85	-1.72	-1.78
Left Resp Samp Wt mg	14.76	6.46	8.29	4.08	3.28	25.92	25.19
Right Cart Wt final	2.41849	2.48315	2.29953	2.67680	2.38855	2.47465	2.66179
Right Cart Wt begin	2.40034	2.47215	2.29618	2.67470	2.37890	2.45352	2.63469
Resp Filter Corr mg	-6.39	-6.83	2.42	-4.66	-1.65	-1.70	-1.83
Right Resp Samp Wt mg	11.76	4.17	5.77	-2.56 *	8.00	19.43	25.27
Total Resp Wt mg	26.52	10.63	14.07	4.08	11.28	45.34	50.46
Total Resp Wt / BZ Wt	25.3	22.6	12.6	6.5	15.2	8.6	11.9

* Note: This value taken as 0.00 for Total Respirator Sample Weight

Apendix II: Organic Vapor Sampling Results by Weight

	BZ Samp OV-1	S.D.	Resp Cart OV-1	S.D.	BZ Samp OV-2	S.D.	Resp Cart OV-2	S.D.	BZ Samp OV-3	S.D.	Resp Cart OV-3	S.D.
	mg	mg	mg	mg	mg	mg	mg	mg	mg	mg	mg	mg
Isopentane												
Methylcyclopentane	0.09	.00	1.24	0.18	0.06	.00	0.65	0.06	0.06	.00	1.25	0.21
n-Heptane	0.28	0.01	3.30	0.45	0.17	.00	1.77	0.14	0.20	.00	4.04	0.64
Methylcyclohexane	0.34	0.02	6.99	0.61	0.22	.00	3.80	0.56	0.30	0.01	9.35	1.06
n-Octane	0.31	0.02	5.76	0.52	0.24	.00	3.90	0.22				
1,1,1-Trichloroethane	0.05	.00									1.28	0.33
Methyl Ethyl Ketone	2.18	0.04	13.31	5.52	1.87	0.06	27.97	4.22			0.12	0.14
Isopropanol					0.60	0.14			0.17	0.01	2.73	0.47
Trichloroethylene	1.27	0.02	17.78	1.75	1.77	0.04	20.93	1.52	0.67	0.01	22.01	4.15
Toluene	3.01	0.29	42.15	4.82	2.21	0.06	30.48	2.19	1.02	0.03	19.69	3.15
Ethlyene Dichloride	1.43	0.04	13.79	1.40	1.48	0.03	16.23	0.99	0.01	0.01	0.09	0.20
p-Xylene	0.25	.00	3.85	0.43	0.35	0.02	6.15	0.55	0.12	.00	2.66	0.34
m-Xylene	0.95	0.02	17.49	1.94	0.98	0.07	20.67	2.23				
o-Xylene	0.41	0.02	7.08	0.78	0.49	.00	10.67	3.16	0.04	.00	1.03	0.14

	BZ Sample OV-4	S.D.	Resp Cart OV-4	S.D.	BZ Sample OV-5	S.D.	Resp Cart OV-5	S.D.
	mg	mg	mg	mg	mg	mg	mg	mg
Isopentane	0.02	.00						
Methylcyclopentane	0.09	.00	1.88	0.93	0.01	.00	0.21	0.06
n-Heptane	0.31	.00	5.26	0.87	0.02	.00	0.60	0.16
Methylcyclohexane	0.32	.00	8.77	0.98				
n-Octane	0.03	.00			0.67	.00	20.25	3.09
1,1,1-Trichloroethane							15.90	17.25
Methyl Ethyl Ketone					0.10	.00	2.74	0.40
Isopropanol	0.08	0.01			0.30	0.45	56.74	13.13
Trichloroethylene					0.89	0.01	19.83	2.74
Toluene	1.32	0.02	22.49	1.17	1.17	0.01	33.96	4.06
Ethlyene Dichloride					0.24	0.01	4.19	0.63
p-Xylene	0.12	.00	1.84	1.26	0.11	.00	2.82	0.34
m-Xylene					0.28	0.01	7.87	0.96
o-Xylene	0.03	.00	0.41	2.09	0.08	.00	0.98	0.25

Appendix III

Dust/Mist Sampling Concentrations

by Respirator Flow Model

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 1: Code: V11-E8-R11

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 11: 0.01394 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 8: 3400 cal/min (238 Watts)
Basal Metabolic Rate estimated from Reference 11: 71.74 watts/ lpm of oxygen required

Sample #		1	2	3	4	5	6	7
Operation	Units	Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol Rate O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Vol Rate O2 (AT)	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol Rate O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Total Energy Req	cal/min	3400.00	3400.00	3400.00	3400.00	3400.00	3400.00	3400.00
Total Energy Req	Watts	237.09	237.09	237.09	237.09	237.09	237.09	237.09
Std Metabolism	watt/lpm	71.74	71.94	71.94	71.94	71.94	71.94	71.94
Basal Rate	Watts	45.44	45.57	44.72	47.27	45.57	45.57	45.57
Energy Req (work)	Watts	191.65	191.52	192.37	189.82	191.52	191.52	191.52
Vol Rate O2 (Work)	lpm	2.67	2.67	2.68	2.65	2.67	2.67	2.67
Total Rate O2 Req	lpm	3.31	3.30	3.30	3.30	3.30	3.30	3.30
% of AT Required	%	1.70	1.70	1.76	1.57	2.19	1.70	1.70
% of Vol O2 (max)	%	0.95	0.95	0.98	0.88	1.23	0.95	0.95
Vol Rate Expir/Vol Rate O2		26.50	26.50	26.50	26.50	37.70	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	4.40	6.90	4.40	4.40
Time of Work	min	55.00	59.00	48.00	20.00	33.00	120.00	49.00
Total Vol Exp (Ave)	liters	4818.98	5166.60	4203.38	1751.35	4111.14	10508.33	4290.90
Total Vol Exp (Max)		5619.11	6024.45	4901.30	2042.14	4863.57	12253.11	5003.35
Total Vol Exp (Min)		4018.84	4308.75	3505.46	1460.56	3358.70	8763.55	3578.45
Conc (min)	mg/m^3	6.60	2.47	4.01	2.79	3.36	5.17	14.10
Conc (ave)	mg/m^3	5.50	2.06	3.35	2.33	2.74	4.32	11.76
Conc (max)	mg/m^3	4.72	1.76	2.87	2.00	2.32	3.70	10.08

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 2: Code: V11-E8-R6

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 11: 0.01394 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 8: 3400 cal/min (238 Watts)
Basal Metabolic Rate estimated from Reference 6: 107.53 watts/ lpm of oxygen required

Sample #		1	2	3	4	5	6	7
Operation	Units	Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol Rate O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Vol Rate O2 (AT)	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol Rate O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Total Energy Req	cal/min	3400.00	3400.00	3400.00	3400.00	3400.00	3400.00	3400.00
Total Energy Req	Watts	237.09	237.09	237.09	237.09	237.09	237.09	237.09
Std Metabolism	watt/lpm	107.53	107.53	107.53	107.53	107.53	107.53	107.53
Basal Rate	Watts	68.11	68.11	66.84	70.65	68.11	68.11	68.11
Energy Req (work)	Watts	168.98	168.98	170.25	166.44	168.98	168.98	168.98
Vol Rate O2 (Work)	lpm	2.36	2.36	2.37	2.32	2.36	2.36	2.36
Total Rate O2 Req	lpm	2.99	2.99	3.00	2.98	2.99	2.99	2.99
% of AT Required	%	1.54	1.54	1.59	1.41	1.98	1.54	1.54
% of Vol O2 (max)	%	0.86	0.86	0.89	0.79	1.11	0.86	0.86
Vol Rate Expir/Vol Rate O2		26.50	26.50	26.50	26.50	37.70	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	4.40	6.90	4.40	4.40
Time of Work	min	55.00	59.00	48.00	20.00	33.00	120.00	49.00
Total Vol Exp (Ave)	liters	4358.13	4675.09	3810.97	1578.52	3720.04	9508.66	3882.70
Total Vol Exp (Max)		5081.75	5451.33	4443.74	1840.61	4400.89	11087.45	4527.38
Total Vol Exp (Min)		3634.52	3898.85	3178.21	1316.42	3039.18	7929.86	3238.03
Conc (min)	mg/m^3	7.30	2.73	4.43	3.10	3.71	5.72	15.58
Conc (ave)	mg/m^3	6.09	2.27	3.69	2.58	3.03	4.77	12.99
Conc (max)	mg/m^3	5.22	1.95	3.17	2.21	2.56	4.09	11.14

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 3: Code: V11-E8-R12

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 11: 0.01394 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 8: 3400 cal/min (238 Watts)
Basal Metabolic Rate estimated from Reference 12: See Table 5.

Sample #		1	2	3	4	5	6	7
Operation	Units	Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol Rate O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Vol Rate O2 (AT)	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol Rate O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Total Energy Req	cal/min	3400.00	3400.00	3400.00	3400.00	3400.00	3400.00	3400.00
Total Energy Req	Watts	237.09	237.09	237.09	237.09	237.09	237.09	237.09
Std Metabolism	cal/m^2/hr	40.24	40.24	40.24	40.24	40.24	40.24	40.24
Basal Rate	Watts	0.10	0.10	0.09	0.10	0.10	0.10	0.10
Energy Req (work)	Watts	237.00	237.00	237.00	236.99	237.00	237.00	237.00
Vol Rate O2 (Work)	lpm	3.31	3.31	3.31	3.31	3.31	3.31	3.31
Total Rate O2 Req	lpm	3.94	3.94	3.93	3.96	3.94	3.94	3.94
% of AT Required	%	2.03	2.03	2.09	1.88	2.61	2.03	2.03
% of Vol O2 (max)	%	1.13	1.13	1.17	1.05	1.46	1.13	1.13
Vol Rate Expir/Vol Rate O2		37.70	37.70	37.70	37.70	37.70	37.70	37.70
Vol Expir/Vol O2	+/-	6.90	6.90	6.90	6.90	6.90	6.90	6.90
Time of Work	min	55.00	59.00	48.00	20.00	33.00	120.00	49.00
Total Vol Exp (Ave)	liters	8166.94	8760.90	7106.17	2987.58	4900.16	17818.78	7276.00
Total Vol Exp (Max)		9661.69	10364.35	8406.77	3534.38	5797.01	21080.04	8607.68
Total Vol Exp (Min)		6672.20	7157.45	5805.57	2440.78	4003.32	14557.52	5944.32
Conc (min)	mg/m^3	3.97	1.48	2.42	1.67	2.82	3.11	8.49
Conc (ave)	mg/m^3	3.25	1.21	1.98	1.36	2.30	2.54	6.93
Conc (max)	mg/m^3	2.74	1.03	1.67	1.15	1.95	2.15	5.86

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 4: Code: V11-E10-R11

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 11: 0.01394 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 10: See Table 4.
Basal Metabolic Rate estimated from Reference 11: 71.4 watts/ lpm of oxygen required

Sample #		1	2	3	4	5	6	7
Operation		Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Anerobic Threshold	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Energy Req Standing	cal/min	2850.00	2850.00	2050.00	2050.00	2850.00	2850.00	2850.00
Energy Req Standing	Watts	198.74	198.74	142.95	142.95	198.74	198.74	198.74
Std Metabolism	watt/lpm	71.70	71.70	71.70	71.70	71.70	71.70	71.70
Basal Rate	Watts	45.42	45.42	44.57	47.11	45.42	45.42	45.42
Energy Req (work)	Watts	153.32	153.32	98.38	95.84	153.32	153.32	153.32
Vol O2 (Work)	lpm	2.14	2.14	1.37	1.34	2.14	2.14	2.14
Total O2 Required	lpm	2.77	2.77	1.99	1.99	2.77	2.77	2.77
% of AT Required	%	1.43	1.43	1.06	0.94	1.84	1.43	1.43
% of Vol O2 (max)	%	0.80	0.80	0.59	0.53	1.03	0.80	0.80
Vol Expir/Vol O2		26.50	26.50	26.50	28.50	37.70	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	8.10	6.90	4.40	4.40
Time of Standing	min	42.00	57.00	41.00	20.00	26.00	50.00	23.00
Energy Req Sitting	cal/min	2550.00	2550.00	1750.00	1750.00	2550.00	2550.00	2550.00
Energy Req Sitting	Watts	177.82	177.82	122.03	122.03	177.82	177.82	177.82
Std Metabolism	watt/lpm	107.53	107.53	107.53	107.53	107.53	107.53	107.53
Basal Rate	Watts	68.11	68.11	66.84	70.65	68.11	68.11	68.11
Energy Req (work)	Watts	109.71	109.71	55.19	51.38	109.71	109.71	109.71
Vol O2 (Work)	lpm	1.53	1.53	0.77	0.72	1.53	1.53	1.53
Total O2 Required	lpm	2.16	2.16	1.39	1.37	2.16	2.16	2.16
% of AT Required	%	1.11	1.11	0.74	0.65	1.43	1.11	1.11
% of Vol O2 (max)	%	0.62	0.62	0.41	0.36	0.80	0.62	0.62
Vol Expir/Vol O2		26.50	26.50	28.50	28.50	26.50	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	8.10	8.10	4.40	4.40	4.40
Time of Sitting	min	2.00	0.00	0.00	0.00	8.00	18.00	6.00

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Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 4: (con't)

Sample #		1	2	3	4	5	6	7
Operation		Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Energy Req Stooping	cal/min	3050.00	3050.00	2250.00	2250.00	3050.00	3050.00	3050.00
Energy Req Stooping	Watts	212.69	212.69	156.90	156.90	212.69	212.69	212.69
Std Metabolism	watt/lpm	107.53	107.53	107.53	107.53	107.53	107.53	107.53
Basal Rate	Watts	68.11	68.11	66.84	70.65	68.11	68.11	68.11
Energy Req (work)	Watts	144.57	144.57	90.06	86.25	144.57	144.57	144.57
Vol O2 (Work)	lpm	2.02	2.02	1.26	1.20	2.02	2.02	2.02
Total O2 Required	lpm	2.65	2.65	1.88	1.86	2.65	2.65	2.65
% of AT Required	%	1.36	1.36	1.00	0.88	1.76	1.36	1.36
% of Vol O2 (max)	%	0.76	0.76	0.56	0.49	0.98	0.76	0.76
Vol Expir/Vol O2		26.50	26.50	28.50	28.50	26.50	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	8.10	8.10	4.40	4.40	4.40
Time of Stooping	min	0.00	0.00	7.00	0.00	0.00	26.00	0.00
Energy Req Kneeling	cal/min	2750.00	2750.00	1950.00	1950.00	2750.00	2750.00	2750.00
Energy Req Kneeling	Watts	191.77	191.77	135.98	135.98	191.77	191.77	191.77
Std Metabolism	watt/lpm	107.53	107.53	107.53	107.53	107.53	107.53	107.53
Basal Rate	Watts	68.11	68.11	66.84	70.65	68.11	68.11	68.11
Energy Req (work)	Watts	123.65	123.65	69.14	65.33	123.65	123.65	123.65
Vol O2 (Work)	lpm	1.72	1.72	0.96	0.91	1.72	1.72	1.72
Total O2 Required	lpm	2.36	2.36	1.59	1.57	2.36	2.36	2.36
% of AT Required	%	1.21	1.21	0.84	0.74	1.56	1.21	1.21
% of Vol O2 (max)	%	0.68	0.68	0.47	0.42	0.88	0.68	0.68
Vol Expir/Vol O2		26.50	26.50	28.50	28.50	26.50	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	8.10	8.10	4.40	4.40	4.40
Time of Stooping	min	11.00	2.00	0.00	0.00	0.00	7.00	20.00
Vol Exp (Ave)	liters	3886.96	4311.68	2540.75	1136.41	3175.51	6967.62	3283.10
Vol Exp (Max)		4532.34	5027.58	3006.87	1459.39	3748.92	8124.51	3828.22
Vol Exp (Min)		3241.58	3595.78	2074.62	813.43	2602.11	5810.73	2737.98
Conc (min)	mg/m^3	8.18	2.95	6.78	5.01	2.31	6.92	16.44
Conc (ave)	mg/m^3	6.82	2.46	5.54	3.59	1.89	5.77	13.71
Conc (max)	mg/m^3	5.85	2.11	4.68	2.79	1.60	4.95	11.76

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 5: Code: V11-E10-R6

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 11: 0.01394 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 10: See Table 4.
Basal Metabolic Rate estimated from Reference 6: 107.53 watts/ lpm of oxygen required

Sample #		1	2	3	4	5	6	7
Operation		Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Anerobic Threshold	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Energy Req Standing	cal/min	2850.00	2850.00	2050.00	2050.00	2850.00	2850.00	2850.00
Energy Req Standing	Watts	198.74	198.74	142.95	142.95	198.74	198.74	198.74
Std Metabolism	watt/lpm	107.53	107.53	107.53	107.53	107.53	107.53	107.53
Basal Rate	Watts	68.11	68.11	66.84	70.65	68.11	68.11	68.11
Energy Req (work)	Watts	130.63	130.63	76.11	72.30	130.63	130.63	130.63
Vol O2 (Work)	lpm	1.82	1.82	1.06	1.01	1.82	1.82	1.82
Total O2 Required	lpm	2.46	2.46	1.68	1.67	2.46	2.46	2.46
% of AT Required	%	1.26	1.26	0.89	0.79	1.63	1.26	1.26
% of Vol O2 (max)	%	0.71	0.71	0.50	0.44	0.91	0.71	0.71
Vol Expir/Vol O2		26.50	26.50	28.50	28.50	26.50	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	8.10	8.10	4.40	4.40	4.40
Time of Standing	min	42.00	57.00	41.00	20.00	26.00	50.00	23.00
Energy Req Sitting	cal/min	2550.00	2550.00	1750.00	1750.00	2550.00	2550.00	2550.00
Energy Req Sitting	Watts	177.82	177.82	122.03	122.03	177.82	177.82	177.82
Std Metabolism	watt/lpm	71.70	71.70	71.70	71.70	71.70	71.70	71.70
Basal Rate	Watts	45.42	45.42	44.57	47.11	45.42	45.42	45.42
Energy Req (work)	Watts	132.40	132.40	77.46	74.92	132.40	132.40	132.40
Vol O2 (Work)	lpm	1.85	1.85	1.08	1.04	1.85	1.85	1.85
Total O2 Required	lpm	2.48	2.48	1.70	1.70	2.48	2.48	2.48
% of AT Required	%	1.28	1.28	0.90	0.81	1.64	1.28	1.28
% of Vol O2 (max)	%	0.71	0.71	0.51	0.45	0.92	0.71	0.71
Vol Expir/Vol O2		26.50	26.50	28.50	28.50	26.50	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	8.10	8.10	4.40	4.40	4.40
Time of Sitting	min	2.00	0.00	0.00	0.00	8.00	18.00	6.00

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Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 5: (con't)

Sample #		1	2	3	4	5	6	7
Operation		Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Energy Req Stooping	cal/min	3050.00	3050.00	2250.00	2250.00	3050.00	3050.00	3050.00
Energy Req Stooping	Watts	212.69	212.69	156.90	156.90	212.69	212.69	212.69
Std Metabolism	watt/lpm	71.70	71.70	71.70	71.70	71.70	71.70	71.70
Basal Rate	Watts	45.42	45.42	44.57	47.11	45.42	45.42	45.42
Energy Req (work)	Watts	167.27	167.27	112.33	109.79	167.27	167.27	167.27
Vol O2 (Work)	lpm	2.33	2.33	1.57	1.53	2.33	2.33	2.33
Total O2 Required	lpm	2.97	2.97	2.19	2.19	2.97	2.97	2.97
% of AT Required	%	1.53	1.53	1.16	1.04	1.97	1.53	1.53
% of Vol O2 (max)	%	0.85	0.85	0.65	0.58	1.10	0.85	0.85
Vol Expir/Vol O2		26.50	26.50	26.50	26.50	37.70	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	4.40	6.90	4.40	4.40
Time of Stooping	min	0.00	0.00	7.00	0.00	0.00	26.00	0.00
Energy Req Kneeling	cal/min	2750.00	2750.00	1950.00	1950.00	2750.00	2750.00	2750.00
Energy Req Kneeling	Watts	191.77	191.77	135.98	135.98	191.77	191.77	191.77
Std Metabolism	watt/lpm	71.70	71.70	71.70	71.70	71.70	71.70	71.70
Basal Rate	Watts	45.42	45.42	44.57	47.11	45.42	45.42	45.42
Energy Req (work)	Watts	146.35	146.35	91.41	88.87	146.35	146.35	146.35
Vol O2 (Work)	lpm	2.04	2.04	1.27	1.24	2.04	2.04	2.04
Total O2 Required	lpm	2.67	2.67	1.90	1.90	2.67	2.67	2.67
% of AT Required	%	1.38	1.38	1.01	0.90	1.77	1.38	1.38
% of Vol O2 (max)	%	0.77	0.77	0.56	0.50	0.99	0.77	0.77
Vol Expir/Vol O2		26.50	26.50	26.50	28.50	26.50	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	8.10	4.40	4.40	4.40
Time of Stooping	min	11.00	2.00	0.00	0.00	0.00	7.00	20.00
Vol Exp (Ave)	liters	3643.74	3850.40	2372.64	949.28	2217.42	6976.01	3308.26
Vol Exp (Max)		4248.74	4489.71	2999.00	1219.08	2585.60	8134.29	3857.56
Vol Exp (Min)		3038.74	3211.09	1746.28	679.49	1849.24	5817.73	2758.97
Conc (min)	mg/m^3	8.73	3.31	8.05	6.00	3.24	6.91	16.31
Conc (ave)	mg/m^3	7.28	2.76	5.93	4.29	2.70	5.76	13.61
Conc (max)	mg/m^3	6.24	2.37	4.69	3.34	2.32	4.94	11.67

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 6: Code: V11-E10-R12

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 11: 0.01394 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 10: See Table 4.
Basal Metabolic Rate estimated from Reference 12: See Table 5.

Sample #		1	2	3	4	5	6	7
Operation		Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Anerobic Threshold	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Energy Req Standing	cal/min	2850.00	2850.00	2050.00	2050.00	2850.00	2850.00	2850.00
Energy Req Standing	Watts	198.74	198.74	142.95	142.95	198.74	198.74	198.74
Std Metabolism	cal/m^2/hr	40.24	40.24	40.24	40.24	40.24	40.24	40.24
Basal Rate	Watts	0.10	0.10	0.09	0.10	0.10	0.10	0.10
Energy Req (work)	Watts	198.64	198.64	142.86	142.85	198.64	198.64	198.64
Vol O2 (Work)	lpm	2.77	2.77	1.99	1.99	2.77	2.77	2.77
Total O2 Required	lpm	3.40	3.40	2.61	2.65	3.40	3.40	3.40
% of AT Required	%	1.75	1.75	1.39	1.26	2.26	1.75	1.75
% of Vol O2 (max)	%	0.98	0.98	0.78	0.70	1.26	0.98	0.98
Vol Expir/Vol O2		26.50	26.50	26.50	26.50	37.70	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	4.40	6.90	4.40	4.40
Time of Standing	min	42.00	57.00	41.00	20.00	26.00	50.00	23.00
Energy Req Sitting	cal/min	2550.00	2550.00	1750.00	1750.00	2550.00	2550.00	2550.00
Energy Req Sitting	Watts	177.82	177.82	122.03	122.03	177.82	177.82	177.82
Std Metabolism	cal/m^2/hr	40.24	40.24	40.24	40.24	40.24	40.24	40.24
Basal Rate	Watts	0.10	0.10	0.09	0.10	0.10	0.10	0.10
Energy Req (work)	Watts	177.72	177.72	121.94	121.93	177.72	177.72	177.72
Vol O2 (Work)	lpm	2.48	2.48	1.70	1.70	2.48	2.48	2.48
Total O2 Required	lpm	3.11	3.11	2.32	2.36	3.11	3.11	3.11
% of AT Required	%	1.60	1.60	1.23	1.12	2.06	1.60	1.60
% of Vol O2 (max)	%	0.90	0.90	0.69	0.63	1.16	0.90	0.90
Vol Expir/Vol O2		26.50	26.50	26.50	26.50	37.70	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	4.40	6.90	4.40	4.40
Time of Sitting	min	2.00	0.00	0.00	0.00	8.00	18.00	6.00

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Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 6: (con't)

Sample #		1	2	3	4	5	6	7
Operation		Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Energy Req Stooping	cal/min	3050.00	3050.00	2250.00	2250.00	3050.00	3050.00	3050.00
Energy Req Stooping	Watts	212.69	212.69	156.90	156.90	212.69	212.69	212.69
Std Metabolism	cal/m^2/hr	40.24	40.24	40.24	40.24	40.24	40.24	40.24
Basal Rate	Watts	0.10	0.10	0.09	0.10	0.10	0.10	0.10
Energy Req (work)	Watts	212.59	212.59	156.80	156.80	212.59	212.59	212.59
Vol O2 (Work)	lpm	2.96	2.96	2.19	2.19	2.96	2.96	2.96
Total O2 Required	lpm	3.60	3.60	2.81	2.84	3.60	3.60	3.60
% of AT Required	%	1.85	1.85	1.49	1.35	2.39	1.85	1.85
% of Vol O2 (max)	%	1.04	1.04	0.84	0.75	1.34	1.04	1.04
Vol Expir/Vol O2		37.70	37.70	26.50	26.50	37.70	37.70	37.70
Vol Expir/Vol O2	+/-	6.90	6.90	4.40	4.40	6.90	6.90	6.90
Time of Stooping	min	0.00	0.00	7.00	0.00	0.00	26.00	0.00
Energy Req Kneeling	cal/min	2750.00	2750.00	1950.00	1950.00	2750.00	2750.00	2750.00
Energy Req Kneeling	Watts	191.77	191.77	135.98	135.98	191.77	191.77	191.77
Std Metabolism	cal/m^2/hr	40.24	40.24	40.24	40.24	40.24	40.24	40.24
Basal Rate	Watts	0.10	0.10	0.09	0.10	0.10	0.10	0.10
Energy Req (work)	Watts	191.67	191.67	135.88	135.88	191.67	191.67	191.67
Vol O2 (Work)	lpm	2.67	2.67	1.90	1.90	2.67	2.67	2.67
Total O2 Required	lpm	3.31	3.31	2.52	2.55	3.31	3.31	3.31
% of AT Required	%	1.70	1.70	1.34	1.21	2.19	1.70	1.70
% of Vol O2 (max)	%	0.95	0.95	0.75	0.68	1.23	0.95	0.95
Vol Expir/Vol O2		26.50	26.50	26.50	26.50	37.70	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	4.40	6.90	4.40	4.40
Time of Stooping	min	11.00	2.00	0.00	0.00	0.00	7.00	20.00
Vol Exp (Ave)	liters	4917.26	5316.73	3361.09	1404.17	4275.03	10134.98	4321.93
Vol Exp (Max)		5733.72	6199.51	3919.16	1637.32	5057.46	11877.68	5039.54
Vol Exp (Min)		4100.81	4433.95	2803.03	1171.03	3492.60	8392.28	3604.33
Conc (min)	mg/m^3	6.47	2.40	5.02	3.48	1.72	4.79	12.49
Conc (ave)	mg/m^3	5.39	2.00	4.18	2.90	1.40	3.97	10.41
Conc (max)	mg/m^3	4.63	1.71	3.59	2.49	1.19	3.38	8.93

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 7: Code: V11-E9-R11

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 11: 0.01394 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 9: 2000 cal/min (140 Watts)
Basal Metabolic Rate estimated from Reference 11: 71.74 watts/ lpm of oxygen required

Sample #		1	2	3	4	5	6	7
Operation	Units	Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol Rate O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Vol Rate O2 (AT)	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol Rate O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Total Energy Req	cal/min	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00
Total Energy Req	Watts	139.47	139.47	139.47	139.47	139.47	139.47	139.47
Std Metabolism	watt/lpm	71.74	71.94	71.94	71.94	71.94	71.94	71.94
Basal Rate	Watts	45.44	45.57	44.72	47.27	45.57	45.57	45.57
Energy Req (work)	Watts	94.03	93.90	94.75	92.19	93.90	93.90	93.90
Vol Rate O2 (Work)	lpm	1.31	1.31	1.32	1.29	1.31	1.31	1.31
Total Rate O2 Req	lpm	1.94	1.94	1.94	1.94	1.94	1.94	1.94
% of AT Required	%	1.00	1.00	1.03	0.92	1.29	1.00	1.00
% of Vol O2 (max)	%	0.56	0.56	0.58	0.52	0.72	0.56	0.56
Vol Rate Expir/Vol Rate O2		26.50	28.50	26.50	28.50	26.50	28.50	28.50
Vol Expir/Vol O2	+/-	4.40	8.10	4.40	8.10	4.40	8.10	8.10
Time of Work	min	55.00	59.00	48.00	20.00	33.00	120.00	49.00
Total Vol Exp (Ave)	liters	2834.51	3267.08	2471.49	1107.44	1699.11	6644.90	2713.33
Total Vol Exp (Max)		3305.15	4195.61	2881.85	1422.18	1981.23	8533.45	3484.49
Total Vol Exp (Min)		2363.88	2338.54	2061.13	792.69	1417.00	4756.35	1942.18
Conc (min)	mg/m^3	11.22	4.54	6.82	5.14	7.96	9.53	25.98
Conc (ave)	mg/m^3	9.36	3.25	5.69	3.68	6.64	6.82	18.60
Conc (max)	mg/m^3	8.02	2.53	4.88	2.87	5.69	5.31	14.48

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 8:   Code: V11-E9-R6

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 11: 0.01394 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 9: 2000 cal/min (140 Watts)
Basal Metabolic Rate estimated from Reference 6: 107.53 watts/ lpm of oxygen required

Sample #		1	2	3	4	5	6	7
Operation	Units	Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol Rate O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Vol Rate O2 (AT)	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol Rate O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Total Energy Req	cal/min	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00
Total Energy Req	Watts	139.47	139.47	139.47	139.47	139.47	139.47	139.47
Std Metabolism	watt/lpm	107.53	107.53	107.53	107.53	107.53	107.53	107.53
Basal Rate	Watts	68.11	68.11	66.84	70.65	68.11	68.11	68.11
Energy Req (work)	Watts	71.35	71.35	72.63	68.81	71.35	71.35	71.35
Vol Rate O2 (Work)	lpm	1.00	1.00	1.01	0.96	1.00	1.00	1.00
Total Rate O2 Req	lpm	1.63	1.63	1.63	1.62	1.63	1.63	1.63
% of AT Required	%	0.84	0.84	0.87	0.77	1.08	0.84	0.84
% of Vol O2 (max)	%	0.47	0.47	0.49	0.43	0.60	0.47	0.47
Vol Rate Expir/Vol Rate O2		28.50	28.50	28.50	28.50	26.50	28.50	28.50
Vol Expir/Vol O2	+/-	8.10	8.10	8.10	8.10	4.40	8.10	8.10
Time of Work	min	55.00	59.00	48.00	20.00	33.00	120.00	49.00
Total Vol Exp (Ave)	liters	2552.82	2738.47	2235.99	921.56	1424.20	5569.78	2274.33
Total Vol Exp (Max)		3278.35	3516.78	2871.48	1183.48	1660.67	7152.77	2920.71
Total Vol Exp (Min)		1827.28	1960.17	1600.50	659.65	1187.73	3986.79	1627.94
Conc (min)	mg/m^3	14.51	5.42	8.79	6.18	9.49	11.37	30.99
Conc (ave)	mg/m^3	10.39	3.88	6.29	4.42	7.92	8.14	22.18
Conc (max)	mg/m^3	8.09	3.02	4.90	3.44	6.79	6.34	17.28

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 9: Code: V11-E9-R12

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 11: 0.01394 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 9: 2000 cal/min (140 Watts)
Basal Metabolic Rate estimated from Reference 12: See Table 5.

Sample #		1	2	3	4	5	6	7
Operation	Units	Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol Rate O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Vol Rate O2 (AT)	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol Rate O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Total Energy Req	cal/min	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00
Total Energy Req	Watts	139.47	139.47	139.47	139.47	139.47	139.47	139.47
Std Metabolism	cal/m^2/hr	40.24	40.24	40.24	40.24	40.24	40.24	40.24
Basal Rate	Watts	0.10	0.10	0.09	0.10	0.10	0.10	0.10
Energy Req (work)	Watts	139.37	139.37	139.37	139.37	139.37	139.37	139.37
Vol Rate O2 (Work)	lpm	1.94	1.94	1.94	1.94	1.94	1.94	1.94
Total Rate O2 Req	lpm	2.58	2.58	2.57	2.60	2.58	2.58	2.58
% of AT Required	%	1.33	1.33	1.36	1.23	1.71	1.33	1.33
% of Vol O2 (max)	%	0.74	0.74	0.76	0.69	0.96	0.74	0.74
Vol Rate Expir/Vol Rate O2		26.50	26.50	26.50	26.50	26.50	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	4.40	4.40	4.40	4.40
Time of Work	min	55.00	59.00	48.00	20.00	33.00	120.00	49.00
Total Vol Exp (Ave)	liters	3756.22	4029.40	3263.16	1378.40	2253.73	8195.40	3346.45
Total Vol Exp (Max)		4379.90	4698.44	3804.97	1607.26	2627.94	9556.14	3902.09
Total Vol Exp (Min)		3132.55	3360.37	2721.35	1149.53	1879.53	6834.65	2790.82
Conc (min)	mg/m^3	8.47	3.16	5.17	3.54	6.00	6.63	18.08
Conc (ave)	mg/m^3	7.06	2.64	4.31	2.96	5.00	5.53	15.08
Conc (max)	mg/m^3	6.05	2.26	3.70	2.54	4.29	4.75	12.93

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 10: Code: V6-E8-R11

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 6: 0.0093 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 8: 3400 cal/min (238 Watts)
Basal Metabolic Rate estimated from Reference 11: 71.74 watts/ lpm of oxygen required

Sample #		1	2	3	4	5	6	7
Operation	Units	Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol Rate O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Vol Rate O2 (AT)	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol Rate O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Total Energy Req	cal/min	3400.00	3400.00	3400.00	3400.00	3400.00	3400.00	3400.00
Total Energy Req	Watts	237.09	237.09	237.09	237.09	237.09	237.09	237.09
Std Metabolism	watt/lpm	71.74	71.94	71.94	71.94	71.94	71.94	71.94
Basal Rate	Watts	45.44	45.57	44.72	47.27	45.57	45.57	45.57
Energy Req (work)	Watts	191.65	191.52	192.37	189.82	191.52	191.52	191.52
Vol Rate O2 (Work)	lpm	1.78	1.78	1.79	1.77	1.78	1.78	1.78
Total Rate O2 Req	lpm	2.42	2.41	2.41	2.42	2.41	2.41	2.41
% of AT Required	%	1.24	1.24	1.28	1.15	1.60	1.24	1.24
% of Vol O2 (max)	%	0.70	0.70	0.72	0.64	0.90	0.70	0.70
Vol Rate Expir/Vol Rate O2		26.50	26.50	26.50	26.50	26.50	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	4.40	4.40	4.40	4.40
Time of Work	min	55.00	59.00	48.00	20.00	33.00	120.00	49.00
Total Vol Exp (Ave)	liters	3521.03	3775.20	3066.38	1283.88	2111.55	7678.38	3135.34
Total Vol Exp (Max)		4105.65	4402.03	3575.51	1497.05	2462.15	8953.28	3655.92
Total Vol Exp (Min)		2936.40	3148.38	2557.24	1070.70	1760.96	6403.48	2614.75
Conc (min)	mg/m^3	9.03	3.37	5.50	3.81	6.40	7.08	19.30
Conc (ave)	mg/m^3	7.53	2.81	4.59	3.17	5.34	5.91	16.09
Conc (max)	mg/m^3	6.46	2.41	3.93	2.72	4.58	5.06	13.80

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 11: Code: V6-E8-R6

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 6: 0.0093 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 8: 3400 cal/min (238 Watts)
Basal Metabolic Rate estimated from Reference 6: 107.53 watts/ lpm of oxygen required

Sample #		1	2	3	4	5	6	7
Operation	Units	Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol Rate O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Vol Rate O2 (AT)	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol Rate O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Total Energy Req	cal/min	3400.00	3400.00	3400.00	3400.00	3400.00	3400.00	3400.00
Total Energy Req	Watts	237.09	237.09	237.09	237.09	237.09	237.09	237.09
Standard Metabolism	watt/lpm	107.53	107.53	107.53	107.53	107.53	107.53	107.53
Basal Rate	Watts	68.11	68.11	66.84	70.65	68.11	68.11	68.11
Energy Req (work)	Watts	168.98	168.98	170.25	166.44	168.98	168.98	168.98
Vol Rate O2 (Work)	lpm	1.57	1.57	1.58	1.55	1.57	1.57	1.57
Total Rate O2 Req	lpm	2.20	2.20	2.20	2.20	2.20	2.20	2.20
% of AT Required	%	1.13	1.13	1.17	1.04	1.46	1.13	1.13
% of Vol O2 (max)	%	0.63	0.63	0.66	0.58	0.82	0.63	0.63
Vol Rate Expir/Vol Rate O2		26.50	26.50	26.50	26.50	26.50	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	4.40	4.40	4.40	4.40
Time of Work	min	55.00	59.00	48.00	20.00	33.00	120.00	49.00
Total Vol Exp (Ave)	liters	3213.73	3447.45	2804.71	1168.63	1928.24	7011.76	2863.14
Total Vol Exp (Max)		3747.33	4019.86	3270.39	1362.66	2248.40	8175.98	3338.53
Total Vol Exp (Min)		2680.13	2875.04	2339.02	974.59	1608.08	5847.55	2387.75
Conc (min)	mg/m^3	9.90	3.70	6.01	4.18	7.01	7.75	21.13
Conc (ave)	mg/m^3	8.25	3.08	5.01	3.49	5.85	6.47	17.62
Conc (max)	mg/m^3	7.08	2.64	4.30	2.99	5.02	5.55	15.11

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 12: Code: V6-E8-R12

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 6: 0.0093 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 8: 3400 cal/min (238 Watts)
Basal Metabolic Rate estimated from Reference 12: See Table 5.

Sample #		1	2	3	4	5	6	7
Operation	Units	Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol Rate O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Vol Rate O2 (AT)	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol Rate O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Total Energy Req	cal/min	3400.00	3400.00	3400.00	3400.00	3400.00	3400.00	3400.00
Total Energy Req	Watts	237.09	237.09	237.09	237.09	237.09	237.09	237.09
Std Metabolism	cal/m^2/hr	40.24	40.24	40.24	40.24	40.24	40.24	40.24
Basal Rate	Watts	0.10	0.10	0.09	0.10	0.10	0.10	0.10
Energy Req (work)	Watts	237.00	237.00	237.00	236.99	237.00	237.00	237.00
Vol Rate O2 (Work)	lpm	2.20	2.20	2.20	2.20	2.20	2.20	2.20
Total Rate O2 Req	lpm	2.84	2.84	2.83	2.86	2.84	2.84	2.84
% of AT Required	%	1.46	1.46	1.50	1.36	1.88	1.46	1.46
% of Vol O2 (max)	%	0.82	0.82	0.84	0.76	1.05	0.82	0.82
Vol Rate Expir/Vol Rate O2		26.50	26.50	26.50	26.50	37.70	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	4.40	6.90	4.40	4.40
Time of Work	min	55.00	59.00	48.00	20.00	33.00	120.00	49.00
Total Vol Exp (Ave)	liters	4135.65	4436.43	3594.29	1516.38	3530.13	9023.24	3684.49
Total Vol Exp (Max)		4822.33	5173.04	4191.07	1768.16	4176.23	10521.44	4296.26
Total Vol Exp (Min)		3448.98	3699.81	2997.50	1264.61	2884.03	7525.04	3072.73
Conc (min)	mg/m^3	7.69	2.87	4.69	3.22	3.91	6.03	16.42
Conc (ave)	mg/m^3	6.41	2.39	3.91	2.69	3.19	5.03	13.69
Conc (max)	mg/m^3	5.50	2.05	3.36	2.30	2.70	4.31	11.74

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 13: Code: V6-E10-R11

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 6: 0.0093 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 10: See Table 4.
Basal Metabolic Rate estimated from Reference 11: 71.4 watts/ lpm of oxygen required

Sample #		1	2	3	4	5	6	7
Operation		Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Anerobic Threshold	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Energy Req Standing	cal/min	2850.00	2850.00	2050.00	2050.00	2850.00	2850.00	2850.00
Energy Req Standing	Watts	198.74	198.74	142.95	142.95	198.74	198.74	198.74
Std Metabolism	watt/lpm	71.70	71.70	71.70	71.70	71.70	71.70	71.70
Basal Rate	Watts	45.42	45.42	44.57	47.11	45.42	45.42	45.42
Energy Req (work)	Watts	153.32	153.32	98.38	95.84	153.32	153.32	153.32
Vol O2 (Work)	lpm	1.43	1.43	0.91	0.89	1.43	1.43	1.43
Total O2 Required	lpm	2.06	2.06	1.54	1.55	2.06	2.06	2.06
% of AT Required	%	1.06	1.06	0.82	0.73	1.37	1.06	1.06
% of Vol O2 (max)	%	0.59	0.59	0.46	0.41	0.76	0.59	0.59
Vol Expir/Vol O2		26.50	26.50	28.50	28.50	26.50	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	8.10	8.10	4.40	4.40	4.40
Time of Standing	min	42.00	57.00	41.00	20.00	26.00	50.00	23.00
Energy Req Sitting	cal/min	2550.00	2550.00	1750.00	1750.00	2550.00	2550.00	2550.00
Energy Req Sitting	Watts	177.82	177.82	122.03	122.03	177.82	177.82	177.82
Std Metabolism	watt/lpm	107.53	107.53	107.53	107.53	107.53	107.53	107.53
Basal Rate	Watts	68.11	68.11	66.84	70.65	68.11	68.11	68.11
Energy Req (work)	Watts	109.71	109.71	55.19	51.38	109.71	109.71	109.71
Vol O2 (Work)	lpm	1.02	1.02	0.51	0.48	1.02	1.02	1.02
Total O2 Required	lpm	2.16	2.16	1.39	1.37	2.16	2.16	2.16
% of AT Required	%	1.11	1.11	0.74	0.65	1.43	1.11	1.11
% of Vol O2 (max)	%	0.62	0.62	0.41	0.36	0.80	0.62	0.62
Vol Expir/Vol O2		26.50	26.50	28.50	28.50	26.50	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	8.10	8.10	4.40	4.40	4.40
Time of Sitting	min	2.00	0.00	0.00	0.00	8.00	18.00	6.00

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Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 13: (con't)

Sample #		1	2	3	4	5	6	7
Operation		Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Energy Req Stooping	cal/min	3050.00	3050.00	2250.00	2250.00	3050.00	3050.00	3050.00
Energy Req Stooping	Watts	212.69	212.69	156.90	156.90	212.69	212.69	212.69
Std Metabolism	watt/lpm	107.53	107.53	107.53	107.53	107.53	107.53	107.53
Basal Rate	Watts	68.11	68.11	66.84	70.65	68.11	68.11	68.11
Energy Req (work)	Watts	144.57	144.57	90.06	86.25	144.57	144.57	144.57
Vol O2 (Work)	lpm	1.34	1.34	0.84	0.80	1.34	1.34	1.34
Total O2 Required	lpm	2.65	2.65	1.88	1.86	2.65	2.65	2.65
% of AT Required	%	1.36	1.36	1.00	0.88	1.76	1.36	1.36
% of Vol O2 (max)	%	0.76	0.76	0.56	0.49	0.98	0.76	0.76
Vol Expir/Vol O2		26.50	26.50	28.50	28.50	26.50	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	8.10	8.10	4.40	4.40	4.40
Time of Stooping	min	0.00	0.00	7.00	0.00	0.00	26.00	0.00
Energy Req Kneeling	cal/min	2750.00	2750.00	1950.00	1950.00	2750.00	2750.00	2750.00
Energy Req Kneeling	Watts	191.77	191.77	135.98	135.98	191.77	191.77	191.77
Std Metabolism	watt/lpm	107.53	107.53	107.53	107.53	107.53	107.53	107.53
Basal Rate	Watts	68.11	68.11	66.84	70.65	68.11	68.11	68.11
Energy Req (work)	Watts	123.65	123.65	69.14	65.33	123.65	123.65	123.65
Vol O2 (Work)	lpm	1.15	1.15	0.64	0.61	1.15	1.15	1.15
Total O2 Required	lpm	2.36	2.36	1.59	1.57	2.36	2.36	2.36
% of AT Required	%	1.21	1.21	0.84	0.74	1.56	1.21	1.21
% of Vol O2 (max)	%	0.68	0.68	0.47	0.42	0.88	0.68	0.68
Vol Expir/Vol O2		26.50	26.50	28.50	28.50	26.50	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	8.10	8.10	4.40	4.40	4.40
Time of Stooping	min	11.00	2.00	0.00	0.00	0.00	7.00	20.00
Vol Exp (Ave)	liters	3094.04	3235.57	2170.06	882.58	1877.53	6023.67	2848.88
Vol Exp (Max)		3607.77	3772.80	2786.82	1133.41	2189.27	7023.82	3321.91
Vol Exp (Min)		2580.31	2698.34	1553.31	631.74	1565.79	5023.51	2375.86
Conc (min)	mg/m^3	10.28	3.94	9.05	6.45	3.83	8.00	18.95
Conc (ave)	mg/m^3	8.57	3.28	6.48	4.62	3.19	6.67	15.80
Conc (max)	mg/m^3	7.35	2.82	5.05	3.60	2.74	5.72	13.55

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 14: Code: V6-E10-R6

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 6: 0.0093 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 10: See Table 4.
Basal Metabolic Rate estimated from Reference 6: 107.53 watts/ lpm of oxygen required

Sample #		1	2	3	4	5	6	7
Operation		Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Anerobic Threshold	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Energy Req Standing	cal/min	2850.00	2850.00	2050.00	2050.00	2850.00	2850.00	2850.00
Energy Req Standing	Watts	198.74	198.74	142.95	142.95	198.74	198.74	198.74
Std Metabolism	watt/lpm	107.53	107.53	107.53	107.53	107.53	107.53	107.53
Basal Rate	Watts	68.11	68.11	66.84	70.65	68.11	68.11	68.11
Energy Req (work)	Watts	130.63	130.63	76.11	72.30	130.63	130.63	130.63
Vol O2 (Work)	lpm	1.21	1.21	0.71	0.67	1.21	1.21	1.21
Total O2 Required	lpm	1.85	1.85	1.33	1.33	1.85	1.85	1.85
% of AT Required	%	0.95	0.95	0.71	0.63	1.23	0.95	0.95
% of Vol O2 (max)	%	0.53	0.53	0.40	0.35	0.69	0.53	0.53
Vol Expir/Vol O2		28.50	28.50	28.50	28.50	26.50	28.50	28.50
Vol Expir/Vol O2	+/-	8.10	8.10	8.10	8.10	4.40	8.10	8.10
Time of Standing	min	42.00	57.00	41.00	20.00	26.00	50.00	23.00
Energy Req Sitting	cal/min	2550.00	2550.00	1750.00	1750.00	2550.00	2550.00	2550.00
Energy Req Sitting	Watts	177.82	177.82	122.03	122.03	177.82	177.82	177.82
Std Metabolism	watt/lpm	71.70	71.70	71.70	71.70	71.70	71.70	71.70
Basal Rate	Watts	45.42	45.42	44.57	47.11	45.42	45.42	45.42
Energy Req (work)	Watts	132.40	132.40	77.46	74.92	132.40	132.40	132.40
Vol O2 (Work)	lpm	1.23	1.23	0.72	0.70	1.23	1.23	1.23
Total O2 Required	lpm	2.48	2.48	1.70	1.70	2.48	2.48	2.48
% of AT Required	%	1.28	1.28	0.90	0.81	1.64	1.28	1.28
% of Vol O2 (max)	%	0.71	0.71	0.51	0.45	0.92	0.71	0.71
Vol Expir/Vol O2		26.50	26.50	28.50	28.50	26.50	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	8.10	8.10	4.40	4.40	4.40
Time of Sitting	min	2.00	0.00	0.00	0.00	8.00	18.00	6.00

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Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 14: (con't)

Sample #		1	2	3	4	5	6	7
Operation		Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Energy Req Stooping	cal/min	3050.00	3050.00	2250.00	2250.00	3050.00	3050.00	3050.00
Energy Req Stooping	Watts	212.69	212.69	156.90	156.90	212.69	212.69	212.69
Std Metabolism	watt/lpm	71.70	71.70	71.70	71.70	71.70	71.70	71.70
Basal Rate	Watts	45.42	45.42	44.57	47.11	45.42	45.42	45.42
Energy Req (work)	Watts	167.27	167.27	112.33	109.79	167.27	167.27	167.27
Vol O2 (Work)	lpm	1.56	1.56	1.04	1.02	1.56	1.56	1.56
Total O2 Required	lpm	2.97	2.97	2.19	2.19	2.97	2.97	2.97
% of AT Required	%	1.53	1.53	1.16	1.04	1.97	1.53	1.53
% of Vol O2 (max)	%	0.85	0.85	0.65	0.58	1.10	0.85	0.85
Vol Expir/Vol O2		26.50	26.50	26.50	26.50	37.70	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	4.40	6.90	4.40	4.40
Time of Stooping	min	0.00	0.00	7.00	0.00	0.00	26.00	0.00
Energy Req Kneeling	cal/min	2750.00	2750.00	1950.00	1950.00	2750.00	2750.00	2750.00
Energy Req Kneeling	Watts	191.77	191.77	135.98	135.98	191.77	191.77	191.77
Std Metabolism	watt/lpm	71.70	71.70	71.70	71.70	71.70	71.70	71.70
Basal Rate	Watts	45.42	45.42	44.57	47.11	45.42	45.42	45.42
Energy Req (work)	Watts	146.35	146.35	91.41	88.87	146.35	146.35	146.35
Vol O2 (Work)	lpm	1.36	1.36	0.85	0.83	1.36	1.36	1.36
Total O2 Required	lpm	2.67	2.67	1.90	1.90	2.67	2.67	2.67
% of AT Required	%	1.38	1.38	1.01	0.90	1.77	1.38	1.38
% of Vol O2 (max)	%	0.77	0.77	0.56	0.50	0.99	0.77	0.77
Vol Expir/Vol O2		26.50	26.50	26.50	28.50	26.50	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	8.10	4.40	4.40	4.40
Time of Stooping	min	11.00	2.00	0.00	0.00	0.00	7.00	20.00
Vol Exp (Ave)	liters	3123.43	3144.27	1959.39	757.79	1799.21	6356.59	3023.33
Vol Exp (Max)		3903.48	4021.15	2468.30	973.16	2097.95	7723.27	3668.49
Vol Exp (Min)		2343.38	2267.38	1450.48	542.42	1500.48	4989.92	2378.17
Conc (min)	mg/m^3	11.32	4.69	9.70	7.51	4.00	8.05	18.93
Conc (ave)	mg/m^3	8.49	3.38	7.18	5.38	3.33	6.32	14.89
Conc (max)	mg/m^3	6.79	2.64	5.70	4.19	2.86	5.20	12.27

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 15: Code: V6-E10-R12

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 6: 0.0093 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 10: See Table 4.
Basal Metabolic Rate estimated from Reference 12: See Table 5.

Sample #		1	2	3	4	5	6	7
Operation		Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Anerobic Threshold	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Energy Req Standing	cal/min	2850.00	2850.00	2050.00	2050.00	2850.00	2850.00	2850.00
Energy Req Standing	Watts	198.74	198.74	142.95	142.95	198.74	198.74	198.74
Std Metabolism	cal/m^2/hr	40.24	40.24	40.24	40.24	40.24	40.24	40.24
Basal Rate	Watts	0.10	0.10	0.09	0.10	0.10	0.10	0.10
Energy Req (work)	Watts	198.64	198.64	142.86	142.85	198.64	198.64	198.64
Vol O2 (Work)	lpm	1.85	1.85	1.33	1.33	1.85	1.85	1.85
Total O2 Required	lpm	2.48	2.48	1.95	1.99	2.48	2.48	2.48
% of AT Required	%	1.28	1.28	1.04	0.94	1.64	1.28	1.28
% of Vol O2 (max)	%	0.71	0.71	0.58	0.53	0.92	0.71	0.71
Vol Expir/Vol O2		26.50	26.50	26.50	28.50	26.50	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	8.10	4.40	4.40	4.40
Time of Standing	min	42.00	57.00	41.00	20.00	26.00	50.00	23.00
Energy Req Sitting	cal/min	2550.00	2550.00	1750.00	1750.00	2550.00	2550.00	2550.00
Energy Req Sitting	Watts	177.82	177.82	122.03	122.03	177.82	177.82	177.82
Std Metabolism	cal/m^2/hr	40.24	40.24	40.24	40.24	40.24	40.24	40.24
Basal Rate	Watts	0.10	0.10	0.09	0.10	0.10	0.10	0.10
Energy Req (work)	Watts	177.72	177.72	121.94	121.93	177.72	177.72	177.72
Vol O2 (Work)	lpm	1.65	1.65	1.13	1.13	1.65	1.65	1.65
Total O2 Required	lpm	3.11	3.11	2.32	2.36	3.11	3.11	3.11
% of AT Required	%	1.60	1.60	1.23	1.12	2.06	1.60	1.60
% of Vol O2 (max)	%	0.90	0.90	0.69	0.63	1.16	0.90	0.90
Vol Expir/Vol O2		26.50	26.50	26.50	26.50	37.70	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	4.40	6.90	4.40	4.40
Time of Sitting	min	2.00	0.00	0.00	0.00	8.00	18.00	6.00

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Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 15: (con't)

Sample #		1	2	3	4	5	6	7
Operation		Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Energy Req Stooping	cal/min	3050.00	3050.00	2250.00	2250.00	3050.00	3050.00	3050.00
Energy Req Stooping	Watts	212.69	212.69	156.90	156.90	212.69	212.69	212.69
Std Metabolism	cal/m^2/hr	40.24	40.24	40.24	40.24	40.24	40.24	40.24
Basal Rate	Watts	0.10	0.10	0.09	0.10	0.10	0.10	0.10
Energy Req (work)	Watts	212.59	212.59	156.80	156.80	212.59	212.59	212.59
Vol O2 (Work)	lpm	1.98	1.98	1.46	1.46	1.98	1.98	1.98
Total O2 Required	lpm	3.60	3.60	2.81	2.84	3.60	3.60	3.60
% of AT Required	%	1.85	1.85	1.49	1.35	2.39	1.85	1.85
% of Vol O2 (max)	%	1.04	1.04	0.84	0.75	1.34	1.04	1.04
Vol Expir/Vol O2		37.70	37.70	26.50	26.50	37.70	37.70	37.70
Vol Expir/Vol O2	+/-	6.90	6.90	4.40	4.40	6.90	6.90	6.90
Time of Stooping	min	0.00	0.00	7.00	0.00	0.00	26.00	0.00
Energy Req Kneeling	cal/min	2750.00	2750.00	1950.00	1950.00	2750.00	2750.00	2750.00
Energy Req Kneeling	Watts	191.77	191.77	135.98	135.98	191.77	191.77	191.77
Std Metabolism	cal/m^2/hr	40.24	40.24	40.24	40.24	40.24	40.24	40.24
Basal Rate	Watts	0.10	0.10	0.09	0.10	0.10	0.10	0.10
Energy Req (work)	Watts	191.67	191.67	135.88	135.88	191.67	191.67	191.67
Vol O2 (Work)	lpm	1.78	1.78	1.26	1.26	1.78	1.78	1.78
Total O2 Required	lpm	3.31	3.31	2.52	2.55	3.31	3.31	3.31
% of AT Required	%	1.70	1.70	1.34	1.21	2.19	1.70	1.70
% of Vol O2 (max)	%	0.95	0.95	0.75	0.68	1.23	0.95	0.95
Vol Expir/Vol O2		26.50	26.50	26.50	26.50	37.70	26.50	26.50
Vol Expir/Vol O2	+/-	4.40	4.40	4.40	4.40	6.90	4.40	4.40
Time of Stooping	min	11.00	2.00	0.00	0.00	0.00	7.00	20.00
Vol Exp (Ave)	liters	3889.95	3922.52	2639.87	1131.79	2647.88	8911.99	3759.36
Vol Exp (Max)		4535.83	4573.80	3078.19	1453.46	3103.47	10451.63	4383.55
Vol Exp (Min)		3244.07	3271.23	2201.55	810.13	2192.29	7372.35	3135.16
Conc (min)	mg/m^3	8.17	3.25	6.39	5.03	2.74	5.45	14.36
Conc (ave)	mg/m^3	6.82	2.71	5.33	3.60	2.27	4.51	11.97
Conc (max)	mg/m^3	5.85	2.32	4.57	2.80	1.93	3.84	10.27

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 16: Code: V6-E9-R11

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 6: 0.0093 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 9: 2000 cal/min (140 Watts)
Basal Metabolic Rate estimated from Reference 11: 71.74 watts/ lpm of oxygen required

Sample #		1	2	3	4	5	6	7
Operation	Units	Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol Rate O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Vol Rate O2 (AT)	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol Rate O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Total Energy Req	cal/min	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00
Total Energy Req	Watts	139.47	139.47	139.47	139.47	139.47	139.47	139.47
Std Metabolism	watt/lpm	71.74	71.94	71.94	71.94	71.94	71.94	71.94
Basal Rate	Watts	45.44	45.57	44.72	47.27	45.57	45.57	45.57
Energy Req (work)	Watts	94.03	93.90	94.75	92.19	93.90	93.90	93.90
Vol Rate O2 (Work)	lpm	0.87	0.87	0.88	0.86	0.87	0.87	0.87
Total Rate O2 Req	lpm	1.51	1.51	1.50	1.51	1.51	1.51	1.51
% of AT Required	%	0.78	0.77	0.80	0.72	1.00	0.77	0.77
% of Vol O2 (max)	%	0.43	0.43	0.45	0.40	0.56	0.43	0.43
Vol Rate Expir/Vol Rate O2		28.50	28.50	28.50	28.50	28.50	28.50	28.50
Vol Expir/Vol O2	+/-	8.10	8.10	8.10	8.10	8.10	8.10	8.10
Time of Work	min	55.00	59.00	48.00	20.00	33.00	120.00	49.00
Total Vol Exp (Ave)	liters	2363.60	2533.45	2055.76	863.26	1417.01	5152.78	2104.05
Total Vol Exp (Max)		3035.35	3253.48	2640.03	1108.60	1819.74	6617.25	2702.04
Total Vol Exp (Min)		1691.84	1813.42	1471.49	617.91	1014.28	3688.30	1506.06
Conc (min)	mg/m^3	15.68	5.86	9.56	6.59	11.12	12.29	33.50
Conc (ave)	mg/m^3	11.22	4.19	6.84	4.72	7.96	8.80	23.98
Conc (max)	mg/m^3	8.74	3.27	5.33	3.68	6.20	6.85	18.67

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 17: Code: V6-E9-R6

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 6: 0.0093 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 9: 2000 cal/min (140 Watts)
Basal Metabolic Rate estimated from Reference 6: 107.53 watts/ lpm of oxygen required

Sample #		1	2	3	4	5	6	7
Operation	Units	Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol Rate O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Vol Rate O2 (AT)	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol Rate O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Total Energy Req	cal/min	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00
Total Energy Req	Watts	139.47	139.47	139.47	139.47	139.47	139.47	139.47
Std Metabolism	watt/lpm	107.53	107.53	107.53	107.53	107.53	107.53	107.53
Basal Rate	Watts	68.11	68.11	66.84	70.65	68.11	68.11	68.11
Energy Req (work)	Watts	71.35	71.35	72.63	68.81	71.35	71.35	71.35
Vol Rate O2 (Work)	lpm	0.66	0.66	0.68	0.64	0.66	0.66	0.66
Total Rate O2 Req	lpm	1.30	1.30	1.30	1.30	1.30	1.30	1.30
% of AT Required	%	0.67	0.67	0.69	0.61	0.86	0.67	0.67
% of Vol O2 (max)	%	0.37	0.37	0.39	0.34	0.48	0.37	0.37
Vol Rate Expir/Vol Rate O2		28.50	28.50	28.50	28.50	28.50	28.50	28.50
Vol Expir/Vol O2	+/-	8.10	8.10	8.10	8.10	8.10	8.10	8.10
Time of Work	min	55.00	59.00	48.00	20.00	33.00	120.00	49.00
Total Vol Exp (Ave)	liters	2033.10	2180.96	1774.34	739.31	1219.86	4435.86	1811.31
Total Vol Exp (Max)		2610.93	2800.81	2278.63	949.43	1566.56	5696.57	2326.10
Total Vol Exp (Min)		1455.27	1561.11	1270.06	529.19	873.16	3175.14	1296.51
Conc (min)	mg/m^3	18.22	6.81	11.07	7.70	12.91	14.28	38.92
Conc (ave)	mg/m^3	13.04	4.87	7.93	5.51	9.24	10.22	27.86
Conc (max)	mg/m^3	10.16	3.79	6.17	4.29	7.20	7.96	21.69

Appendix III: Dust/Mist Sampling Results for Respirator Flow Model # 18: Code: V6-E9-R12

Increase Volume Rate of Oxygen per Increase in Work Rate From Ref 6: 0.0093 lpm O2/watt
Ergonomic Estimate of Total Energy Required from Reference 9: 2000 cal/min (140 Watts)
Basal Metabolic Rate estimated from Reference 12: See Table 5.

Sample #		1	2	3	4	5	6	7
Operation	Units	Sanding	Sanding	Painting	Painting	Sanding	Sanding	Sanding
Height	cm	182.88	182.88	180.34	187.96	182.88	182.88	182.88
Weight	kg	83.78	83.78	81.77	87.79	83.78	83.78	83.78
Age	years	25.00	25.00	26.00	21.00	50.00	25.00	25.00
Vol Rate O2 (max)	lpm	3.47	3.47	3.36	3.77	2.69	3.47	3.47
Vol Rate O2 (AT)	lpm	1.94	1.94	1.88	2.11	1.51	1.94	1.94
Vol Rate O2 (0 Watts)	lpm	0.63	0.63	0.62	0.66	0.63	0.63	0.63
Total Energy Req	cal/min	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00	2000.00
Total Energy Req	Watts	139.47	139.47	139.47	139.47	139.47	139.47	139.47
Std Metabolism	cal/m^2/hr	40.24	40.24	40.24	40.24	40.24	40.24	40.24
Basal Rate	Watts	0.10	0.10	0.09	0.10	0.10	0.10	0.10
Energy Req (work)	Watts	139.37	139.37	139.37	139.37	139.37	139.37	139.37
Vol Rate O2 (Work)	lpm	1.30	1.30	1.30	1.30	1.30	1.30	1.30
Total Rate O2 Req	lpm	1.93	1.93	1.92	1.95	1.93	1.93	1.93
% of AT Required	%	0.99	0.99	1.02	0.93	1.28	0.99	0.99
% of Vol O2 (max)	%	0.56	0.56	0.57	0.52	0.72	0.56	0.56
Vol Rate Expir/Vol Rate O2		28.50	28.50	26.50	28.50	26.50	28.50	28.50
Vol Expir/Vol O2	+/-	8.10	8.10	4.40	8.10	4.40	8.10	8.10
Time of Work	min	55.00	59.00	48.00	20.00	33.00	120.00	49.00
Total Vol Exp (Ave)	liters	3024.61	3244.58	2439.41	1113.31	1687.41	6599.14	2694.65
Total Vol Exp (Max)		3884.23	4166.72	2844.44	1429.72	1967.59	8474.69	3460.50
Total Vol Exp (Min)		2164.98	2322.44	2034.37	796.90	1407.24	4723.60	1928.80
Conc (min)	mg/m^3	12.25	4.57	6.91	5.11	8.01	9.60	26.16
Conc (ave)	mg/m^3	8.77	3.27	5.77	3.66	6.68	6.87	18.72
Conc (max)	mg/m^3	6.83	2.55	4.94	2.85	5.73	5.35	14.58

Appendix IV

Organic Vapor Sampling Concentrations

by for Respirator Flow Model #17

Appendix IV: Organic Vapor Sampling Results by Concentration
using Airflow Model # 17 for Respirator Cartridge Results

	BZ Sample OV-1		Resp Cart OV-1		BZ Sample OV-2		Resp Cart OV-2		BZ Sample OV-3		Resp Cart OV-3	
Time Sampled (min)	158	min	94	min	97	min	56	min	48	min	48	min
Volume Sampled (m^3)	0.149	m^3	2.07	m^3	0.099	m^3	2.170	m^3	0.047	m^3	1.770	m^3
	mg/m^3	S.D.	mg/m^3	S.D.	mg/m^3	S.D.	mg/m^3	S.D.	mg/m^3	S.D.	mg/m^3	S.D.
Isopentane												
Methylcyclopentane	0.60	0.01	0.60	0.09	0.61	0.04	0.30	0.03	1.33	0.01	0.71	0.12
n-Heptane	1.89	0.04	1.59	0.22	1.72	0.03	0.73	0.07	4.21	0.10	1.75	0.36
Methylcyclohexane	2.28	0.14	3.38	0.29	2.18	0.01	1.56	0.26	6.29	0.16	4.04	0.60
n-Octane	2.10	0.16	2.78	0.25	2.42	0.03	1.60	0.10				
1,1,1-Trichloroethane	0.35	0.01									0.55	0.19
Methyl Ethyl Ketone	14.57	0.26	6.43	2.67	18.79	0.55	11.46	1.95			0.05	0.08
Isopropanol					6.07	1.40			3.52	0.28	1.18	0.27
Trichloroethylene	8.47	0.14	8.59	0.85	17.78	0.38	8.58	0.70	14.13	0.22	9.51	2.34
Toluene	20.13	1.97	20.36	2.33	22.26	0.57	12.49	1.01	21.66	0.56	8.51	1.78
Ethlyene Dichloride	9.57	0.28	6.66	0.67	14.89	0.29	6.65	0.46	0.30	0.22	0.04	0.11
p-Xylene	1.70	0.02	1.86	0.21	3.50	0.23	2.52	0.25	2.50	0.06	1.15	0.19
m-Xylene	6.33	0.11	8.45	0.94	9.82	0.70	8.47	1.03	0.06	0.00	0.00	0.00
o-Xylene	2.76	0.14	3.42	0.38	4.95	0.02	4.37	1.46	0.80	0.06	0.45	0.08

Appendix IV: Organic Vapor Sampling Results by Concentration using Airflow Model # 17 for Respirator Cartridge Results (con't)

	BZ Sample OV-4		Resp Cart OV-4		BZ Sample OV-5		Resp Cart OV-5	
Time Sampled (min)	23	min	23	min	51	min	51	min
Volume Sampled (m^3)	0.033	m^3	0.850	m^3	0.053	m^3	1.885	m^3
	mg/m^3	S.D.	mg/m^3	S.D.	mg/m^3	S.D.	mg/m^3	S.D.
Isopentane	0.46	0.01						
Methylcyclopentane	2.67	0.04	2.21	1.09	0.15	.00	0.11	0.03
n-Heptane	9.36	0.08	6.18	1.02	0.37	0.01	0.32	0.08
Methylcyclohexane	9.56	0.11	10.31	1.15				
n-Octane	0.78	.00			12.63	0.08	10.74	1.64
1,1,1-Trichloroethane							8.44	9.15
Methyl Ethyl Ketone					1.92	0.05	1.46	0.21
Isopropanol	2.50	0.21			5.61	8.48	30.10	6.96
Trichloroethylene					16.80	0.18	10.52	1.45
Toluene	39.60	0.52	26.45	1.38	22.04	0.19	18.01	2.16
Ethlyene Dichloride					4.46	0.15	2.22	0.33
p-Xylene	3.51	0.08	2.17	1.48	2.02	0.02	1.50	0.18
m-Xylene					5.36	0.10	4.18	0.51
o-Xylene	0.93	0.02	0.48	2.46	1.54	0.07	0.52	0.13

Appendix V

Porton Graticule Particle Sizing Data

Appendix V:

Porton Gradicule Particle Sizing of Dust Samples

Gradicule Calibration

Ernst Leitz Wetzler Binocular Microscope
Eyepiece: 12.5x with Porton Gradicule
Object Lense: 10x

Porton #	Stage Micrometer in microns meas	calc	Log(d(i))
1		1.432	
2		2.086	
3		3.041	
4		4.431	
5		6.457	
6	8	9.410	0.903
7	15	13.71	1.176
8	21	19.98	1.322
9	31	29.12	1.491
10	44	42.43	1.643
11	62	61.84	1.792
12	89	90.12	1.949
13	123	131.3	2.089

Regression of Logarithm of Measured Diameter

Regression Output:		
Constant		0
Std Err of Y Est		0.035
R Squared		0.992
No. of Observations		8
Degrees of Freedom		7
X Coefficient(s)	0.162	
Std Err of Coef.	0.001	

Appendix V: Stratified Data For Spray Painting

5 Minute Sampling Period   10X Object Lens

Field	Porton Number 0	1	2	3	4	5	6	7	8	9	10
A		10	6	12	3	4	3	0	0	0	0
B		7	10	2	5	3	3	0	0	0	0
C		16	5	5	5	1	5	1	0	0	0
D		17	16	8	4	3	2	0	0	0	0
E			16	12	6	3	1	3	0	0	0
F					8	4	2	2	0	0	0
G					7	3	3	0	0	0	0
H					9	5	2	0	1	0	0
I					3	1	1	1	0	0	0
Ave per field		12.50	10.60	7.80	5.56	3.00	2.44	0.78	0.11	0.00	

Count Frequency and Mass Frequency

Porton	d(i) um	n(i)	Count Freq	Cumm Count Freq	n(i)*(d(i))^3	Mass Freq	Cumm Mass Freq
1	0.716	12.50	0.292	0.292	4.5886	0.001	0.001
2	1.759	10.60	0.247	0.539	57.732	0.014	0.015
3	2.563	7.80	0.182	0.722	131.46	0.033	0.049
4	3.736	5.56	0.129	0.851	289.76	0.073	0.123
5	5.444	3.00	0.070	0.922	484.21	0.123	0.246
6	7.934	2.44	0.057	0.979	1220.9	0.311	0.558
7	11.56	0.78	0.018	0.997	1202.1	0.306	0.864
8	16.84	0.11	0.002	1	531.46	0.135	1
9	24.55	0.00	0		0	0	
10	35.77	0.00					
11	52.14	0.00					
12	75.98	0.00					
Total		42.78			3922.3		

Appendix V: Stratified Data For Spray Painting

10 Minute Sampling Period   10X Object Lens

	Porton Number										
Field	0	1	2	3	4	5	6	7	8	9	10
A		36	13	6	10	3	1	0	0	0	0
B		46	16	23	8	4	3	1	0	0	0
C			21	7	5	5	4	0	0	0	0
D				21	9	1	4	0	0	0	0
E					15	7	3	0	1	0	0
F					10	6	3	0	0	0	0
G					10	6	1	0	0	0	0
H					6	8	3	2	0	0	0
I					7	5	0	0	0	0	0
Ave per field		41.00	16.67	14.25	8.89	5.00	2.44	0.33	0.11	0.00	

Count Frequency and Mass Frequency

Porton	d(i) um	n(i)	Count Freq	Cumm Count Freq	n(i)*(d(i))^3	Mass Freq	Cumm Mass Freq
1	0.716	41.00	0.462	0.462	15.050	0.003	0.003
2	1.759	16.67	0.187	0.650	90.775	0.023	0.027
3	2.563	14.25	0.160	0.810	240.17	0.061	0.089
4	3.736	8.89	0.100	0.911	463.62	0.119	0.208
5	5.444	5.00	0.056	0.967	807.02	0.207	0.416
6	7.934	2.44	0.027	0.994	1220.9	0.314	0.730
7	11.56	0.33	0.003	0.998	515.22	0.132	0.863
8	16.84	0.11	0.001	1	531.46	0.136	1
9	24.55	0.00					
10	35.77	0.00					
11	52.14	0.00					
12	75.98	0.00					
Total		88.69			3884.3		

Appendix V: Stratified Data For Sanding

5 Minute Sampling Period 10X Object Lens

	Porton Number												
Field	0	1	2	3	4	5	6	7	8	9	10	11	12
A					0	0	2	1	1	2	0	0	0
B					0	1	1	0	1	0	0	0	0
C					0	0	2	4	1	0	1	0	0
D					0	1	1	1	0	0	1	0	0
E					1	2	1	2	0	1	0	0	0
F					0	1	2	2	2	1	0	0	0
G					0	3	4	4	1	1	0	0	0
H					0	0	0	0	2	0	0	0	1
I					1	0	1	1	1	0	0	1	0
Ave per field					0.22	0.89	1.56	1.67	1.00	0.56	0.22	0.11	0.11

Count Frequency and Mass Frequency

Porton	d(i) um	n(i)	Count Freq	Cumm Count Freq	n(i)*(d(i))^3	Mass Freq	Cumm Mass Freq
1	0.716	0.00	0	0	0	0	0
2	1.759	0.00	0	0	0	0	0
3	2.563	0.00	0	0	0	0	0
4	3.736	0.22	0.035	0.035	11.590	0.000	0.000
5	5.444	0.89	0.140	0.175	143.47	0.001	0.001
6	7.934	1.56	0.245	0.421	776.97	0.008	0.010
7	11.56	1.67	0.263	0.684	2576.1	0.028	0.038
8	16.84	1.00	0.157	0.842	4783.2	0.052	0.090
9	24.55	0.56	0.087	0.929	8223.3	0.090	0.181
10	35.77	0.22	0.035	0.964	10179.	0.111	0.292
11	52.14	0.11	0.017	0.982	15749.	0.172	0.465
12	75.98	0.11	0.017	1	48739. 0	0.534	1
Total		6.333			91182.		

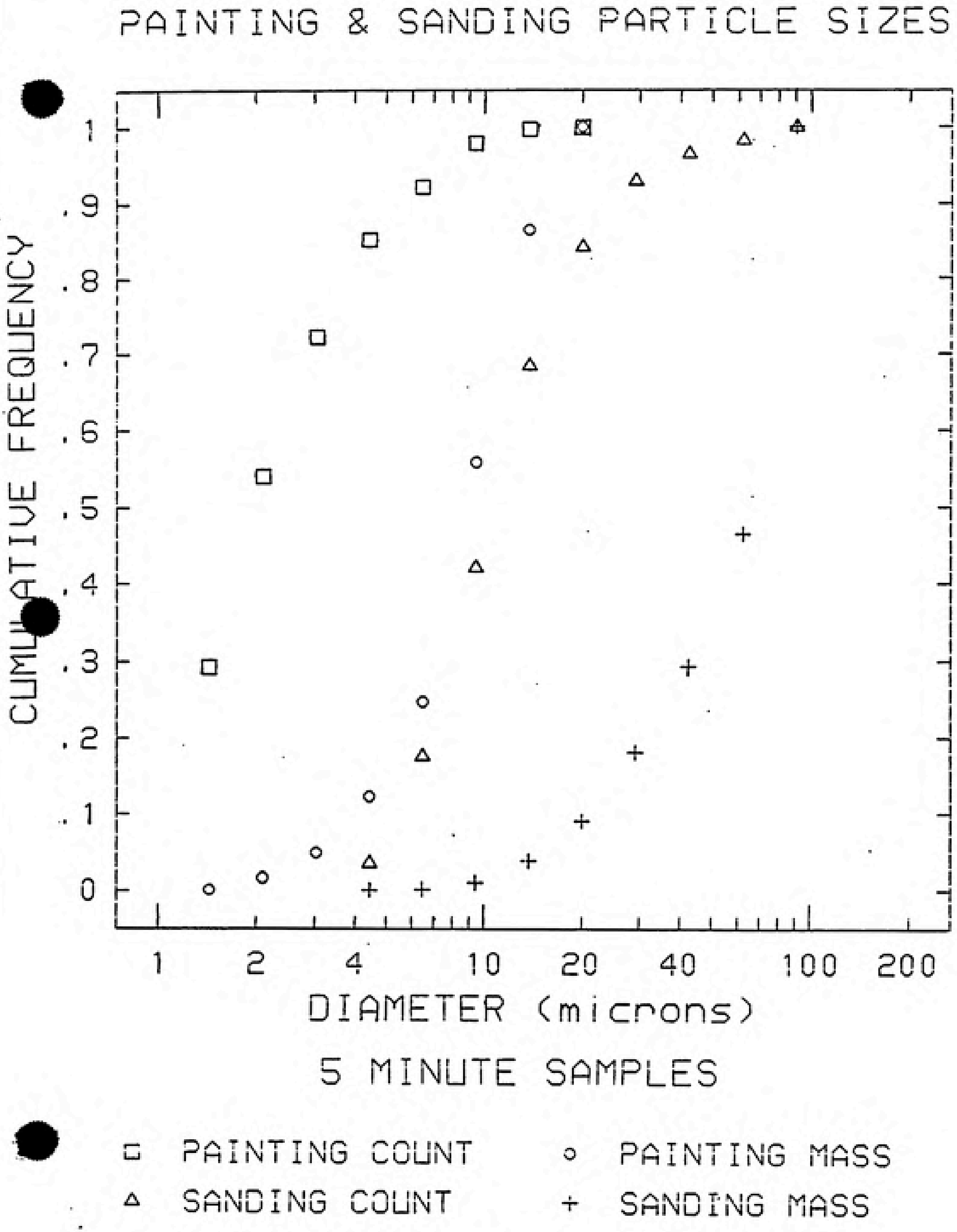
Appendix V: Stratified Data For Sanding

10 Minute Sampling Period 10X Object Lens

Field	Porton Number 0	1	2	3	4	5	6	7	8	9	10	11	12	13
A			0	0	1	9	12	9	4	9	1	1	1	0
B			0	1	3	3	6	5	4	4	1	3	0	1
C			1	2	6	7	6	5	2	7	3	5	0	0
D			1	1	2	6	7	8	5	3	3	2	0	0
E			0	0	1	8	10	5	10	5	1	0	0	1
F			0	0	1	3	7	7	5	3	1	0	0	0
G			0	2	3	5	8	6	3	3	2	1	2	2
H			0	1	3	9	6	10	5	5	2	3	1	0
I			0	0	0	3	7	4	4	3	2	3	3	0
Ave per field					2.22	5.89	7.67	6.56	4.67	4.67	1.78	2.00	0.78	0.44

Count Frequency and Mass Frequency

Porton	d(i) um	n(i)	Count Freq	Cumm Count Freq	n(i)* (d(i))^3	Mass Freq	Cumm Mass Freq
1	0.716	0.00	0	0	0	0	0
2	1.759	0.00	0	0	0	0	0
3	2.563	0.00	0	0	0	0	0
4	3.736	2.22	0.060	0.060	115.90	0.000	0.000
5	5.444	5.89	0.160	0.221	950.49	0.000	0.000
6	7.934	7.67	0.209	0.430	3829.3	0.002	0.003
7	11.56	6.56	0.178	0.609	10132.	0.007	0.010
8	16.84	4.67	0.127	0.736	22321.	0.015	0.026
9	24.55	4.67	0.127	0.863	69075.	0.048	0.075
10	35.77	1.78	0.048	0.912	81432.	0.057	0.132
11	52.14	2.00	0.054	0.966	283498	0.200	0.332
12	75.98	0.78	0.021	0.987	341174	0.240	0.573
13	110.7	0.444	0.012	1	603306	0.426	1
Total		36.66			1E+06		


PAINTING & SANDING PARTICLE SIZES
CUMULATIVE FREQUENCY
1
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40
100
200
DIAMETER (microns)
5 MINUTE SAMPLES
PAINTING COUNT
PAINTING MASS
SANDING COUNT
SANDING MASS