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Chromate Content Bias as a Function of Particle Size in Aircraft Primer Paint Overspray

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THESIS

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AFIT/GEE/ENV/01M-12

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David B. Novy

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Abstract

Spray painting operations using chromate-containing primer paints produce particles which may expose workers to strontium chromate. Chromate contains hexavalent chromium (Cr(VI)) which is a confirmed human carcinogen. It is suspected that the smaller particles contain disproportionately less Cr(VI) than larger particles. In order to determine if a bias in chromate content exists, paint particles were collected and separated based on particle size and the Cr(VI) concentration was determined.

Aviation primer paint from the DeSoto and Deft companies was sprayed in a booth and seven-stage cascade impactors were used to separate particles. The particles were grouped into fourteen distinct bins based on size within an overall range of 0.7 to 34.1 μm mass median aerodynamic diameter. The total mass of dry paint collected in each bin was quantified and the paint was analyzed for Cr(VI) mass. The Cr(VI) mass (μg) was divided by the mass of dry paint (μg) collected to determine the percentage of Cr(VI) per mass of dry paint.

Smaller particles contained significantly less Cr(VI) per mass of dry paint than larger particles. Paint sample particles smaller than 3 μm contained 1.2 % and 1.8 % Cr(VI) per mass of dry paint for DeSoto and Deft paints, respectively, which represents less than 30% of the Cr(VI) mass expected.

CHROMATE CONTENT BIAS AS A FUNCTION OF PARTICLE SIZE IN AIRCRAFT PRIMER PAINT OVERSPRAY

I. Introduction

Background

The United States Air Force's aluminum-skinned aircraft are protected against corrosion by a coat of chromate-based primer paint. The primer hinders the formation of aluminum oxide and provides a more suitable surface for application of the polyurethane top coat.

Primer paint used on USAF aircraft is regulated by four specifications: MIL-P-23377G, MIL-P-85582B, and MIL-P-87112 (military specifications), and TT-P-2760A (a federal specification). MIL-P-23377G is the most heavily used chromate-based primer used in the Air Force today because of its superior adhesion and protection capabilities as well as chemical and solvent resistance. The protection capability of MIL-P-23377G primer is primarily due to the additive strontium chromate ($SrCrO_4$) which is a suspect human carcinogen (Klaassen, 1996:1042). To date, there is no suitable alternative to chromate-containing primer paints capable of providing a similar level of aircraft corrosion protection.

Aircraft are typically painted with High Velocity, Low Pressure (HVLP) spray equipment which applies the primer with an application efficiency rate of approximately 50-80% under laboratory conditions (Carlton and Flynn, 1997). Some fraction of the remainder of the paint will remain suspended as overspray composed of chromate-

containing primer paint particles which present an inhalation risk to workers. Because inhaled particles distribute throughout the lungs based on size, with the smallest particles reaching the lung's deepest regions, the specific chromate content of various particle sizes is of interest to more accurately predict the distribution of chromate in the lungs.

Aside from a better understanding of the deposition of chromate in the lungs, particle size is also an important factor in air filter efficiency. Exhaust air from a paint facility is filtered before the air is released into the atmosphere. However, some fraction of the particles will pass through the filters posing a hazardous air emission from the painting facility. Smaller particles tend to pass through these filters more readily than larger particles. The particles that pass through the filters contribute to air, soil, and water contamination. The degree of chromate contamination is dependent upon not only filter efficiency, but also the mass of chromate in these smaller particles that tend to pass through these filters.

A study by Fox indicated a bias in chromium content based on paint particle size. The study found that particles smaller than 2.5 μm contain disproportionately less chromate (percentage by mass) compared to those particles greater than 2.5 μm (Fox, 2000). The implications of Fox's study indicate previous assumptions may overestimate potential worker exposure to $SrCrO_4$ and overestimate the total quantity of chromate which may bypass a filtration system.

Thesis Objective

The objective of this study is to 1) quantify the chromium concentration within each particle size range collected, and 2) identify differences in chromium concentration bias among particle sizes between two manufacturers of chromate-containing primer

paint. This study will focus on MIL-P-23377G primers manufactured by Deft and DeSoto because these two manufacturers supply the greatest quantities of Air Force primer paints.

II. Literature review

Background

Chromate-containing aerosols are generated in the aerospace industry by the paint application process. Paints are typically applied using spraying equipment to evenly distribute a primer coating on the metal surface of the component or aircraft. HVLP spray equipment delivering paint at 1-10 pounds per square inch (psi) at the nozzle is the current standard of application for USAF painting operations. Under laboratory conditions, the HVLP application method transfers paint with a transfer efficiency of approximately 50-80%. The paint particles which do not adhere to the application surface, referred to as overspray, are carried off by a ventilating airstream typically flowing at a rate of 100 feet per minute (ACGIH, 1995). Depending on the size of the facility and the scope or type of painting required, multiple operators can be involved with a single painting task. The overspray generated by the painting process results in a cloud of chromate-containing particles and is the primary concern for worker exposure to chromate during painting operations.

Health Effects of Strontium Chromate

Strontium chromate ($SrCrO_4$) is the form of chromate most often used in aerospace painting applications due to the corrosion resistance it provides, however, there is sufficient evidence in experimental animals that conclude $SrCrO_4$ is a potent carcinogen (IARC, 1990). Empirical evidence suggests the carcinogenicity of specific chromate salts is linked to the valence state of the chromium ion, with hexavalent chromium (Cr(VI)) presenting the greatest health concern (Jones, 1990; Levy *et al.*,

1986). In a study conducted by Levy et al. (1986), an intrabronchial pellet implantation system was used to observe tumor formation associated with twenty-one chromate salts. In Levy's study, only strontium chromate and zinc chromate, both Cr(VI)-containing salts, yielded statistically significant incidences of bronchial carcinomas. Although this study did not replicate the inhalation method of exposure to chromium-containing aerosols, the evidence for carcinogenicity is substantial (Levy, 1986). Hundreds of additional studies exist indicating the carcinogenicity of Cr(VI) compounds including epidemiological studies of workers in the chrome production, manufacturing, pigment production, ferrochromium production, stainless steel, electroplating, chrome plating, and leather tanning industries (IARC, 1990:85-97).

A threshold concept for carcinogenic potential exists based on the body's physiological capacity to reduce the valence state of Cr(VI) compounds to the relatively non-toxic Cr(III) state before DNA damage occurs (Jones, 1990). Studies have shown the valence state reduction occurs in the bodily fluids (including the epithelial fluid lining the respiratory tract) and at the cellular level (in the cytosol, mitochondria, and microsomes) (Korallus, et al., 1984; DeFlora, 1988; Petrilli and DeFlora, 1988). Levels of ascorbic acid and glutathione in the bronchioles and alveoli further limit the amount of Cr(VI) available for cellular absorption as they both have the potential to reduce Cr(VI) to Cr(III) before absorption can take place (Lewalter and Korallus, 1988).

Johansson et al. (1986) showed that for rabbits exposed to an air concentration of 0.6 and 0.9 mg/m^3 of tri- and hexavalent, respectively, for four to six weeks, six hours per day, five days per week, the only morphological changes observed were limited to the pulmonary alveolar macrophages (PAMs), not lung tissue. The PAMs, which are mobile

in the alveolar region, provide a secondary defense against exposure to Cr(VI) atoms by engulfing and reducing Cr(VI) to its relatively non-toxic trivalent state via enzymatic action (Lewalter and Korallus, 1988).

Chromate Exposure Limits

Both the Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH) have established occupational exposure limits for exposure to $SrCrO_4$. OSHA is a government agency and the only agency that regulates occupational exposures for industry with legal enforcement. The ACGIH is a private organization which focuses on worker safety. The OSHA permissible exposure level (PEL) is a ceiling of 0.1 mg CrO_3/m^3. A ceiling limit is the air concentration that cannot be exceeded during any part of the workday. ACGIH limits exposure to a time-weighted average (TWA) over an 8-hour workday to 0.0005 mg $Cr(VI)/m^3$.

Effect of Particle Size on Particle Deposition

The aerodynamic diameter of an inhaled particle plays a major role in where the particle may deposit within the lungs. Inhaled air follows a tortuous path through the nasopharyngeal region and branching airways in the lung. Each time the air changes direction the momentum of each particle tends to keep the particle on its pre-established trajectory. The tendency of larger particles to maintain trajectories increases the likelihood of impaction on airway surfaces. Particles larger than 10 μm generally deposit in the upper respiratory tract while those between 2 μm and 10 μm will generally deposit in the trachea and the bronchioles. Particles in the range of 0.01 to 2.5 μm have a high probability of depositing in the pulmonary region (Godish, 1991: 156) (See figure 2.1).

Therefore, inhaled particle size affects both the location of deposition in the lungs and the quantity of chromate delivered.

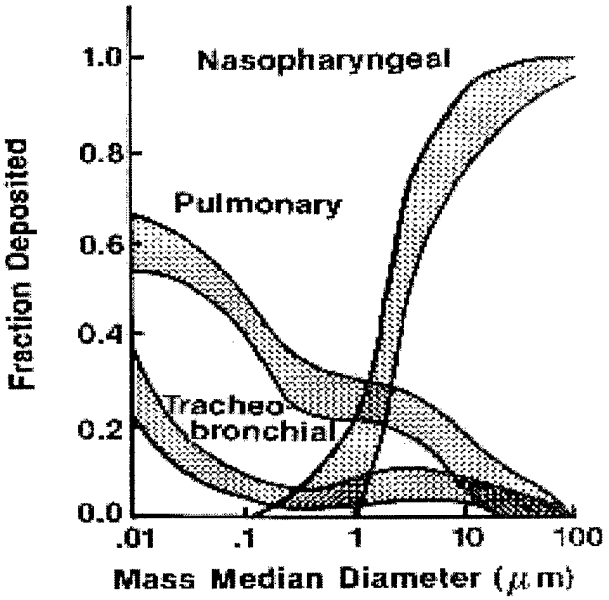

Figure 1. Fractional Deposition of Particles (Task Group on Lung Dynamics, 1966)

Clearance Mechanisms in the Respiratory System

Particle clearance in the respiratory system is performed by two distinct mechanisms: the mucociliary system and the alveolar macrophages (West, 1998: 117-121). Clearance time is dependant upon the region of particle deposition and the means of clearance within that region, but the mucociliary system is considered to be the more efficient clearance mechanism of the two (Klaassen, 1996: 449).

The mucus layer covering the nasopharyngeal and tracheobronchial regions is moved upward by the beating of the underlying cilia. This mucociliary escalator moves deposited particles out of the respiratory system to the esophagus where they are swallowed and passed through the gastrointestinal system (Klaassen, 1996: 448-449).

Mucociliary clearance is quite efficient in healthy individuals and is typically accomplished within 24- to 48-hours for particles deposited in the lower airways of healthy individuals (Lippmann and Schlesinger, 1984:262).

Particles deposited in the lower, or pulmonary region, of the lungs may be cleared in one of several ways (Klaassen, 1996: 449):

1. Particles may be directly trapped on the fluid layer of the airways and cleared upward by the mucociliary escalator.

2. Particles may be phagocytized by macrophages and cleared via the mucociliary escalator, or removed via lymphatic drainage.

3. Material may dissolve from the surface of particles and be removed via the bloodstream or lymph system.

4. Small particles may directly penetrate epithelial membranes.

Minutes after particles are inhaled, they can be found in alveolar macrophages. Many alveolar macrophages are ultimately transported to the mucociliary escalator, however, particles may be sequestered in the lung for long periods of time within alveolar macrophages which migrate into the interstitial tissue instead of being cleared via mucociliary escalation (Klaassen, 1996:449; and West, 1998: 120).

Mechanical Filtration

In the filtration of aerosols, three basic mechanisms are thought to be responsible for the capture of particles in air streams by fibers of filter media. First, direct interception of the particle by the filter media assumes a particle follows a streamline perfectly and because of the particle's size or the proximity of the streamline to the filter fiber, the particle collides with the filter media. Second, convective-diffusion allows for the influence of Brownian motion on very small particles; as the particle approaches the filter fiber, the random motion of the particle can cause it to travel close enough to the filter

media to be captured. The third mechanism responsible for capture is inertial impaction, the same phenomena responsible for the majority of particle deposition in the lungs as it is primarily of importance in filtration of particles from air streams. (Clark, 1996: 410-411)

Paint Application

The spray application process most common in the aerospace industry is compressed air atomization, such as the HVLP spray gun. The spray gun discharges the primer paint through a fluid nozzle and a column of air emitted from the air nozzle surrounds this liquid stream. Shear forces developed along the surface of contact between the two fluids cause the paint liquid to disintegrate into droplets (Bayvel and Orzechowski, 1993). The most important factors affecting the distribution of particle sizes leaving the nozzle are air pressure at the nozzle, liquid paint viscosity, and the ratio of air to liquid mass flow rates (Carlton and Flynn, 1997).

The focus of this study is not to generate a model of particle size distribution within a worker's breathing zone because many factors such as worker orientation, airframe shape, and environmental characteristics will substantially vary worker breathing zone exposures (Carlton and Flynn, 1997; Lefebvre, 1989). Rather, this research quantifies the fraction of Cr(VI) in relation to particle size, independent of worker-specific parameters. The mass of Cr(VI) in particles of various sizes can then be translated into a worker's exposure model based on other particle size distribution sampling.

Paint Overspray Collection

Physical separation of paint particles is necessary to characterize the Cr(VI) concentration based on particle size. Various methods are available to collect particles based on size, including inertial classification, gravitational sedimentation, centrifugation, and thermal precipitation. Inertial classifiers are the most prevalent means of particle collection and include cascade impactors, virtual impactors, and cyclones. Cascade impactors are the primary instruments of choice for collecting and differentiating particles by their aerodynamic characteristics. (Marple et al., 1993: 203-206)

Paint Sample Preparation

Paint particle samples must be transformed into the appropriate physical state for spectroscopic analysis; this is performed by acid digestion. The National Institute for Occupational Safety and Health (NIOSH) method 7082 recommends microwave digestion of paint chips for analysis of lead content and similar methods were indicated for analysis of additional metals, including chromium. Microwave digestion of samples is preferred over hot plate digestion because of factors including chemical hazards, sample loss, and digestion time (Lachas et al., 1998:180).

Cr(VI) Content Bias

In his 2000 report, Fox found a bias in Cr(VI) content (μg Cr/mg paint) based on aerodynamic diameter. His study was limited to seven samples using paint from a single manufacturer, but his data showed that some bias exists between particle size and Cr(VI) content: a statistically significant reduction in Cr(VI) content as a percentage of the total mass of paint solids collected for particles smaller than 2.5 μm contained

$18 \frac{\mu g of Cr}{mg of drypaint}$ compared with particles larger than 2.5μm which contained

$70 \frac{\mu g of Cr}{mg of drypaint}$.

Fox's results provide evidence that the concentration and mass of Cr(VI) deposited in the pulmonary region of the lungs may be significantly less than what is deposited in the upper regions. This also indicates an air filter's removal efficiency for chromate may be higher because larger particles containing a disproportionately larger fraction of Cr(VI) are removed more easily than smaller particles, indicating filter particle efficiency therefore underestimates Cr(VI) filtration efficiency.

Research Focus

This research will determine if different paint mixtures will result in different Cr(VI) biases in particles. The research was designed to allow an exploration of possible manufacturer-specific biases. The paint used will be MIL-P-23377G primer paint, a high solids, solvent-based epoxy paint, manufactured by both the Deft and DeSoto Corporations. This study focuses on identifying the possibility of a bias in Cr(VI) concentration in particles over a wide range of particle sizes (0.7 to 34 μm).

III. Methodology

Overview

The purpose of this study is to collect paint particles of various sizes and quantify the Cr(VI) content per total dry weight of paint collected. Paint samples were sprayed in the Air Force Research Laboratory (AFRL) paint booth at Wright-Patterson Air Force Base, Ohio using a DeVilbiss High Volume-Low Pressure (HVLP) spray gun. The paint particles generated by the spraying were collected and separated based on particle size using four seven-stage cascade impactors manufactured by In-Tox products. After collecting the various sized paint particles, the samples were prepared then analyzed using an Avanta atomic absorption spectrometer with both graphite furnace and flame analysis methods.

Painting Operation

The AFRL paint booth used for this sampling effort is 6.75'x6'x5' and has an average air flow of 151 feet per minute. Temperature and humidity were maintained at 22 degrees Celsius (+/- 2 degrees) and 63% (+/- 3%) for the duration of sampling.

A DeVilbiss HVLP spray gun, product number JGHV-531, was fitted with a DeVilbiss number 46MP air cap. A two-quart, pressure fed paint supply cup was attached to the spray gun and supplied with moisture- and oil-free air per manufacturer's specifications. Paint base and activator were mixed per manufacturers' specification and allowed a 30 minute induction time before the paint was sprayed for sampling. Paint was sprayed from the HVLP gun onto a fixed target with eight inches separating the HVLP nozzle and target. Overspray from the application of primer paint onto the target was

drawn across the booth towards the sampling equipment. In order to collect more particles, a cardboard enclosure was placed around the impactors to reduce the velocity of the particles and increase the collection efficiency. The HVLP spray gun and target were held in fixed positions while the HVLP trigger was held open for the duration of each sampling run. Sample run times ranged from 30 to 52 minutes and 1200 mL of paint was sprayed per run. Viscosity of the paint is expected to account for the range of sampling times. Each can of paint provided enough paint for three sampling sessions and it was noted that the last samples sprayed from a can required more time to spray than the first. It is possibly some of the solvents in the paint had evaporated over the period of time from when the can was initially opened to when the last sample was sprayed and therefore increased the paint viscosity. No affect on the analytical results was noted that could be attributed to the increased sampling time. Pressure settings were held constant within manufacturer recommendations for delivery line air pressure (50 psi), paint cup pressure (15 psi), and nozzle pressure (1.5 psi).

Cascade Impactors

Four seven-stage cascade impactors, were used to collect primer paint overspray samples and aerodynamically separate paint particles into discrete size ranges (See Figure 2). The median particle size collected by each stage is termed the stage Effective Cut-off Diameter (ECD). The median particle size collected on each stage was calculated as follows (equation 1):

$$ECD = (.495\ (\mu)(D_j^3)(n)(\pi)/(Q)(\rho_q))^{1/2} \qquad (1)$$

Where:
- 0.495 = Stokes number for round jets (Hinds, 1982:118)
- D_j^3 = Jet Diameter in cm
- n = number of jets on the stage
- π = 3.1416
- Q = Volumetric flow in cm^3/sec = 10 lpm = 166.67 cm^3/sec
- ρ_q = partial density for aerodynamic equivalent = 1 g/cm^3
- μ = Viscosity of air at 22° C = 1.83 x 10^{-4} g/cm-sec

Collection and separation of the paint particles is achieved by drawing the particles through a series of stages containing jets and impacting the particles onto a surface placed immediately downstream of the jets. Each stage of the impactor contains jets of progressively smaller diameters and a smaller space between the jets and the collecting plate. Stages are placed in series within the impactor so that the particles entering the largest jets pass through progressively smaller jets before leaving the impactor. This configuration facilitates the collection of successively smaller particles on each subsequent impactor stage. (In-Tox Products, 2000)

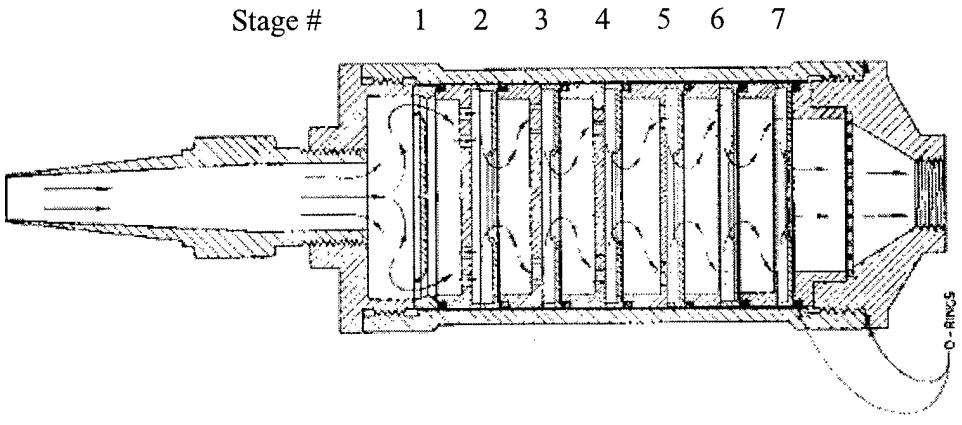

Figure 2. Detail of a Cascade Impactor Showing Air Flow (PCSC, 2000)

Of the four cascade impactors, two were designed to collect particles in a lower range than the other two. The flow rates of each impactor were adjusted to maximize the total particle size range collected. The lower range impactors were held at 18 liters per minute (0.7 μm < ECD<11.4 μm) while the upper range impactors were held at 8 liters per minute (2.7 μm <ECD<34 μm). The ECD calculations using equation 1 for the low and high range impactors are shown in Tables 1 and 2.

Table 1. Lower Particle Size Range Impactor at 18 lpm

Stage #	1	2	3	4	5	6	7
Number of Jets per Stage	1	2	3	4	6	9	12
Average Jet Diameter (cm)	1.1125	0.0635	0.4003	0.2636	0.1679	0.1082	0.07315
ECD 50% (um) (18 LPM)	11.4	7.0	4.3	2.6	1.6	1.0	0.7

Table 2. Upper Particle Size Range Impactor at 8 lpm

Stage #	1	2	3	4	5	6	7
Number of Jets per Stage	1	1	2	2	3	4	6
Average Jet Diameter (cm)	1.7582	1.3208	0.7884	0.5636	0.3914	0.2692	0.1788
ECD 50% (um) (8 LPM)	34.1	22.2	14.5	9.5	6.2	4.1	2.7

Cartridge Filter

A cartridge filter was placed in the sampling array with the impactors. The cartridge filter collects all airborne particle sizes and was used to collect a broad range of particle sizes as a single sample. The paint overspray sample collected from the cartridge filter is used to estimate the average Cr(VI) content of overspray. This data along with

the Material Safety Data Sheets helped to establish the overall Cr(VI) content of the paint.

Sample Substrates

Millipore digestible cellulose ester filters (CEFs) were used on the cascade impactor stages to collect overspray particles. CEFs were ideal for this effort because after paint is collected on the CEF, the CEF can be digested along with the collected paint particles to reduce losses from transferring the paint to a digestion vessel. All samples were weighed three times each, both before and after sampling, and those weights were averaged to determine the pre- and post-weights. Weighing of the substrates was performed in a sealed glovebag which contained Drierite and an Ohaus model AP240 microbalance (Accuracy 0.01 mg). The dry weight of paint collected on each CEF was determined by subtracting the pre-weight from the post-weight. Throughout the process, whenever CEFs were not loaded in the impactors they were stored with Drierite, either in glass desiccation bottles or in a sealed glovebag, for a minimum of 12 hours before weighing to eliminate moisture or unevaporated paint solvents.

Sampling Train

Two Gast pumps were used to draw air through the cascade impactors and cartridge filter. The precise airflow was regulated through an individual flowmeter for each impactor and vacuum pressure was monitored with a magnehelic. Airflow at each impactor was calibrated before and after each sampling run using a Sensidyne Flow Calibrator. A five-gallon receiver tank was placed in-line to minimize fluctuation in flow rate caused by the vacuum pump. One vacuum pump was used to pull air through the lower particle range impactors at a flow rate of 18 liters per minute (lpm) with the second

pump drawing air through the upper particle range impactors at a rate of 8 lpm and the cartridge filter at 10 lpm (See Figure 3). The pumps and flowmeters were placed outside of the paint booth during the painting operation to eliminate any explosion hazard (See Figure 4).

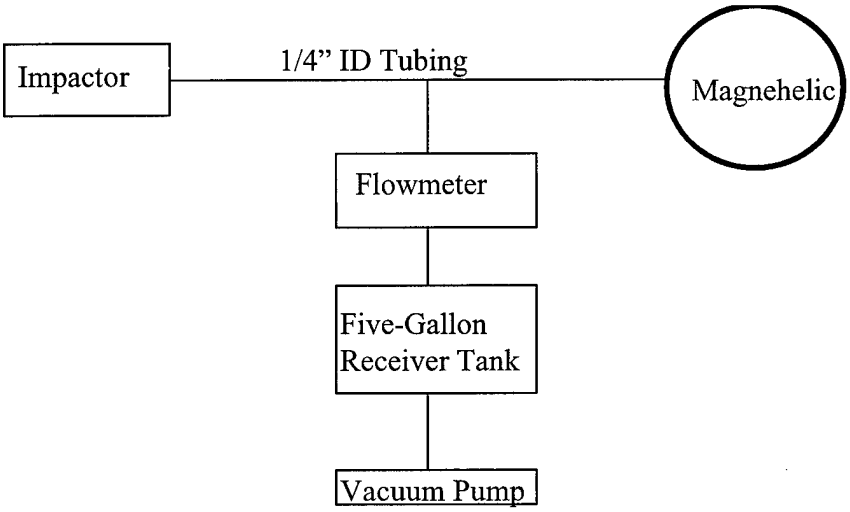

Figure 3. Impactor-Flowmeter-Pump Design

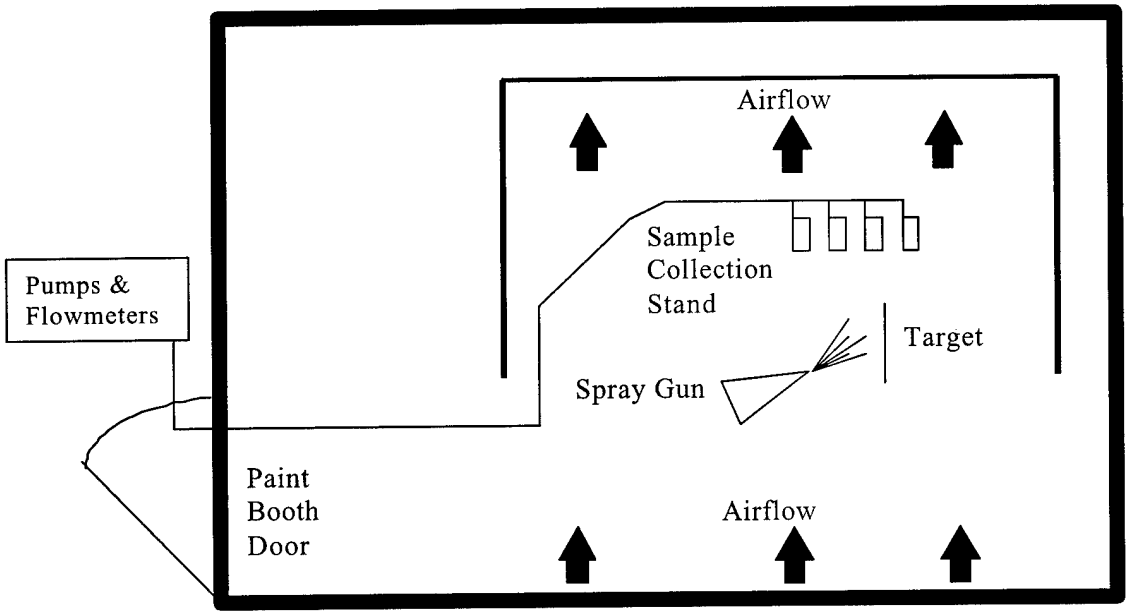

Figure 4. Paint Booth Layout (Not to Scale)

Sample Analysis

After the mass of collected paint particles on each CEF was determined, the paint Figure X samples and CEFs were digested in an OI Analytical Microwave. Each CEF with collected paint was loaded into a separate Teflon microwave digestion vessel and 6.0 mL of reagent-grade, 70% nitric acid was added to the vessel. Microwave vessels were capped, loaded into the microwave carousel, and processed following a modified NIOSH method Number 7082 for digestion of paint chips. The temperature was held at a minimum of 175°C for a minimum of 20 minutes. Pressure within the digestion vessel ranged from 100 to 180 psi, exceeding the NIOSH minimum of 75 psi. This aggressive digestion method is necessary to breakdown the paint matrix.

After microwave digestion, samples were allowed to cool to room temperature and ambient pressure before opening the vessels, typically taking three to four hours. The cooled digestion vessels were opened in a fume hood and triple rinsed with approximately 20 to 25 mL of 7% nitric acid into 30 mL High Density Polyethylene (HDPE) storage bottles. Each storage bottle was pre-weighed on the Ohaus AP240 microbalance and post-weighed after the sample was added to the bottle. The final dilution volume of each sample was determined by subtracting the weight of the paint sample and storage bottle from the total post weight and dividing the remaining mass by the density of the solution. This allowed a more precise determination of the dilution volume, recognizing that 6 mL of the dilution volume was 70% nitric acid and the remainder was 7% nitric acid. All HDPE bottles were pre- and post-weighed three times each and the average of those weights were used to calculate sample volume (See equation 2).

$$SampleVolume(mL) = \frac{(m_1 - m_0) - m_{filter} - (V_D \cdot \rho_{70\%})}{\rho_{7\%}} + V_D \qquad (2)$$

Where: m_0 = Pre-weight of HDPE sample bottle (g)
m_1 = Post-weight of HDPE sample bottle (g)
m_{filter} = Mass of CEF and paint sample (g)
$\rho_{70\%}$ = Density 70% nitric acid (g/mL)
$\rho_{7\%}$ = Density of 7% nitric acid (g/mL)
V_D = Volume of 70% nitric acid used for digestion (mL)

The actual analysis of samples for chromium concentration was performed on a GBC Avanta Atomic Absorption Spectrometer (AAS). Samples expected to contain chromium concentrations in the range of 0 to 999 parts per billion (ppb) were analyzed using the graphite furnace method while those expected to contain chromium

concentrations from 1 to 45 parts per million (ppm) were analyzed using the flame method. No samples analyzed contained more than 45 ppm chromium.

The graphite furnace method was calibrated using the GBC auto-mix feature to establish a 5-point calibration curve (7.5, 20.0, 40, 60, 75 ppb) from a certified 75 ppb standard. The R^2 value for all calibration curves are greater than 0.98. A certified check standard of 25 ppb was used to recalibrate the AAS at approximately every 15 samples. Three replicate measurements were made for each sample following the procedure established in Table 3. The AAS's auto-dilution feature automatically diluted samples that were above the highest point of the calibration curve. Samples that were above the highest point of the calibration curve were auto-diluted 80% by the AAS with deionized water and re-analyzed. Auto-dilution was performed a maximum of two times. Samples with concentrations that were too high for the graphite furnace method with auto-dilution were analyzed with the flame method.

Table 3. AAS Graphite Furnace Parameters

Step	Final Temp. (C)	Ramp Time (s)	Hold Time (s)	Gas Type
Step 1 Inject Sample				
Step 2	80°	5	10	Inert
Step 3	130°	30	10	Inert
Step 4	1400°	15	15	Inert
Step 5 Read Concentration	2500°	1.4	1.6	None
Step 6	2700°	0.5	1.5	Inert

The flame method was established using an air-acetylene flame. The acetylene flow was held at 2.00 liters per minute and compressed air flow was held at 10.0 liters per minute. For the flame method, a calibration curve was established with four standards (1, 5, 10, and 15 ppm) from a certified 1000 ppm source of Cr(VI). The R^2 value for all

calibration curves are above 0.98. A check sample of 10 ppm was run at the end of the each series of 10 to 15 samples to check for a shift in the calibration curve during the run. Samples that were measured at absorbance values outside the calibration curve were manually diluted as needed.

Mass of Cr(VI) per Dry Paint

Chromium concentrations from the AAS were used to determine the Cr(VI) content of the samples per dry weight of paint. The chromium concentrations determined by the AAS for each CEF sample was multiplied by the dilution volume and then divided by the mass of dry paint collected on each CEF to determine the Cr(VI) content per mass of paint (equation 3).

$$Cr(VI)\ per mass of\ dry\ paint = \frac{C_{AAS} \cdot V_D}{m_{c,1} - m_{c,0}} \qquad (3)$$

Where: C_{AAS} = AAS reported concentration (µg/L)
V_D = Sample volume (L) from equation 2
$m_{c,0}$ = CEF pre-weight (µg)
$m_{c,1}$ = CEF post-weight (µg)

IV. Results

Cr(VI) Content per Mass of Paint

Table 4 displays the results of the Cr(VI) analysis. The particle sizes collected are shown in the first column, the average percent mass of Cr(VI) per mass of dry paint, (mass Cr (μg) / mass dry paint (μg)) x 100%, the number of samples for each particle size (n), and the standard deviation (Std. Dev.) of the percent of Cr(VI) for both manufacturers' paints are listed..

Table 4. Average Cr(VI) Content Per Mass of Dry Paint

	Deft			DeSoto		
Particle Size (ECD) (um)	**n**	**Mean % (Cr/paint)**	**Std. Dev.**	**n**	**Mean % (Cr/paint)**	**Std. Dev.**
0.7	17	0.8 %	0.35	17	0.1 %	0.09
1.0	16	1.2 %	0.38	18	0.2 %	0.07
1.6	15	1.8 %	0.5	18	0.6 %	0.19
2.6	18	2.5 %	0.76	18	2.7 %	0.87
2.7	18	2.9 %	0.18	17	2.4 %	1.06
4.1	18	4.5 %	0.83	17	5.5 %	1.45
4.3	17	3.9 %	0.07	18	5.2 %	1.14
6.2	18	5.8 %	0.83	17	6.7 %	1.06
7.0	17	4.6 %	0.32	16	6.8 %	0.91
9.5	17	5.3 %	0.55	17	7.7 %	0.09
11.4	17	6.2 %	0.19	18	9.1 %	0.57
14.5	17	5.8 %	0.45	18	7.3 %	1.18
22.2	18	5.7 %	0.38	17	6.5 %	1.28
34.1	18	5.3 %	0.69	16	7.9 %	1.19
Cartridge Filter	8	6.7 %	0.70	6	9.4 %	0.86

In Figure 5 below, the mean percent Cr(VI) content versus particle size are plotted for both manufacturers. Both manufacturers' paints exhibit the same phenomena: smaller particles tend to have less Cr(VI) per mass of dry paint than larger particles. A decrease

in Cr(VI) content per mass of dry paint for particles less than 10 μm MMAD is noticed with samples obtained from both manufacturers, however, the decrease is more pronounced in the DeSoto paint samples, which had a higher original Cr(VI) content.

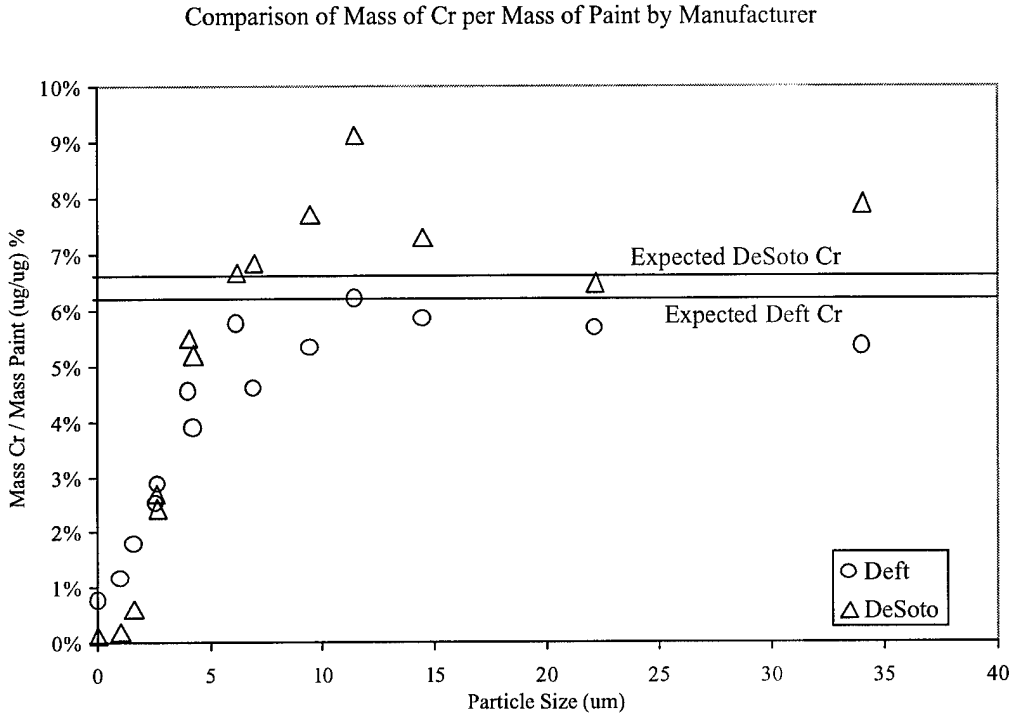

Figure 5. Comparison of Mass Cr per Mass Dry Paint by Manufacturer

Figures 6 and 7 below show a more descriptive breakout of sample data from each manufacturer including individual data points:

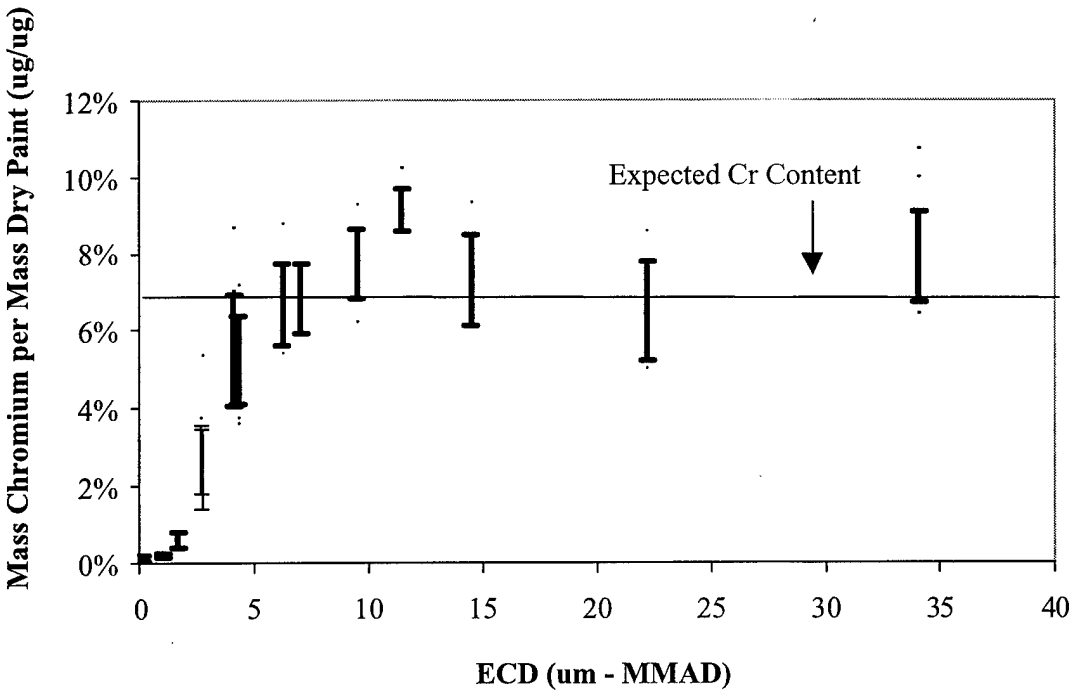

Figure 6. DeSoto Cr(VI) by Mass of Dry Paint
(Bars represent one standard deviation above and below mean)

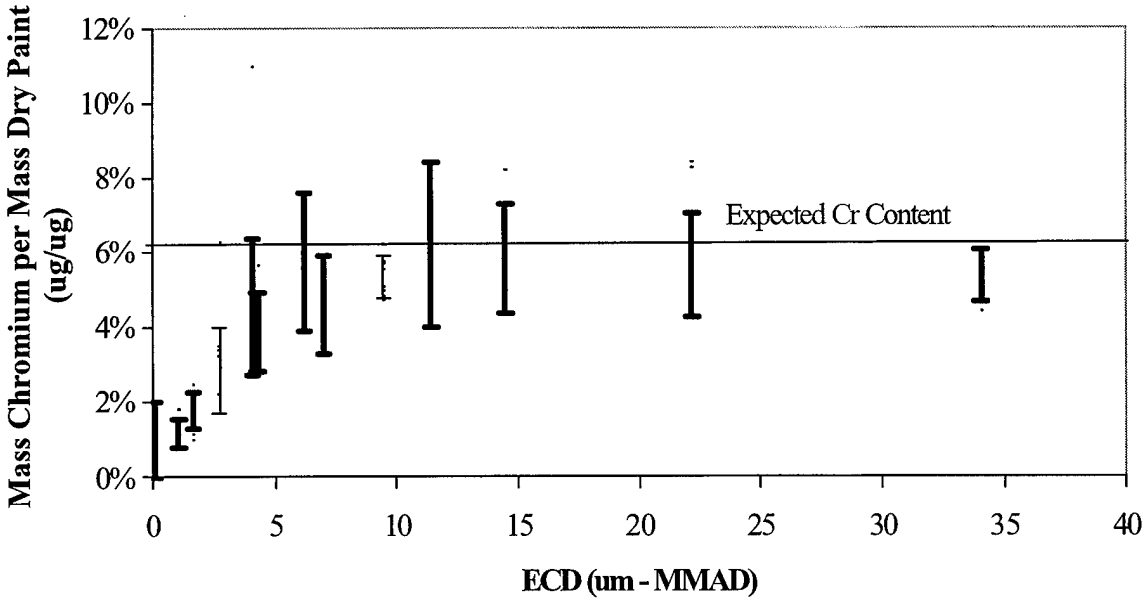

Figure 7. Deft Cr(VI) by Mass of Dry Paint
(Bars represent one standard deviation above and below mean)

Particle Size-dependent Cr(VI) Content Bias

To determine if the chrome contents by particle size are statistically different, a Tukey-Kramer all pairs analysis was applied to the data (Figures 8 and 9). The analysis reveals that Deft particles 2.71 μm (MMAD) and smaller had a statistically significant reduction in Cr(VI) content by mass when compared to particles sized 4.08 μm and larger. The DeSoto paint samples indicated particles collected which were smaller than 4.08 micrometers (MMAD) had a statistically significant reduction in Cr(VI) content by mass when compared to collected particles sized 4.08 micrometers (MMAD) and higher. In the following figures, underlined series indicate particle Cr(VI) contents per mass of dry paint are not significantly different; dotted lines indicate a continuation of the series that excludes a specific particle size (i.e., Cr(VI) content of particle sizes with MMADs of 1.04, 1.64, 2.64, 2.71, and 4.28 μm are not significantly different, excluding 4.08 μm).

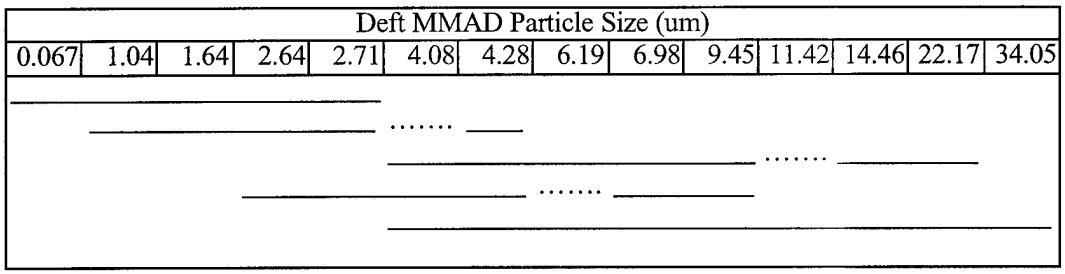

Figure 8. Deft Tukey-Kramer All pairs Analysis (alpha = 0.05)

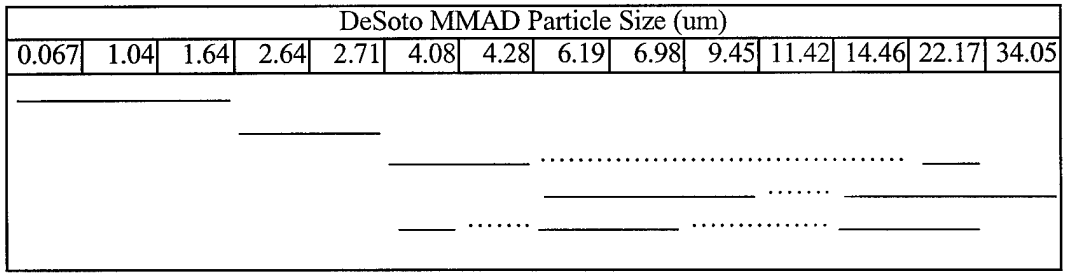

Figure 9. DeSoto Tukey-Kramer All pairs Analysis (alpha = 0.05)

Manufacturer-specfic Bias

These data indicate smaller particle sizes contain far less Cr(VI) per mass of dry paint than the expected concentration. Both paints exhibit a similar phenomena with a statistically significant difference in the mean Cr(VI) content per mass of dry paint for particles equal to and smaller than 4.28 μm. However, as these figures indicate, the Cr(VI) concentration decreases progressively with decreasing particle size.

Common Particle Size-dependent Bias

Both the Deft and DeSoto paints displayed a bias in Cr(VI) content attributable to the size of the particle collected. Cr(VI) concentrations in particles tended to increase with particle size as exhibited below in Table 5.

Table 5. Cr(VI) Content as a Percentage of the Maximum Observed Concentration

	% of Maximum Observed Sample Cr(VI) Concentration	
Particle Size (um)	**Deft**	**DeSoto**
0.7	12 %	1 %
1.0	19 %	2 %
1.6	29 %	7 %
2.6	41 %	29 %
2.7	46 %	27 %
4.1	73 %	60 %
4.3	63 %	57 %
6.2	93 %	73 %
7.0	74 %	75 %
9.5	86 %	84 %
11.4	100 %	100 %
14.5	94 %	80 %
22.2	91 %	71 %
34.1	86 %	86 %

In Table 5, the Cr(VI) concentrations attributable to particle size were compared with the highest observed average concentration of Cr(VI).

V. Discussion

Implications of Cr(VI) Content Bias

The location of particle deposition in the lungs is of particular interest because of the different particle clearance mechanisms within the different regions of the lungs. In general, aerosol particles less than a MMAD of 2.5 μm are capable of reaching the alveolar sacs and larger particles tend to deposit in the upper respiratory airways. The upper regions of the lung clear particulate matter via the mucociliary escalator faster than the alveolar region of the lungs. Because smaller particles that are more likely to reach the deepest regions of the lung contain less chromate than larger particles, the majority of chromate from primer overspray may be cleared from the lungs rapidly, thus reducing the residence time of Cr(VI) in the lungs. It is possible that particles caught in the upper regions of the respiratory system represent less of a toxicological threat than those that reach the alveoli because of their rapid removal via the mucociliary escalator. The data presented here indicate those particles with the greatest potential for reaching the alveolar region of the lungs contain less than 30 percent of the chromate than would be predicted based on the average chromate content of the paint.

In addition to the human health implications, the bias in chromate content may also have implications for quantities of chromate released from industrial paint booths into the atmosphere. Filter efficiency ratings vary with different particle sizes. Efficiency generally increases with larger particle sizes while smaller particles are more likely to escape filtration. Therefore, Cr(VI) concentrations released from filtering

mechanisms would likely be less than expected because as shown here smaller particles contain less chromium per mass of cry paint.

Possible Source of Bias

The physical processes of atomization are likely responsible for the Cr(VI) bias observed in this research. In general, the breakup of a drop in a flowing fluid is controlled by the air pressure acting on the droplets, surface tension of the atomized fluid, and the viscous forces within the droplet (Lefebvre, 1989). The forces acting on the particles deform it in one of three ways. First, the drop may be flattened to form an oblate ellipsoid (flattened ball shape). Subsequent deformation of the particle depends on the magnitude of internal forces which ultimately result in the particle stretching and disintegrating into smaller particles. The second possible deformation results in an elongated, cylindrical thread or ligament which breaks up into smaller particles. The third possible deformation is due to local deformations on the particle's surface creating bulges and protuberances which eventually detach from the parent particle to form smaller particles (Hinze, 1955). Depending on the pressure acting upon the particle surface, these three types of deformations may occur as a shear mechanism where the surface layer of liquid is torn off, rapidly transforming the parent particle into a series of small drops from the surface of the particle. The other mechanism is a chaotic, bursting process where disintegration proceeds so rapidly that shearing is almost unnoticeable (Bayvel and Orzechowski, 1993:71-73).

These modes of primer paint particle disintegration may explain the lower quantities of chromate in smaller particles. Assuming the paint particles form around a core nucleus of homogeneously distributed chromate, if the parent particle of paint were

to remain intact, the chromate content by mass of the parent particle would likely approximate the average chromate content of the paint. If resultant smaller particles were formed by a chaotic burst in which the drop disintegration proceeds so rapidly that little shearing of the surface layer of the parent particle occurs, it could be assumed the resultant smaller particles would approximate the average chromate content of the parent drop. However, if a shearing mechanism is responsible for the disintegration of the parent particle, the smaller particles formed from the surface layer would be composed primarily of binders and solvents resulting in a lower chromate content by mass (Figure 10).

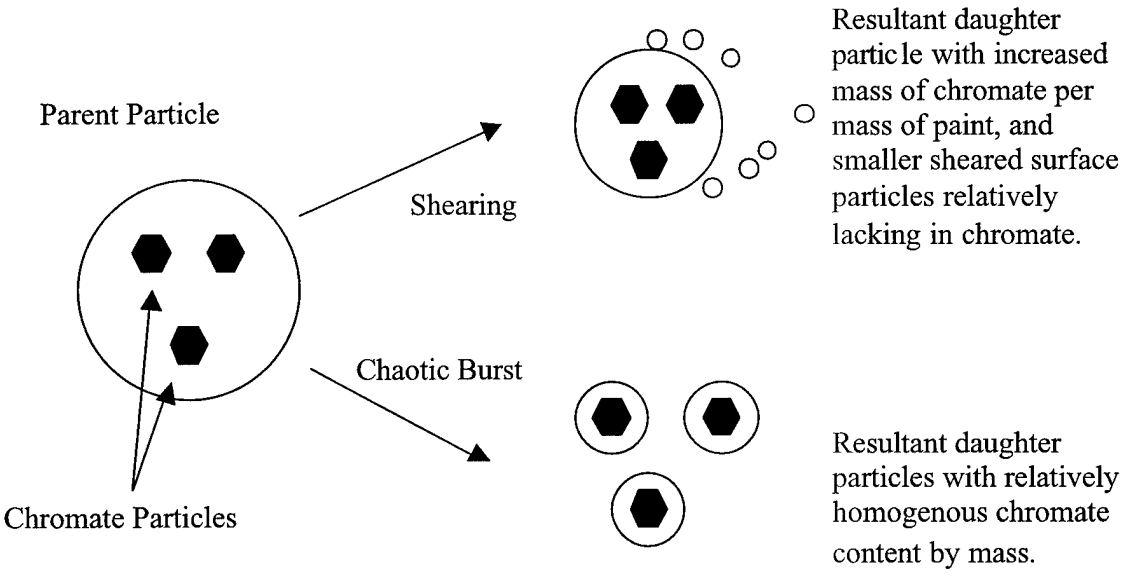

Figure 10. Methods of Particle Disintegration

If the smaller particles formed from the surface layer of a parent particle are relatively lacking in $SrCrO_4$, they would have a smaller mass per unit volume than particles rich in $SrCrO_4$ because the density of chromate is higher than the other paint

constituents (see Table 6). The particles lacking $SrCrO_4$ would behave similarly to particles with smaller MMADs since the MMAD is a function of density. As a result, more paint binders and solvents would be collected than $SrCrO_4$ in the range of the smaller particles and possible account for the limited $SrCrO_4$ found in smaller particles.

Table 6. Density of Primer Paint Constituents

Consitituent	Density (g/mL)
Methyl Ethyl Ketone	0.8
Methyl Isobutyl Ketone	0.8
Methyl Amyl Ketone	0.8
Isopropanol	0.8
Toluene	0.9
Cyclohexanone	0.9
Xylene	0.9
Epoxy Resin	1.2
Crystalline Silica Quartz	2.7
Talc	2.8
Titanium Dioxide	3.9
Strontium Chromate	3.9

Future Study

Epoxy polyamide primer paints, like those tested here, are not the only chromated primer paints in use by the Air Force. Chromated water-based, polyurethane, and polysulfide paints are permitted by specification and should be tested for a similar chromate content bias as well. The different paint matrix constituents of water-based and polysulfide paints may not exhibit the same properties as the epoxy polyamide paints.

The focus of this and other studies has been the application of the primer paint. However, another population at risk for exposure to chromate is that of the sanders involved with refinishing aircraft. According to an epidemiological study by Alexander,

et al, aerospace industry sanders are twice as likely to develop lung cancer as painters (Alexander, et al, 1996). Given that the material of concern is the same for both populations, one could assume the particle size of the toxicant workers are exposed to would account for different levels of exposure between the populations. Paint allowed to cure on the aircraft skin would likely produce paint particles in a range of sizes when sanded, but smaller particles would be less likely to exhibit a bias in chromate content. A characterization of the chromate content of sanded paint particles using cascade impactors could provide valuable insight into worker exposure within the sander population.

Appendix A: Raw Data Tables

The attached tables provide the raw data obtained in this research effort.

Column Heading:	**Explanation:**
Sample Run	"R1", "R2", etc. indicate the sample run number
Impactor	Indicates the type of impactor collecting the samples (i.e. high or low range)
Particle Size (MMAD - μm)	MMAD Particle size in micrometers
Mass of Dry Paint Collected (μg)	(Post-weight of CEF) - (Pre-weight of CEF)
AAS Furnace Cr Concentration (ppb)	AAS furnace method indicated chromium concentration; Cr concentration in the diluted analyte
AAS Flame Cr Concentration (ppm)	AAS flame method indicated chromium concentration; Cr concentration in the diluted analyte
Mass Cr(VI) Collected (μg)	Mass of Cr collected in the paint sample, determined by multiplying the AAS Cr Concentration by the dilution volume.
Mass Cr/Paint (%)	Mass of Cr (μg) per mass of dry paint (μg)

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R1	High Range Impactor #1	34.1	10687	0	34580	1144	10.7%
R1		22.2	2183	0	4726	165	7.5%
R1		14.5	2503	0	5756	201	8.0%
R1		9.5		Sample Lost			
R1		6.2	2353	0	4997	173	7.4%
R1		4.1		Sample Lost			
R1		2.7		Sample Lost			
R1	High Range Impactor #2	34.1	8393	0	18860	642	7.7%
R1		22.2	2153	0	4668	163	7.6%
R1		14.5	1490	0	3421	116	7.8%
R1		9.5	3500	0	8838	301	8.6%
R1		6.2	2230	0	4923	167	7.5%
R1		4.1	933	0	1544	53	5.6%
R1		2.7	437	324	0	11	2.5%
R1	Low Range Impactor #1	11.4	44973	0	125610	4214	9.4%
R1		7.0	4613	0	11886	404	8.7%
R1		4.3	1990	0	3864	134	6.7%
R1		2.6	683	734	609	25	3.6%
R1		1.6	383	99	0	3	0.9%
R1		1.0	253	17	0	1	0.2%
R1		0.7	103	9	0	0	0.3%
R1	Low Range Impactor #2	11.4	44880	0	125286	4254	9.5%
R1		7.0	4233	0	11222	371	8.8%
R1		4.3	2087	0	4585	149	7.2%
R1		2.6	577	780	0	27	4.6%
R1		1.6	380	94	0	3	0.8%
R1		1.0	240	19	0	1	0.3%
R1		0.7	113	10	0	0	0.3%
R1	Cartridge Filter			Sample Lost			

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R2	High Range Impactor #1	34.1	6077	0	16961	605	10.0%
R2		22.2	910	0	2141	72	7.9%
R2		14.5	1393	0	3764	126	9.0%
R2		9.5	2723	0	7227	249	9.1%
R2		6.2		Sample Lost			
R2		4.1	607	1449	0	48	8.0%
R2		2.7	263	285	0	10	3.7%
R2	High Range Impactor #2	34.1	6727	0	13804	477	7.1%
R2		22.2	943	0	2350	81	8.6%
R2		14.5	1190	0	3266	111	9.3%
R2		9.5	2400	0	6532	222	9.3%
R2		6.2	1477	0	3874	129	8.8%
R2		4.1	573	830	0	29	5.1%
R2		2.7	197	320	0	11	5.3%
R2	Low Range Impactor #1	11.4	31230	0	93558	3104	9.9%
R2		7.0	2980	0	5771	185	6.2%
R2		4.3	1617	0	2496	83	5.1%
R2		2.6	667	596	452	20	3.0%
R2		1.6	483	102	0	3	0.7%
R2		1.0	417	19	0	1	0.2%
R2		0.7	370	8	0	0	0.1%
R2	Low Range Impactor #2	11.4	25163	0	75540	2570	10.2%
R2		7.0	3087	0	5754	195	6.3%
R2		4.3	1677	0	2470	81	4.8%
R2		2.6	767	621	528	21	2.8%
R2		1.6	530	88	0	3	0.5%
R2		1.0	477	17	0	1	0.1%
R2		0.7	373	7	0	0	0.1%
R2	Cartridge Filter		31283	0	85896	2865	9.2%

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R3	High Range Impactor #1	34.1	6050	0	12016	410	6.8%
R3		22.2	740	0	1636	57	7.7%
R3		14.5	943	0	2356	79	8.4%
R3		9.5	1490	0	3884	131	8.8%
R3		6.2	830	2227	8490	73	8.8%
R3		4.1	313	785	0	27	8.7%
R3		2.7	110	131	0	4	4.1%
R3		34.1	4577	0	12852	440	9.6%
R3	High Range Impactor #2	22.2	870	0	1324	46	5.3%
R3		14.5	943	2045	1584	70	7.4%
R3		9.5	1630	0	3521	115	7.1%
R3		6.2	1070	0	1882	64	6.0%
R3		4.1	503	779	0	27	5.3%
R3		2.7	177	141	0	5	2.7%
R3		11.4	18987	0	50712	1700	9.0%
R3	Low Range Impactor #1	7.0	1727	0	3792	122	7.1%
R3		4.3	880	0	1639	55	6.2%
R3		2.6	373	436	0	14	3.9%
R3		1.6	227	56	0	2	0.9%
R3		1.0	153	16	0	1	0.3%
R3		0.7	90	8	0	0	0.3%
R3		11.4	18410	0	47584	1586	8.6%
R3	Low Range Impactor #2	7.0	1180	0	2088	70	6.0%
R3		4.3	917	0	1274	42	4.5%
R3		2.6	593	287	0	10	1.6%
R3		1.6	530	55	0	2	0.4%
R3		1.0	423	17	0	1	0.1%
R3		0.7	370	9	0	0	0.1%
R3	Cartridge Filter		16287	0	44008	1481	9.1%

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R4	High Range Impactor #1	34.1	5147	0	11275	387	7.5%
R4		22.2	923	0	0	0	0.0%
R4		14.5	1953	0	4850	162	8.3%
R4		9.5	2287	0	5631	190	8.3%
R4		6.2	1740	0	4002	133	7.7%
R4		4.1	753	0	1178	40	5.3%
R4		2.7	383	224	0	8	2.1%
R4	High Range Impactor #2	34.1	4920	0	8877	315	6.4%
R4		22.2	1470	0	3300	113	7.7%
R4		14.5	1033	0	2436	82	7.9%
R4		9.5	2520	0	5406	178	7.1%
R4		6.2	2043	0	4451	146	7.1%
R4		4.1	210	137	0	5	2.2%
R4		2.7	307	138	0	5	1.6%
R4	Low Range Impactor #1	11.4	27317	0	62568	2194	8.0%
R4		7.0	2130	0	0	0	0.0%
R4		4.3	1397	2765	0	95	6.8%
R4		2.6	580	413	0	14	2.4%
R4		1.6	497	74	0	3	0.5%
R4		1.0	357	34	0	1	0.3%
R4		0.7	280	15	0	1	0.2%
R4	Low Range Impactor #2	11.4	21647	0	56944	1958	9.0%
R4		7.0	3353	0	0	0	0.0%
R4		4.3	1453	3027	0	99	6.8%
R4		2.6	613	496	0	17	2.7%
R4		1.6	457	116	0	4	0.8%
R4		1.0	327	26	0	1	0.3%
R4		0.7	297	14	0	0	0.2%
R4	Cartridge Filter		Sample Lost				

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R5	High Range Impactor #1	34.1	2777	0	5392	175	6.3%
R5		22.2	667	915	0	31	4.6%
R5		14.5	883	1345	0	46	5.3%
R5		9.5	1427	0	2109	70	4.9%
R5		6.2	1107	0	1500	50	4.5%
R5		4.1	630	612	0	21	3.3%
R5		2.7	457	263	0	8	1.8%
R5	High Range Impactor #2	34.1	3413	0	4270	144	4.2%
R5		22.2	963	0	1352	44	4.6%
R5		14.5	683	1132	0	37	5.4%
R5		9.5	1353	0	2080	69	5.1%
R5		6.2	1033	0	1395	48	4.6%
R5		4.1	683	705	0	23	3.4%
R5		2.7	443	239	0	8	1.8%
R5	Low Range Impactor #1	11.4	18467	0	37832	1280	6.9%
R5		7.0	1400	0	1857	64	4.5%
R5		4.3	1010	0	1053	36	3.5%
R5		2.6	637	469	0	16	2.5%
R5		1.6	523	247	0	8	1.6%
R5		1.0	433	142	0	5	1.1%
R5		0.7	370	68	0	2	0.6%
R5	Low Range Impactor #2	11.4	15183	0	29140	1030	6.8%
R5		7.0	1287	2216	0	74	5.7%
R5		4.3	850	1159	0	39	4.6%
R5		2.6	587	481	0	16	2.6%
R5		1.6	480	275	0	9	1.9%
R5		1.0	410	184	0	6	1.5%
R5		0.7	340	64	0	2	0.6%
R5	Cartridge Filter		18233	0	33280	1198	6.6%

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R6	High Range Impactor #1	34.1	3283	0	4588	151	4.6%
R6		22.2	660	0	1000	34	5.1%
R6		14.5	857	0	1250	43	5.0%
R6		9.5	2050	3464	0	115	5.6%
R6		6.2	1240	2310	0	74	6.0%
R6		4.1	660	1063	0	35	5.3%
R6		2.7	427	332	0	12	2.7%
R6	High Range Impactor #2	34.1	3643	0	4825	160	4.4%
R6		22.2	603	1268	0	44	7.3%
R6		14.5	977	0	1604	53	5.5%
R6		9.5	1873	0	3326	106	5.6%
R6		6.2	1370	0	1901	65	4.7%
R6		4.1	653	782	0	25	3.8%
R6		2.7	380	339	0	12	3.1%
R6	Low Range Impactor #1	11.4	18940	0	38048	1285	6.8%
R6		7.0	2120	0	2699	96	4.5%
R6		4.3	1277	0	1287	43	3.3%
R6		2.6	817	567	0	19	2.3%
R6		1.6	577	299	0	10	1.7%
R6		1.0		Sample Lost			
R6		0.7	393	65	0	2	0.5%
R6	Low Range Impactor #2	11.4	17663	0	31084	1098	6.2%
R6		7.0	2377	0	3176	103	4.3%
R6		4.3	1313	0	1365	45	3.5%
R6		2.6	760	558	0	19	2.5%
R6		1.6	563	324	0	11	2.0%
R6		1.0	447	159	0	6	1.2%
R6		0.7	367	86	0	3	0.8%
R6	Cartridge Filter		23880	0	47068	1598	6.7%

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R7	High Range Impactor #1	34.1	3910	0	5880	201	5.1%
R7		22.2	687	1333	0	44	6.5%
R7		14.5	640	1346	0	28	4.3%
R7		9.5	1097	0	1464	47	4.3%
R7		6.2	737	1435	0	47	6.4%
R7		4.1	403	526	0	17	4.2%
R7		2.7	247	195	0	7	2.7%
R7	High Range Impactor #2	34.1	4083	0	7065	228	5.6%
R7		22.2	530	946	0	21	3.9%
R7		14.5	707	1417	0	47	6.6%
R7		9.5	1093	0	1498	51	4.7%
R7		6.2	733	1331	0	44	6.0%
R7		4.1	457	547	0	18	4.0%
R7		2.7	263	195	0	6	2.5%
R7	Low Range Impactor #1	11.4	13013	0	24132	836	6.4%
R7		7.0	910	1473	0	47	5.2%
R7		4.3	680	720	0	24	3.5%
R7		2.6	453	295	0	10	2.1%
R7		1.6	300	162	0	5	1.8%
R7		1.0	300	95	0	3	1.1%
R7		0.7	280	44	0	1	0.5%
R7	Low Range Impactor #2	11.4	12053	0	19542	668	5.5%
R7		7.0	803	1597	0	51	6.3%
R7		4.3	637	923	0	30	4.8%
R7		2.6	413	292	0	10	2.4%
R7		1.6	320	180	0	6	1.9%
R7		1.0	283	105	0	2	0.7%
R7		0.7	247	64	0	2	0.9%
R7	Cartridge Filter		18633	0	37372	1247	6.7%

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R8	High Range Impactor #1	34.1	4670	0	12140	247	5.3%
R8		22.2	677	0	1028	32	4.7%
R8		14.5	913	0	1547	49	5.4%
R8		9.5	1563	0	2794	90	5.7%
R8		6.2	1090	0	3647	114	10.5%
R8		4.1	487	1785	0	53	10.9%
R8		2.7	307	329	0	11	3.5%
R8	High Range Impactor #2	34.1	4040	0	7177	244	6.0%
R8		22.2	490	1317	0	41	8.4%
R8		14.5	807	0	1393	46	5.7%
R8		9.5	1263	0	2380	72	5.7%
R8		6.2	973	0	1600	51	5.3%
R8		4.1	447	663	0	22	4.9%
R8		2.7	190	290	0	9	4.9%
R8	Low Range Impactor #1	11.4	21010	0	43956	1444	6.9%
R8		7.0	1387	0	2176	70	5.1%
R8		4.3	720	1299	0	40	5.6%
R8		2.6	397	386	0	13	3.4%
R8		1.6	287	213	0	7	2.4%
R8		1.0	193	109	0	3	1.8%
R8		0.7	133	55	0	2	1.3%
R8	Low Range Impactor #2	11.4	19053	0	41040	1297	6.8%
R8		7.0	1343	0	2013	65	4.8%
R8		4.3	783	1173	0	39	5.0%
R8		2.6	347	335	0	11	3.2%
R8		1.6	237	187	0	6	2.7%
R8		1.0	157	91	0	3	1.8%
R8		0.7	107	64	0	2	1.8%
R8	Cartridge Filter		24633	0	61668	2016	8.2%

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R9	High Range Impactor #1	34.1	7200	0	17134	546	7.6%
R9		22.2	803	0	1813	46	5.7%
R9		14.5	1070	0	2181	68	6.3%
R9		9.5	1850	0	4420	140	7.5%
R9		6.2	1190	0	2472	76	6.4%
R9		4.1	540	1110	0	28	5.1%
R9		2.7	293	181	0	5	1.8%
R9	High Range Impactor #2	34.1	6180	0	14785	470	7.6%
R9		22.2	660	0	1183	36	5.5%
R9		14.5	1053	0	2353	70	6.6%
R9		9.5	1847	0	4681	144	7.8%
R9		6.2	1000	0	2069	64	6.4%
R9		4.1	493	893	0	28	5.7%
R9		2.7	227	269	0	5	2.3%
R9	Low Range Impactor #1	11.4	25667	0	74826	2562	10.0%
R9		7.0	2037	0	3660	121	6.0%
R9		4.3	1053	0	1191	38	3.6%
R9		2.6	520	387	0	12	2.4%
R9		1.6	467	56	0	2	0.4%
R9		1.0	363	15	0	0	0.1%
R9		0.7	327	9	0	0	0.1%
R9	Low Range Impactor #2	11.4	23150	0	62768	2070	8.9%
R9		7.0	1837	0	4227	133	7.3%
R9		4.3	977	0	1527	47	4.8%
R9		2.6	433	395	0	12	2.7%
R9		1.6	337	55	0	2	0.5%
R9		1.0	270	19	0	1	0.2%
R9		0.7	210	9	0	0	0.1%
R9	Cartridge Filter		28903	0	80028	2528	8.7%

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R10	High Range Impactor #1	34.1	4130	0	6891	222	5.4%
R10		22.2	610	1218	0	39	6.3%
R10		14.5	743	1443	0	47	6.3%
R10		9.5	1350	0	2027	67	4.9%
R10		6.2	890	0	1058	34	3.9%
R10		4.1	400	465	0	15	3.7%
R10		2.7	280	257	0	8	2.9%
R10	High Range Impactor #2	34.1	3693	0	5959	187	5.1%
R10		22.2	507	779	0	25	4.8%
R10		14.5	773	0	1201	38	5.0%
R10		9.5	1163	0	1783	59	5.0%
R10		6.2	870	0	1237	38	4.4%
R10		4.1	430	469	0	16	3.6%
R10		2.7	287	208	0	7	2.3%
R10	Low Range Impactor #1	11.4	18783	0	40320	1253	6.7%
R10		7.0	927	0	1173	38	4.1%
R10		4.3	620	864	0	26	4.2%
R10		2.6	440	410	0	13	3.0%
R10		1.6	353	232	0	7	2.0%
R10		1.0	277	114	0	4	1.3%
R10		0.7	250	61	0	2	0.7%
R10	Low Range Impactor #2	11.4	15720	0	30364	1022	6.5%
R10		7.0		Sample Lost			
R10		4.3	527	653	0	22	4.1%
R10		2.6	363	404	0	13	3.5%
R10		1.6	303	181	0	7	2.4%
R10		1.0	253	109	0	3	1.3%
R10		0.7	220	53	0	2	0.8%
R10	Cartridge Filter		21487	0	45136	1432	6.7%

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R11	High Range Impactor #1	34.1	8363	0	11683	385	4.6%
R11		22.2	1280	0	2014	64	5.0%
R11		14.5	1517	0	2507	77	5.1%
R11		9.5	2140	0	3610	108	5.1%
R11		6.2	1547	0	2011	66	4.2%
R11		4.1	687	728	467	23	3.3%
R11		2.7	483	307	395	10	2.0%
R11	High Range Impactor #2	34.1	7880	0	11966	384	4.9%
R11		22.2	930	0	1104	36	3.8%
R11		14.5	1373	0	2115	66	4.8%
R11		9.5	2227	0	3611	116	5.2%
R11		6.2	1507	0	2084	70	4.6%
R11		4.1	757	748	566	25	3.3%
R11		2.7	513	325	0	11	2.1%
R11	Low Range Impactor #1	11.4	28500	0	0	0	0.0%
R11		7.0	2100	0	3141	102	4.9%
R11		4.3	1113	0	1121	35	3.1%
R11		2.6	773	644	52	20	2.5%
R11		1.6	520	229	0	8	1.5%
R11		1.0	417	125	0	4	0.9%
R11		0.7	383	62	0	2	0.5%
R11	Low Range Impactor #2	11.4	26627	68	0	2	0.0%
R11		7.0	2083	0	43	1	0.1%
R11		4.3	1010	229	182	7	0.7%
R11		2.6	617	2	0	0	0.0%
R11		1.6	497	0	0	0	0.0%
R11		1.0	390	0	0	0	0.0%
R11		0.7	330	0	4603	161	48.7%
R11	Cartridge Filter		57690	0	546	17	0.0%

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R12	High Range Impactor #1	34.1	6467	0	10148	320	4.9%
R12		22.2	830	0	1192	37	4.4%
R12		14.5	1343	0	2137	65	4.8%
R12		9.5	1317	0	1830	63	4.8%
R12		6.2	1047	0	1404	43	4.1%
R12		4.1	573	560	0	17	2.9%
R12		2.7	400	220	0	7	1.8%
R12	High Range Impactor #2	34.1	6190	0	9962	328	5.3%
R12		22.2	517	0	1213	36	7.1%
R12		14.5	637	0	2034	65	10.3%
R12		9.5	1147	0	0	0	0.0%
R12		6.2	800	0	1444	48	5.9%
R12		4.1	317	531	0	18	5.6%
R12		2.7	120	226	0	7	6.2%
R12	Low Range Impactor #1	11.4	22900	0	59340	1983	8.7%
R12		7.0	1077	0	1583	49	4.6%
R12		4.3	747	823	709	26	3.5%
R12		2.6	493	339	0	11	2.2%
R12		1.6	313	121	0	4	1.1%
R12		1.0	343	49	0	2	0.5%
R12		0.7	260	27	0	1	0.3%
R12	Low Range Impactor #2	11.4	22800	0	63452	1977	8.7%
R12		7.0	1550	0	2391	74	4.8%
R12		4.3	867	917	766	32	3.7%
R12		2.6	537	368	0	12	2.2%
R12		1.6	397	123	0	4	1.0%
R12		1.0	313	53	0	2	0.5%
R12		0.7	230	29	0	1	0.4%
R12	Cartridge Filter		28963	0	61512	2003	6.9%

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R13	High Range Impactor #1	34.1	2633	0	4589	157	5.9%
R13		22.2	333	641	0	21	6.2%
R13		14.5		Sample Lost			
R13		9.5	867	0	1691	54	6.2%
R13		6.2	657	1260	964	41	6.3%
R13		4.1	360	506	0	16	4.5%
R13		2.7	193	146	0	5	2.4%
R13	High Range Impactor #2	34.1	2437	0	4466	150	6.2%
R13		22.2	360	574	0	20	5.4%
R13		14.5	477	889	0	29	6.1%
R13		9.5	837	0	1481	49	5.8%
R13		6.2	520	1147	0	35	6.8%
R13		4.1	273	382	0	13	4.7%
R13		2.7	203	156	0	5	2.6%
R13	Low Range Impactor #1	11.4	11130	0	21145	649	5.8%
R13		7.0	500	875	0	28	5.6%
R13		4.3	420	614	0	19	4.4%
R13		2.6	297	286	0	9	3.0%
R13		1.6	267	99	0	3	1.1%
R13		1.0	177	66	0	2	1.2%
R13		0.7	160	53	0	2	1.1%
R13	Low Range Impactor #2	11.4	11477	0	20171	657	5.7%
R13		7.0	750	1202	962	41	5.4%
R13		4.3	573	0	0	0	0.0%
R13		2.6	337	239	0	8	2.4%
R13		1.6		Sample Lost			
R13		1.0	283	86	0	3	1.0%
R13		0.7	207	48	0	2	0.7%
R13	Cartridge Filter		12323	0	20087	693	5.6%

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R14	High Range Impactor #1	34.1	4877	0	9061	280	5.7%
R14		22.2	600	1599	0	49	8.2%
R14		14.5	637	0	1261	52	8.2%
R14		9.5	1017	0	2027	65	6.4%
R14		6.2	703	0	1126	38	5.4%
R14		4.1	247	496	0	15	6.3%
R14		2.7	133	177	0	5	4.0%
R14	High Range Impactor #2	34.1	5087	0	11066	336	6.6%
R14		22.2	643	1082	839	36	5.6%
R14		14.5	790	0	1292	43	5.4%
R14		9.5	1187	0	2088	65	5.5%
R14		6.2	737	2271	952	73	9.9%
R14		4.1	380	450	0	15	3.9%
R14		2.7	293	209	0	7	2.2%
R14	Low Range Impactor #1	11.4	16760	0	46320	1469	8.8%
R14		7.0	780	0	1134	36	4.6%
R14		4.3	477	685	0	22	4.5%
R14		2.6	400	425	0	13	3.2%
R14		1.6	307	178	0	6	1.9%
R14		1.0	217	75	0	2	1.1%
R14		0.7	180	53	0	2	0.9%
R14	Low Range Impactor #2	11.4	16900	0	11710	366	2.2%
R14		7.0	1077	0	1330	43	4.0%
R14		4.3	570	691	0	22	3.9%
R14		2.6	430	327	0	10	2.4%
R14		1.6	0	0	0	0	0.0%
R14		1.0	273	125	0	4	1.4%
R14		0.7	237	50	0	2	0.7%
R14	Cartridge Filter		22493	0	45584	1458	6.5%

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R15	High Range Impactor #1	34.1	9273	0	19440	656	7.1%
R15		22.2	1447	0	3170	99	6.9%
R15		14.5	1013	0	1845	57	5.6%
R15		9.5	2253	0	5295	164	7.3%
R15		6.2	1377	0	2122	74	5.4%
R15		4.1	690	1113	829	37	5.4%
R15		2.7	417	204	0	6	1.5%
R15	High Range Impactor #2	34.1	8023	0	18670	610	7.6%
R15		22.2	1073	0	2189	69	6.4%
R15		14.5	1270	0	3011	95	7.5%
R15		9.5	2073	0	5029	161	7.8%
R15		6.2	1343	0	2518	83	6.2%
R15		4.1	673	1069	771	36	5.4%
R15		2.7	383	192	0	6	1.7%
R15	Low Range Impactor #1	11.4	33673	0	96330	2987	8.9%
R15		7.0	2123	0	4823	161	7.6%
R15		4.3	1097	0	2031	66	6.0%
R15		2.6	427	532	0	16	3.7%
R15		1.6	287	64	0	3	0.9%
R15		1.0	217	18	0	1	0.2%
R15		0.7	173	8	0	0	0.1%
R15	Low Range Impactor #2	11.4	33503	0	93036	3006	9.0%
R15		7.0	2453	0	4894	152	6.2%
R15		4.3	1360	0	2081	71	5.2%
R15		2.6	637	0	369	12	1.8%
R15		1.6	467	55	0	2	0.4%
R15		1.0	390	15	0	1	0.1%
R15		0.7	307	8	0	0	0.1%
R15	Cartridge Filter		47170	0	168333	5247	11.1%

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R16	High Range Impactor #1	34.1	5843	0	15035	467	8.0%
R16		22.2	847	0	1962	60	7.0%
R16		14.5	1013	0	2623	78	7.7%
R16		9.5	1537	0	4087	123	8.0%
R16		6.2	993	0	2015	67	6.8%
R16		4.1	410	961	0	29	7.0%
R16		2.7	200	168	0	5	2.6%
R16	High Range Impactor #2	34.1	5783	0	14996	463	8.0%
R16		22.2	640	0	1218	39	6.1%
R16		14.5	957	0	2096	66	6.9%
R16		9.5	1570	0	4073	124	7.9%
R16		6.2	1043	0	2224	68	6.5%
R16		4.1	443	821	0	26	5.9%
R16		2.7	190	170	0	5	2.8%
R16	Low Range Impactor #1	11.4	27280	0	71030	2304	8.4%
R16		7.0	1677	0	3964	121	7.2%
R16		4.3	830	0	1430	44	5.4%
R16		2.6	327	328	0	11	3.3%
R16		1.6	250	62	0	2	0.8%
R16		1.0	190	18	0	1	0.3%
R16		0.7	173	0	0	0	0.0%
R16	Low Range Impactor #2	11.4	23877	0	61790	2031	8.5%
R16		7.0	2003	0	4495	136	6.8%
R16		4.3	1043	0	1448	45	4.3%
R16		2.6	463	280	0	9	1.9%
R16		1.6	380	58	0	2	0.4%
R16		1.0	323	10	0	0	0.1%
R16		0.7	290	7	0	0	0.1%
R16	Cartridge Filter		Sample Lost				

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R17	High Range Impactor #1	34.1	6933	0	15979	533	7.7%
R17		22.2	903	0	1593	34	3.7%
R17		14.5	983	0	1958	60	6.1%
R17		9.5	1903	0	3812	128	6.7%
R17		6.2	1037	0	1948	60	5.8%
R17		4.1	493	740	0	23	4.7%
R17		2.7	303	130	0	4	1.4%
R17	High Range Impactor #2	34.1			Sample Lost		
R17		22.2	1090	0	1631	55	5.0%
R17		14.5	927	0	1478	44	4.7%
R17		9.5	1617	0	3184	104	6.5%
R17		6.2	1107	0	1826	59	5.3%
R17		4.1	573	706	0	22	3.9%
R17		2.7	313	158	0	5	1.7%
R17	Low Range Impactor #1	11.4	24583	0	67780	2204	9.0%
R17		7.0	1947	0	3498	112	5.8%
R17		4.3	1067	0	1237	39	3.7%
R17		2.6	557	228	0	7	1.3%
R17		1.6	383	58	0	2	0.5%
R17		1.0	323	20	0	1	0.2%
R17		0.7	273	9	0	0	0.1%
R17	Low Range Impactor #2	11.4	26703	0	74840	2430	9.1%
R17		7.0	2147	0	4366	140	6.5%
R17		4.3	1043	0	1229	39	3.7%
R17		2.6	503	352	0	12	2.3%
R17		1.6	380	57	0	2	0.5%
R17		1.0	297	15	0	0	0.2%
R17		0.7	240	0	0	0	0.0%
R17	Cartridge Filter		40367	0	105240	3686	9.1%

Sample Run	Impactor	Particle Size (MMAD - um)	Mass of Dry Paint Collected (ug)	AAS Furnace Cr Concentration (ug/L)	AAS Flame Cr Concentration (ug/L)	Mass Cr(VI) Collected (ug)	Mass Cr/Paint (%)
R18	High Range Impactor #1	34.1			Sample Lost		
R18		22.2	1197	0	2083	65	5.4%
R18		14.5	2327	0	4973	158	6.8%
R18		9.5	1953	0	3977	121	6.2%
R18		6.2	1490	0	2727	83	5.5%
R18		4.1	720	1173	678	39	5.4%
R18		2.7	437	263	0	8	1.9%
R18	High Range Impactor #2	34.1	8380	0	18798	590	7.0%
R18		22.2	1280	0	2483	79	6.2%
R18		14.5	1540	0	3441	104	6.7%
R18		9.5	2223	0	5011	160	7.2%
R18		6.2	1477	0	2795	88	6.0%
R18		4.1	717	1094	808	35	4.8%
R18		2.7	423	232	0	8	1.8%
R18	Low Range Impactor #1	11.4	25587	0	74820	2386	9.3%
R18		7.0	2517	0	5856	169	6.7%
R18		4.3	1357	0	2094	65	4.8%
R18		2.6	603	388	0	12	1.9%
R18		1.6	527	104	0	3	0.6%
R18		1.0	443	27	0	1	0.2%
R18		0.7	390	13	0	0	0.1%
R18	Low Range Impactor #2	11.4	35397	0	114340	3431	9.7%
R18		7.0	2773	0	5274	175	6.3%
R18		4.3	1360	0	1976	62	4.6%
R18		2.6	673	504	368	15	2.2%
R18		1.6	490	70	0	2	0.5%
R18		1.0	433	18	0	1	0.1%
R18		0.7	387	10	0	0	0.1%
R18	Cartridge Filter		44900	0	130600	4076	9.1%

Appendix B: Deft Material Safety Data Sheet

MATERIAL SAFETY DATA SHEET Printed : 02/28/01
For Coatings, Resins and Related Materials
Revised : 11/30/99

SECTION I - PRODUCT IDENTIFICATION

Manufacturer: KEPT, INC. (CAGE CODE 33481)
17451 VON KARMAN AVENUE
IRVINE CA
92614

Information Phone: (949) 474-9400
Emergency Phone: (800) 424-9300
CHEMTREC Phone: 800-424-9300

Hazard Ratings: Health - 4
None -> extreme Fire - 3
0 ---> 4 Reactivity - 1

Product Class: TYPE I, CLASS C
Trade Name : MIL-PRF-23377G (MIL-P-23377G)
Product Code : 029040
U.A.S. Number: NONE

SECTION II - HAZARDOUS INGREDIENTS

Ingredients	CAS #	Weight %	Exposure Limits ACGIH TLV	ACGIH STEL	OSHA PEL	OSHA STEL	VP mm HG
BENZENE,1-CHLORO-4 TRIFLUOROMETHYL	98-56-6	< 5.	N.E.	N.E.	N.E.	N.E.	5.3 @ 68F
BENZENE,1-CHLORO-2 TRIFLUOROMETHYL	88-16-4	< 0.1	N.E.	N.E.	N.E.	N.E.	5.3 @ 68F
N-BUTYL ACETATE	123-86-4	< 5.	150 ppm	200 ppm	150 ppm	200 ppm	13 @ 68F
METHYL n-PROPYL KETONE	107-87-9	25.	200 ppm	250 ppm	200 ppm	250 ppm	27.8 @ 68F
STRONTIUM CHROMATE	7789-06-2	25.			.1 ppm	N.E.	
		The ACGIH TWA for Strontium Chromate (CAS 7789-06-2) as Cr is 0.0005 mg/m3.					
C9&10 AROMATIC HYDROCARBON	64742-95-6	< 5.	N.E.	N.E.	N.E.	N.E.	3 @ 68F
		Manufacturer recommends a PEL of 100 ppm.					
N-METHYLPYRROLIDONE	872-50-4	< 1.	N.E.	N.E.	N.E.	N.E.	.5 @ 77F
		N-METHYLPYRROLIDONE, CAS # 872-50-4, ESTIMATED TLV TWA 100 PPM. (FTR GAF CORPORATION)					

THE ABOVE LISTED PRODUCTS ARE ON THE TSCA INVENTORY LIST.
ALSO ANY UNLISTED INGREDIENTS.

N.E. = Not Established

SECTION III - PHYSICAL DATA

Boiling Range: 213 - 396 Deg. F Vapor Density: Heavier than Air.
Evap. Rate: 1.65 x n-Butyl Acetate Liquid Density: Heavier than Water.
Volatiles vol % 44.8 Wgt% 27.6 Wgt per gallon: 11.23 Pounds.
Spec. Gravity: 1.34814

Appearance: YELLOW LIQUID WITH SOLVENT ODOR
V.O.C.: 361 G/L
SOLUBILITY IN WATER: Insoluble PH: Not applicable
AUTOIGNITION TEMPERATURE: No information found
DECOMPOSITION TEMPERATURE: No information found
CORROSION RATE: No information found
VISCOSITY: Thin liquid to heavy viscous material

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Flammability Class: IB Flash Point:46 F TCC LEL: 0.90% UEL: 10.50%
EXTINGUISHING MEDIA:
FOAM, ALCOHOL FOAM, CO2, DRY CHEMICAL, WATER FOG**
SPECIAL FIREFIGHTING PROCEDURES:
Full fire fighting equipment with self-contained breathing apparatus and full protective clothing should be worn by fire fighters. Water may be used to cool closed containers to prevent pressure build-up, auto ignition or explosion.
UNUSUAL FIRE & EXPLOSION HAZARDS:
Keep containers tightly closed. Isolate from heat, sparks, electrical equipment and open flame. Closed containers may explode when exposed to extreme heat. Application to hot surfaces requires special precautions. During emergency conditions overexposure to decomposition products may cause a health hazard. Symptoms may not be immediately apparent.

SECTION V - HEALTH HAZARD DATA

PERMISSIBLE EXPOSURE LEVEL:
SEE SECTION II, HAZARDOUS INGREDIENTS.
EFFECTS OF OVEREXPOSURE:
INHALATION: Irritation of the respiratory tract & acute nervous system depression characterized by the following progressive steps: headache, dizziness, staggering gait, confusion, unconsciousness or coma.
SKIN AND EYE CONTACT: SKIN: Contact with the skin can cause irritation. Symptoms may be swelling, redness, and rash.
EYES: Liquid, aerosols, or vapors are irritating and may cause tearing, redness, and swelling accompanied by a stinging sensation.
SKIN ABSORPTION: Prolonged or repeated contact can cause moderate irritation, drying, and defatting of the skin which can cause the skin to crack.
INGESTION: Acute: Can result in irritation and possible

corrosive action in the mouth, stomach tissue and digestive tract. Vomiting may cause aspiration of the solvent, resultin in chemical pneumonitis.
HEALTH HAZARDS (ACUTE AND CHRONIC)
ACUTE: Vapors are irritating to eyes, nose, and throat. Inhalation may cause headaches, difficult breathing and loss consciousness.
CHRONIC: Prolonged contact will cause drying and cracking of skin, due to defatting action. Skin sensitization, asthma or other allergic responses may develop. Repeated and prolonged exposure may cause delayed effects involving the blood, gastr intestinal, nervous and reproductive systems.
PRIMARY ROUTE(S) OF ENTRY:
TOPICAL (SKIN CONTACT): Yes
INGESTION (GASTRO-INTESTINAL): No
INHALATION (LUNGS): Yes
CARCINOGENICITY:
NTP?: YES, IARC MONOGRAPHS?: YES, OSHA REGULATED?: YES
MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE:
Asthma and any other respiratory disorders. Skin allergies, eczema, and dermititis.

-FIRST AID:
INHALATION: Move to an area free from risk of further exposur Restore breathing. Asthmatic type symptoms may develop and ma be immediate or delayed by several hours. Obtain medical attention.
SKIN: Remove contaminated clothing. Wash affected areas thoroughly with soap and water. Wash contaminated clothing thoroughly before reuse.
EYES: Flush with clean lukewarm water (low pressure) for at least 15 minutes, occasionally lifting eyelids. Obtain medical attention.
INGESTION: Do not induce vomiting. Do not give anything to an unconscious person. Obtain medical attention.

SECTION VI - REACTIVITY DATA

STABLITY: [ ] Unstable [x] Stable
HAZARDOUS POLYMERIZATION: [ ] May occur [x] Will not occur

-INCOMPATIBILITY
STRONG OXIDIZING AGENTS AND STRONG LEWIS OR MINERAL ACIDS.

-CONDITIONS TO AVOID:
HIGH TEMPERATURES, SPARKS, OR OPEN FLAMES. AVOID UNCONTROLLED REACTIONS WITH AMINES.

-HAZARDOUS DECOMPOSITION PRODUCTS:
BY HIGH HEAT/TEMPERATURE: Carbon monoxide, carbon dioxide, and oxides of nitrogen. Aldehydes and acids may be formed dur combustion. Chromium oxides when burned.

SECTION VII - SPILL OR LEAK PROCEDURES

-STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Evacuate all non-essential personnel. Remove all sources of ignition (flame, spark sources, hot surfaces). Ventilate area Contain and remove with inert absorbent and non-sparking tool

-WASTE DISPOSAL METHOD:
Waste must be disposed of in accordance with federal, state, l local environmental control regulations. Empty containers must be handled with care, due to product residue and flammable va DO NOT incinerate closed containers.
ALSO SEE SECTION IV, V, VI, FOR OTHER PRECAUTIONS.
EPA HAZARDOUS WASTE NUMBER/CODE: D001, D007, F003, F005
HAZARDOUS WASTE CHARACTERISTICS:
IGNITABILITY: YES
CORROSIVITY: NO
REACTIVITY: YES

SECTION VIII - SPECIAL PROTECTION INFORMATION:

-RESPIRATORY PROTECTION:
A respirator that is recommended or approved for use in an organic vapor environment (air purifying or fresh air supplied is necessary. Observe OSHA regulations for respirator use. Ventilation should be provided to keep exposure levels below t OSHA permissible limits.

-VENTILATION:
Exhaust ventilation sufficient to keep the airborne concentra- tions of solvent vapors or mists below their respective TLV's must be utilized. Remove all ignition sources (heat, sparks, flame, and hot surfaces).

-PROTECTIVE GLOVES:
Protective gloves are recommended (cotton, neoprene, rubber, polyethylene) to prevent skin contact.

-EYE PROTECTION:
The use of safety eyewear is recommended, including splash guards or side shields, chemical goggles or face shields.

-OTHER PROTECTIVE EQUIPMENT:
The use of long sleeve and long leg clothing is recommended. Remove and wash contaminated clothing before reuse.

SECTION IX - SPECIAL PRECAUTIONS

(continued on next page)

SECTION IX - SPECIAL PRECAUTIONS (cont.)

OTHER PROTECTIVE EQUIPMENT:

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING:

Store in buildings designed to comply with OSHA 1910.106 Avoid storing near high temperatures, fire, open flames, and spark sources. Store in tightly closed containers. Store in well ventilated areas.

OTHER PRECAUTIONS:

Keep containers tight and upright to prevent leakage. Prevent prolonged breathing of vapors or spray mists. Prolonged over-exposure may cause an allergic reaction. Avoid contact with skin and eyes. Do not take internally. Do not handle until the manufacturers safety precautions have been read and understood. Wash hands before eating, smoking, or using washroom. Smoke in smoking areas ONLY.

*** TRANSPORTATION INFORMATION ***

APPLICABLE REGULATIONS: 49 CFR (YES); IMCO (NO); IATA (NO)
MILITARY AIR (AFR 71-4) (NO)
PROPER SHIPPING NAME: Paint
REPORTABLE QUANTITY: Not applicable
HAZARD CLASS: Flammable liquid 3
THIS MATERIAL WHEN PACKAGED IN CONTAINERS OF 1 LITER OR LESS QUALIFIES AS PAINT IN LIMITED QUANTITY OF CLASS 3.
REQUIRED LABELS: Flammable liquid
U.S. POSTAL REGULATIONS: Not allowed to send via US POSTAL SERVICE.

*** DISCLAIMER ***

Information contained herein is furnished without warranty of any kind. Employers should use this information only as a supplement to other information gathered by them and must make independent determination of suitability and completeness of information from all sources to assure proper use of the materials and for the safety and health of their employees.

ACTUAL VOC DETERMINED PER EPA REFERENCE METHOD 24.

SECTION X - REGULATORY INFORMATION

-SARA 313:
This product contains the following toxic chemicals subject to reporting requirements of section 313 of the Emergency Planning and Community Right To Know Act of 1986 and of 40 CFR 372:

CAS#	Chemical Name	Percent by Weight
7789-06-2	STRONTIUM CHROMATE	22.54

This product contains chromium (hexavalent compound), 26% by weight.

-PROP 65-CARCINOGENIC
WARNING: This product contains a chemical known to the state of California to cause cancer.

CAS#	Chemical Name
7789-06-2	STRONTIUM CHROMATE

This product contains chromium (hexavalent compound).

-PROP 65-TERATOGENIC
WARNING: This product contains a chemical known to the state of California to cause birth defects or other reproductive har

CAS#	Chemical Name
	None

-PROP 65-CARCINOGENIC & TERATOGENIC
WARNING: This product may contain a chemical known to the stat California to cause cancer or birth defects or other reproduct

CAS#	Chemical Name
	None

MATERIAL SAFETY DATA SHEET Printed : 02/28/01
For Coatings, Resins and Related Materials
Revised : 11/30/99

SECTION I - PRODUCT IDENTIFICATION

Manufacturer: DEFT, INC. (CAGE CODE 33461)
17451 VON KARMAN AVENUE
IRVINE CA
92614

Information Phone: (949) 474-0400
Emergency Phone: (800) 424-9300
CHEMTREC Phone: 800-424-9300

Product Class: TYPE 1, CLASS C
Trade Name : MIL-PRF-23377G (MIL-P-23377G)
Product Code : 02Y040CAT
I.A.S. Number: NONE

Hazard Ratings: Health - 3
none => extreme Fire - 3
0 ----> 4 Reactivity - 1

SECTION II - HAZARDOUS INGREDIENTS

Ingredients	CAS #	Weight %	ACGIH TLV	ACGIH STEL	OSHA PEL	OSHA PEL	VP mm HG
ALIPHATIC AMINE	80-05-7	5.	N.E.	N.E.	N.E.	N.E.	
Contains Bisphenol A (CAS # 80-05-7) less than 55%.							
ALIPHATIC AMINE	25184-52-3	< 5.	N.E.	N.E.	N.E.	N.E.	
Contains Bisphenol A (CAS # 80-05-7) less than 55%.							
ALIPHATIC AMINE	103-83-3	< 1.	N.E.	N.E.	N.E.	N.E.	
Contains Bisphenol A (CAS # 80-05-7) less than 55%.							
ALIPHATIC AMINE	140-31-8	5.	N.E.	N.E.	N.E.	N.E.	
Contains Bisphenol A (CAS # 80-05-7) less than 55%.							
N-BUTYL ALCOHOL	78-92-2	30.	100 ppm	N.E.	100 ppm	N.E.	12.5 @ 68F
C8&10 AROMATIC HYDROCARBON	64742-95-6	< 5.	N.E.	N.E.	N.E.	N.E.	3 @ 68F
Manufacturer recommends a PEL of 100 ppm.							
AMINO SILANE ESTER	1760-24-3	< 1.	200 ppm	250 ppm	200 ppm	250ppm	
EPOXY RESIN HARDENER	90-72-2	< 5.	N.E.	N.E.	N.E.	N.E.	0 @ 70F
EPOXY RESIN HARDENER	71074-89-0	< 1.	N.E.	N.E.	N.E.	N.E.	0 @ 70F

THE ABOVE LISTED PRODUCTS ARE ON THE TSCA INVENTORY LIST.
ALSO ANY UNLISTED INGREDIENTS.

N.E. = Not Established

SECTION III - PHYSICAL DATA

Boiling Range: 211 - 401 Deg. F
Evap. Rate: 0.63 x n-Butyl Acetate
Volatiles vol % 34.8 Wgt% 29.7

Vapor Density: Heavier than Air.
Liquid Density: Lighter than Water.
Wgt per gallon: 7.90 Pounds.
Spec. Gravity: 0.94838

Appearance: AMBER LIQUID WITH SOLVENT ODOR
V.O.C.: 281
SOLUBILITY IN WATER: Insoluble PH: Not applicable
AUTOIGNITION TEMPERATURE: No information found
DECOMPOSITION TEMPERATURE: No information found
CORROSION RATE: No information found
VISCOSITY: Thin liquid to heavy viscous material

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Flammability Class: IB Flash Point:72 F TCC LEL: 1.00% UEL: 9.80%
EXTINGUISHING MEDIA:
FOAM, ALCOHOL FOAM, CO2, DRY CHEMICAL, WATER FOG
SPECIAL FIREFIGHTING PROCEDURES:
Full fire fighting equipment with self-contained breathing apparatus and full protective clothing should be worn by fire fighters. Water may be used to cool closed containers to prevent pressure build-up, auto ignition or explosion.
UNUSUAL FIRE & EXPLOSION HAZARDS:
Keep containers tightly closed. Isolate from heat, sparks, electrical equipment and open flame. Closed containers may explode when exposed to extreme heat. Application to hot surfaces requires special precautions. During emergency conditions overexposure to decomposition products may cause a health hazard. Symptoms may not be immediately apparent.

SECTION V - HEALTH HAZARD DATA

PERMISSIBLE EXPOSURE LEVEL:
SEE SECTION II, HAZARDOUS INGREDIENTS.
EFFECTS OF OVEREXPOSURE:
INHALATION: Irritation of the respiratory tract & acute nervous system depression characterized by the following progressive steps: headache, dizziness, staggering gait, confusion, unconsciousness or coma.

SKIN AND EYE CONTACT: SKIN: Contact with the skin can cause irritation. Symptoms may be swelling, redness, and rash. EYES: Liquid, aerosols, or vapors are irritating and may cause tearing, redness, and swelling accompanied by a stinging sensation.

SKIN ABSORPTION: Prolonged or repeated contact can cause moderate irritation, drying, and defatting of the skin which cause the skin to crack.

INGESTION: Acute: Can result in irritation and possible corrosive action in the mouth, stomach tissue and digestive tract. Vomiting may cause aspiration of the solvent, resultin in chemical pneumonitis.

HEALTH HAZARDS (ACUTE AND CHRONIC)
ACUTE: Vapors are irritating to eyes, nose, and throat. Inhalation may cause headaches, difficult breathing and loss consciousness.
CHRONIC: Prolonged contact will cause drying and cracking of skin, due to defatting action. Skin sensitization, asthma or other allergic responses may develop. Potential for kidney an liver damage.

PRIMARY ROUTE(S) OF ENTRY:
TOPICAL (SKIN CONTACT): Yes
INGESTION (GASTRO-INTESTINAL): No
INHALATION (LUNGS): Yes

CARCINOGENICITY:
NTP?: NO, IARC MONOGRAPHS?: NO, OSHA REGULATED?: NO

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE:
Asthma and any other respiratory disorders, skin allergies, eczema, and dermititis.

-FIRST AID:
INHALATION: Move to an area free from risk of further exposur Restore breathing. Asthmatic type symptoms may develop and ma be immediate or delayed by several hours. Obtain medical attention.

SKIN: Remove contaminated clothing. Wash affected areas thoroughly with soap and water. Wash contaminated clothing thoroughly before reuse.

EYES: Flush with clean lukewarm water (low pressure) for at least 15 minutes, occasionally lifting eyelids. Obtain medical attention.

INGESTION: Do not induce vomiting. Do not give anything to an unconscious person. Obtain medical attention.

SECTION VI - REACTIVITY DATA

STABILITY: [ ] Unstable [x] Stable
HAZARDOUS POLYMERIZATION: [ ] May occur [x] Will not occur

-INCOMPATIBILITY
OXIDIZING MATERIALS AND STRONG ACIDS. EPOXY RESINS UNDER UNCONTROLLED CONDITIONS.

-CONDITIONS TO AVOID:
HIGH TEMPERATURES. EPOXY RESINS UNDER UNCONTROLLED CONDITIONS

-HAZARDOUS DECOMPOSITION PRODUCTS:
BY HIGH HEAT/TEMPERATURE: Carbon monoxide, carbon dioxide, and oxides of nitrogen.

SECTION VII - SPILL OR LEAK PROCEDURES

-STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Evacuate all non-essential personnel. Remove all sources of ignition (flame, spark sources, hot surfaces). Ventilate area Contain and remove with inert absorbent and non-sparking tool

-WASTE DISPOSAL METHOD:
Waste must be disposed of in accordance with federal, state, local environmental control regulations. Empty containers must be handled with care, due to product residue and flammable va DO NOT incinerate closed containers.
ALSO SEE SECTION IV, V, VI, FOR OTHER PRECAUTIONS.
EPA HAZARDOUS WASTE NUMBER/CODE: D001, F003, F005
HAZARDOUS WASTE CHARACTERISTICS:
IGNITABILITY: YES
CORROSIVITY: NO
REACTIVITY: YES

SECTION VIII - SPECIAL PROTECTION INFORMATION:

-RESPIRATORY PROTECTION:
A respirator that is recommended or approved for use in an organic vapor environment (air purifying or fresh air supplie is necessary. Observe OSHA regulations for respirator use. Ventilation should be provided to keep exposure levels below t OSHA permissible limits.

-VENTILATION:
Exhaust ventilation sufficient to keep the airborne concentrations of solvent vapors or mists below their respective TLV's must be utilized. Remove all ignition sources (heat, sparks, flame, and hot surfaces).

-PROTECTIVE GLOVES:
(continued on next page)

SECTION VIII - SPECIAL PROTECTION INFORMATION: (cont.)

PROTECTIVE GLOVES:
Protective gloves are recommended (cotton, neoprene, rubber, polyethylene) to prevent skin contact.

EYE PROTECTION:
The use of safety eyewear is recommended, including splash guards or side shields, chemical goggles or face shields.

OTHER PROTECTIVE EQUIPMENT:
The use of long sleeve and long leg clothing is recommended. Remove and wash contaminated clothing before reuse.

SECTION IX - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING:
Store in buildings designed to comply with OSHA 1910.106 Avoid storing near high temperatures, fire, open flames, and spark sources. Store in tightly closed containers. Store in well ventilated areas.

OTHER PRECAUTIONS:
Keep containers tight and upright to prevent leakage. Prevent prolonged breathing of vapors or spray mists. Prolonged over-exposure may cause an allergic reaction. Avoid contact with skin and eyes. Do not take internally. Do not handle until the manufacturers safety precautions have been read and understood. Wash hands before eating, smoking, or using washroom. Smoke in smoking areas ONLY.

*** TRANSPORTATION INFORMATION ***

APPLICABLE REGULATIONS: 49 CFR (YES); IMCO (NO); IATA (NO)
MILITARY AIR (AFR 71-4) (NO)
PROPER SHIPPING NAME: Paint UN NUMBER: UN-1263
REPORTABLE QUANTITY: Not applicable
HAZARD CLASS: Flammable liquid 3
THIS MATERIAL WHEN PACKAGED IN CONTAINERS OF 1 LITER OR LESS QUALIFIES AS PAINT IN LIMITED QUANTITY OF CLASS 3.
REQUIRED LABELS: Flammable liquid
U.S. POSTAL REGULATIONS: Not allowed to send via US POSTAL SERVICE.

*** DISCLAIMER ***

Information contained herein is furnished without warranty of any kind. Employers should use the information only as a supplement to other information gathered by them and must make independent determination of suitability and completeness of information from all sources to assure proper use of the materials and for the safety and health of their employees.

ACTUAL VOC DETERMINED PER EPA REFERENCE METHOD 24.

SECTION X - REGULATORY INFORMATION

-SARA 313:
This product contains the following toxic chemicals subject to reporting requirements of section 313 of the Emergency Planning and Community Right To Know Act of 1986 and of 40 CFR 372:

CAS#	Chemical Name	Percent by Weight
78-92-2	sec-BUTYL ALCOHOL	28.47

-PROP 65-CARCINOGENIC
WARNING: This product contains a chemical known to the state of California to cause cancer.

CAS#	Chemical Name
	None

-PROP 65-TERATOGENIC
WARNING: This product contains a chemical known to the state of California to cause birth defects or other reproductive har

CAS#	Chemical Name
	None

-PROP 65-CARCINOGENIC & TERATOGENIC
WARNING: This product may contain a chemical known to the stat California to cause cancer or birth defects or other reproduct

CAS#	Chemical Name
	None

Appendix C: DeSoto Material Safety Data Sheet

MATERIAL SAFETY DATA SHEET Printed : 07/09/97

Revised : 01/16/95

SECTION I - PRODUCT INDENTIFICATION

Manufacturer: COURTAULDS AEROSPACE
5430 SAN FERNANDO ROAD,
P.O.BOX 1800
GLENDALE CA 91209

Information Phone: (818) 240-2060
Emergency Phone: (800) 228-5635
CHEMTREC Phone: (800) 424-9300

Product Class: EPOXY
Trade Name : 513X390 EPOXY POLYAMIDE PRIMER
Product Code : 513X390
MSDS ID No. : MS5711A00
D.O.T. Hazard Class : Flammable liquid
Proper Shipping Name: Paint
Hazard Class 3 Packing Group 2
Reportable Quantity: See section VII

Hazard Ratings: Health - 2
none => extreme Fire - 3
0 ---> 4 Reactivity - 0

Personal Protection - H

UN #: UN1263

SECTION II - INGREDIENTS

Hazardous Ingredients	CAS #	Weight %	--- Exposure Limits --- ACGIH/TLV		OSHA/PEL		VP mm HG
*METHYL ETHYL KETONE	000078-93-3	5.	200	ppm	200	ppm	70
		STEL=	300		300		
* ENE	000108-88-3	15.	50	ppm	100	ppm	23
		STEL=	- - - - -		150		
*XYLENE	001330-20-7	10.	100	ppm	100	ppm	6.6
		STEL=	150		150		
EPOXY RESIN	025036-25-3	25.	Undetermined				N/AP
*STRONTIUM CHROMATE	007789-06-2	20.	0.0005 As Cr mg/M3		- - - - -		N/AP
		STEL=	- - - -		0.05 As Cr	mg/M3	
CHROMIC ACID,STRONTIUM SALT							
TITANIUM DIOXIDE @	013463-67-7	< 5.	10	mg/M3	10	mg/M3	N/AP
ISOPROPYL ALCOHOL	000067-63-0	< 5.	400	ppm	400	ppm	44
		STEL=	500		500		
TALC @	014807-96-6	15.	2	mg/M3	2	mg/M3	N/AP
METHYL AMYL KETONE	000110-43-0	< 5.	50	ppm	100	ppm	2.1

COURTAULDS AEROSPACE
Material Safety Data Sheet for: 513X390

SECTION II - (cont.)

*** ALL Ingredients in this product are listed in the T.S.C.A. Inventory.

@ -> These items are listed as required by 29CFR 1910:1200 because they appear on airborne contaminants list. However, in this product they are in fully encapsulated form and therefore are not hazardous to users under normal circumstances. If the cured product is sanded or ground so as to release respirable particles, suitable respiratory protection should be used.

* -> These items are subject to the reporting requirements of section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

SECTION III - PHYSICAL DATA

Boiling Range: 175 - 300 Deg. F
Evap. Rate: Unavailable
Volatiles volume: 60.4 %
Vapor Density: Heavier than Air.
Liquid Density: Heavier than Water.
Wgt per gallon: 10.84 Pounds.
Spec. Gravity: 1.301

Appearance: YELLOW LIQUID, SOLVENT ODOR
V.O.C. (GR/L): 592 W/910X624&010X311 @4/4/1

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Flammability Class: FLAMMABLE Flash Point: 22 F Setaflash LEL: Unknown

-EXTINGUISHING MEDIA:
Carbon dioxide, dry chemical or foam.

-SPECIAL FIREFIGHTING PROCEDURES:
Water spray may be ineffective. cool fire exposed containers with water. Fog nozzles are preferrable. Wear NIOSH/MSHA approved self-contained breathing apparatus and protective clothing to prevent contact with skin and eyes.

-UNUSUAL FIRE & EXPLOSION HAZARDS:
Vapors may accumulate in inadequately ventilated or confined areas. Vapors may form explosive mixtures with air. Vapors may travel long distances. Flashback or Flame to the handling site may occur. Closed containers may explode when exposed to extreme heat.

SECTION V - HEALTH HAZARD DATA

-PERMISSIBLE EXPOSURE LEVEL:
See section II (not established for product).

(cont.)

SECTION V - HEALTH HAZARD DATA (cont.)

-PERMISSIBLE EXPOSURE LEVEL: (cont.)
-EFFECTS OF OVEREXPOSURE:

MEK

EYES: MAY CAUSE BURNING, TEARING AND REDDENING. POSSIBLE TRANSIENT CORNEAL CLOUDING.
SKIN: PROLONGED EXPOSURE MAY CAUSE REDNESS, BURNING, DRYING AND CRACKING OF SKIN.
INHALATION: MAY CAUSE COUGHING, CHEST PAINS, THROAT IRRITATION. MAY CAUSE HEADACHES AND DIZZINESS; MAY BE ANESTHETIC AND MAY CAUSE OTHER CENTRAL NERVOUS SYSTEM EFFECTS. REVERSIBLE LIVER DAMAGE IS POSSIBLE AT HIGH DOSES.
INGESTION: MAY CAUSE DROWSINESS, DIZZINESS, AND NAUSEA.

TOLUENE

EYES: MAY CAUSE BURNING, TEARING AND REDDENING.
SKIN: PROLONGED EXPOSURE MAY CAUSE DRYING AND CRACKING OF SKIN, AND POSSIBLE DERMATITIS.
INHALATION: MAY CAUSE DIZZINESS, DROWSINESS AND FATIGUE. MAY CAUSE LIVER AND KIDNEY DAMAGE.
INGESTION: MAY CAUSE DROWSINESS, DIZZINESS AND NAUSEA.
EFFECTS OF LONG-TERM (CHRONIC) EXPOSURE
MAY CAUSE DISTURBANCE IN MEMORY, THINKING ABILITY, EMOTIONS AND COORDINATION.

THIS CHEMICAL IS ON THE LIST ENTITLED "CHEMICALS KNOWN BY THE STATE OF CALIFORNIA TO CAUSE REPRODUCTIVE TOXICITY".

XYLENE

EYES: MAY CAUSE BURNING, TEARING AND REDDENING.
SKIN: PROLONGED EXPOSURE MAY CAUSE DRYING AND CRACKING OF SKIN POSSIBLE DERMATITIS. THIS PRODUCT MAY BE ABSORBED THROUGH THE SKIN.
INHALATION: MAY CAUSE DIZZINESS, DROWSINESS AND FATIGUE. MAY CAUSE LIVER OR KIDNEY DAMAGE.
INGESTION: MAY CAUSE IRRITATION OF THE DIGESTIVE TRACT. SIGNS OF NERVOUS SYSTEM DEPRESSION (DROWSINESS, DIZZINESS, LOSS OF COORDINATION, AND FATIGUE). ASPIRATION HAZARD-THIS MATERIAL CAN ENTER LUNGS

(cont.)

SECTION V - HEALTH HAZARD DATA (cont.)

EFFECTS OF OVEREXPOSURE: (cont.)
DURING SWALLOWING OR VOMITING AND CAUSE LUNG INFLAMMATION AND DAMAGE.

BISPHENOL A / EPICHLOROHYDRIN RESIN

EYES: MAY CAUSE MECHANICAL IRRITATION.
SKIN: MAY CAUSE SKIN SENSITIZATION.
INHALATION: MAY CAUSE IRRITATION TO RESPIRATORY TRACT.
INGESTION: LOW ORDER OF ACUTE ORAL TOXICITY.

STRONTIUM CHROMATE *** C A R C I N O G E N *** BY NTP AND IARC

HEXAVALENT CHROMIUM COMPOUNDS ARE ON THE LIST ENTITLED "CHEMICALS KNOWN BY THE STATE OF CALIFORNIA TO CAUSE CANCER".

EYES: NO DATA.
SKIN: IRRITANT. POSSIBLE PAINLESS PENETRATING ULCERS OF SKIN. SENSITIZATION IN SOME INDIVIDUALS.
INHALATION: MAY CAUSE MUCOUS MEMBRANE IRRITATION AND PENETRATING ULCERS OF THE NOSE, PERFORATION OF CARTILAGINOUS NASAL SEPTUM. JAUNDICE AND KIDNEY DAMAGE REPORTED.
INGESTION: NO DATA.

ISOPROPYL ALCOHOL

EYES: IRRITANT.
SKIN: IRRITANT.
INHALATION: MAY CAUSE NOSE AND THROAT IRRITATION. MAY CAUSE FLUSHING, HEADACHE, DIZZINESS, MENTAL DEPRESSION, NAUSEA, VOMITING, NARCOSIS ANESTHESIA AND COMA.
INGESTION: MAY CAUSE HEADACHE, DIZZINESS, MENTAL DEPRESSION, NAUSEA, VOMITING, NARCOSIS, ANESTHESIA AND COMA.

MAK

EYES: MAY CAUSE BURNING, TEARING AND REDDENING.
SKIN: PROLONGED EXPOSURE MAY CAUSE DRYING AND CRACKING OF SKIN. POSSIBLE DERMATITIES.
INHALATION: MAY CAUSE DIZZINESS, DROWSINESS AND FATIGUE.
INGESTION: MAY CAUSE DROWSINESS, DIZZINESS AND NAUSEA.

(cont.)

SECTION V - HEALTH HAZARD DATA (cont.)

-EFFECTS OF OVEREXPOSURE: (cont.)
-FIRST AID:
Eyes: Flush with water for 15 minutes. Get medical attention.
Skin: Wash with soap and water. Do not use solvents.
Remove contaminated clothing and wash before reuse.
If symptoms persist, get medical attention.
Inhalation: Remove to fresh air from exposure. Give artificial respiration or cardiopulmonary resuscitation (CPR) if breathing is difficult, get medical attention.
Ingestion: Get medical attention.

SECTION VI - REACTIVITY DATA

STABLITY: [ ] Unstable [x] Stable
HAZARDOUS POLYMERIZATION: [ ] May occur [x] Will not occur
-INCOMPATIBILITY
None recognized unless noted below.
-CONDITIONS TO AVOID:
None recognized unless noted below.
-HAZARDOUS DECOMPOSITION PRODUCTS:
Products of combustion are hazardous including carbon dioxide and carbon monoxide.

SECTION VII - SPILL OR LEAK PROCEDURES

-STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Protect from ignition. Wear air-supplied respirator for unventilated spill. Cover with absorbent material and scoop into container. Clean residue with a suitable solvent.
CERCLA RQ FOR MEK IS 5,000 LBS.
CERCLA RQ FOR TOLUENE IS 1,000 LBS.
CERCLA RQ FOR XYLENE IS 1,000 LBS.
CERCLA RQ FOR STRONTIUM CHROMATE IS 10 LBS.
-WASTE DISPOSAL METHOD:
When disposing of this material, ensure that it is packaged, stored, transported and otherwise managed in accordance with local, state and federal regulations.

SECTION VIII - SPECIAL PROTECTION INFORMATION:

-RESPIRATORY PROTECTION:
When spraying or applying in any circumstances likely to produce airborne level of hazardous ingredients in excess of TLV, use an organic vapor cartridge or air-supplied respirator.
-VENTILATION:
General ventilation to maintain vapors below TLV and PEL.
-PROTECTIVE GLOVES:
Solvent resistant gloves. During spray application, complete
(cont.)

SECTION VIII - SPECIAL PROTECTION INFORMATION: (cont.)

-PROTECTIVE GLOVES: (cont.)
skin protection is required.
-EYE PROTECTION:
Goggles or full-face shield.
-OTHER PROTECTIVE EQUIPMENT:
Avoid skin contact by use of other protective clothing. Safety shower, eye bath and washing facilities should be available.

SECTION IX - SPECIAL PRECAUTIONS

-PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING:
Keep container tightly closed. Isolate from heat, electrical equipment, sparks and flame. Do not store above 120 deg.F.
-OTHER INFORMATION :
Empty drums may contain explosive vapors. Do not cut, puncture or weld on or near drum.
Vapors of this product are heavier than air and may collect in low or confined areas.

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Vita

Captain David B. Novy graduated from Randolph-Macon Academy in Front Royal, Virginia, in May 1992. He entered undergraduate studies at the Illinois Institute of Technology in Chicago, Illinois, where he graduated with a Bachelor of Science degree in Civil Engineering in May 1996. He was commissioned a Second Lieutenant through Air Force Reserve Officer Training Corps Detachment 195 that same year.

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13. SUPPLEMENTARY NOTES

14. ABSTRACT

Spray painting operations using chromate-containing primer paints produce particles which may expose workers to strontium chromate. Chromate contains hexavalent chromium (Cr(VI)) which is a confirmed human carcinogen. It is suspected that the smaller particles contain disproportionately less Cr(VI) than larger particles. In order to determine if a bias in chromate content exists, paint particles were collected and separated based on particle size and the Cr(VI) concentration was determined. Aviation primer paint from the DeSoto and Deft companies was sprayed in a booth and seven-stage cascade impactors were used to separate particles. The particles were grouped into fourteen distinct bins based on size within an overall range of 0.7 to 34.1 μm mass median aerodynamic diameter. The total mass of dry paint collected in each bin was quantified and the paint was analyzed for Cr(VI) mass. The Cr(VI) mass (μg) was divided by the mass of dry paint (μg) collected to determine the percentage of Cr(VI) per mass of dry paint. Smaller particles contained significantly less Cr(VI) per mass of dry paint than larger particles. Paint sample particles smaller than 3 μm contained 1.2 % and 1.8 % Cr(VI) per mass of dry paint for DeSoto and Deft paints, respectively, which represents less than 30% of the Cr(VI) mass expected.

15. SUBJECT TERMS

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