

Guidelines for Controlling Health Hazards in Painting Operations

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December 2012



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CHAPTER 1 INTRODUCTION

1-1. PURPOSE. This technical guide—

a. Provides occupational health, environmental, and procedural information and guidance associated with controlling health hazards in painting operations within the Army. Special emphasis is provided on Chemical Agent Resistant Coating (CARC) and Water Dispersible Chemical Agent Resistant Coating (WDCARC).

b. Applies to the painting of tactical military materiel and their components. It does not apply to the painting of facilities or structures.

c. Implements the provisions of Army Regulation (AR) 40-5, and Department of the Army Pamphlet (DA Pam) 40-11. Additional information on paint systems and techniques for application and painting equipment is presented in Technical Manual (TM) 43-0139, Technical Bulletin (TB) 43-0242 and Military Detail Specification (MIL-DTL)-53072C.

1-2. REFERENCES. Required and related publications are listed in Appendix A.

1-3. EXPLANATION OF ABBREVIATIONS AND TERMS. Abbreviations and special terms used in this technical guide are explained in the glossary.

1-4. BACKGROUND.

a. The primary function of painting is to protect metal and other material against corrosion. Additional functions of painting are identification, camouflage, and enhanced visibility. Paint is composed of a pigment and a vehicle. The pigment, or solid component dispersed in paint, provides the color in the paint and allows a film to form on the surface of a material. The vehicle is the liquid portion of the paint which includes components such as binders, extenders, flow additives and volatile components known as thinners (solvents). The materials used in paint may be potentially hazardous to personnel and the environment. This document consolidates information on the paint systems used by the U.S. Army. It also provides guidance on the recognition, evaluation, and control of potential health and environmental hazards associated with specific operations.

b. Vehicles and equipment were traditionally painted with enamel and lacquer paint systems. These systems have been replaced with CARC. The CARC is a coating system that utilizes pretreatments, primers and topcoats designed to provide surfaces

that are easily and effectively decontaminated after exposure to liquid chemical agents and are superior in durability and service life to enamel and lacquer paints. Early formulations of CARC paint were solvent based and contained lead and hexavalent chromium. In response to more stringent health and environmental regulations, WDCARC paint was developed. The lead and chromium were removed and the levels of volatile organic compounds (VOCs) were reduced. Since WDCARC paint is thinned using de-ionized water, its VOCs and volatile organic emissions (VOEs) are substantially lower than conventional CARC paint. In addition it is more durable, while retaining the properties of agent resistance and signature reduction. A solvent-based CARC with lower VOC and VOE profiles is still available.

1-5. STANDARDS. In overseas workplaces, where the applicable Status of Forces Agreements specifically require that U.S. Forces comply with host country law, host country standards take precedence if stricter than U.S. requirements. If host country law is less stringent or nonexistent, Army requirements apply.

CHAPTER 2
RECOGNITION, EVALUATION, AND CONTROL OF POTENTIAL HEALTH AND
ENVIRONMENTAL HAZARDS ASSOCIATED WITH SPECIFIC OPERATIONS

2-1. SPRAY PAINTING (recognition).

a. Paint which is a mixture of solvents, pigments, and additives form aerosols, mists, and vapors during the spray operations. Some painting additives and pigments contain highly toxic materials such as hexamethylene diisocyanate (HDI) and toxic metals. Spray painting operations may present both health and physical hazards to the worker.

b. Potential health hazards may include exposure to solid and liquid aerosols as well as organic solvent vapors. Although the most common means of exposure is through inhalation, dermal adsorption of paint components can also occur. See Chapter 7 for more information on health hazards associated with painting operations.

c. Physical hazards include the following:

(1) Exposure to flammable/combustible liquids, aerosols, and vapors generated from the solvents within the paint creating a fire hazard.

(2) Pressure equipment used in painting operations may expose workers to the dangers associated with using compressed air systems including noise and flying debris. See Chapter 7 for more information on hazards associated with painting operations.

d. Worker exposure to excessive contaminant concentration may occur due to—

(1) Ventilation rates vary in spray booths or are inadequate.

(2) The potential for reduced air flow in and around equipment to be sprayed exists due to dead air pockets or low air flow.

(3) The worker is often positioned between the work and the ventilation exhaust.

(4) The worker does not properly use supplementary personal protective equipment (PPE) or the equipment is inadequate.

(5) Blow back associated with compressed air units bounces droplets into breathing areas.

e. Spray cabinets or conveyor-type booths do not present as great a potential for exposure because the worker is usually not located between the material painted and the source of exhaust ventilation.

f. When spray painting is conducted outdoors, the level and type of respiratory protection depends on air movement and whether or not the spraying is conducted in a confined space.

2-2. SPRAY PAINTING (evaluation and control).

a. The evaluation begins by observing the operation. Information on the material being used and the equipment being painted must be gathered, along with the material safety data sheets (MSDSs) to identify the contaminants being released during the operation.

(1) Statistically valid personal samples must be collected for contaminants generated, particularly for HDI, chromium VI (hexavalent chromium), lead, and organic solvents. Sampling methods to collect these contaminants should be chosen per Chapter 6.

(2) The sampling results determine the required types and level of respiratory protection and engineering controls. The PPE includes respirators to control inhalation hazards and may include boots, hard hats, eye, hand, and body protection. The specific pieces of PPE required will depend on the contaminant levels and length of time spent at the operation. There is more PPE discussed in Chapter 3.

b. The most common exposure control methods for spray paint operations is the use of spray paint booths or rooms. The acceptability of a paint booth or room is based on observing the operation, obtaining representative atmospheric sampling, and determining the physical parameters.

(1) Paint spray booths allow for the painting of a wide range of parts, equipment including vehicles. Booth sizes range from bench top units for small parts to walk-in booths for vehicles. For optimum performance, consideration must be given to selection, design, construction, location, use, and performance. Within a given booth the type of spray gun chosen will have a significant impact on the amount of overspray (amount of paint that is sprayed but not deposited on the painting surface) produced. High Volume, Low Pressure (HVLP) guns minimize overspray which reduces operational cost and contaminant air emissions.

(2) Inadequate ventilation (when compared with the requirements shown in

29 Code of Federal Regulations (CFR) 1910.94 Table G-10) will not require upgrade unless an exposure exceeding the appropriate standard has been documented. Therefore, sampling data is critical to documenting the hazard potential of a painting operation.

(3) For more information on physical parameters and evaluation methodology for spray booths or spray rooms see Appendix C.

c. Noise levels at or above 85 decibels, A-weighted scale (dBA) mandate enrollment in the Army's Hearing Conservation Program (DA PAM 40-501). Noise readings should be taken during the operations to determine exposure levels. Areas with noise levels at or above 85 dBA should be posted with appropriate signage. Common noise control methods used include enclosing the operation or the addition of acoustic shields between the worker and the noise source. An acoustic shield is most effective when its smaller dimension is at least three times the wavelength of the noise source. If these control methods fail to reduce noise to acceptable levels or are simply impractical (operation is not stationary), hearing protective devices, such as ear plugs or ear muffs, may be necessary.

2-3. POWDER COATING (recognition). Powder coating is similar to spray painting in many respects however the main difference is that powder coats do not require solvents to keep the binder and fillers in liquid suspension. The coating is applied electrostatically, and then heat cured in an oven. Hazards associated with powder coating operations include fire/explosions, electrical shock and heat. The electrostatic spray process is capable of producing significant static charges on un-grounded metal parts. Powder coatings are also flammable and can form explosive aerosols in the work area. Powder curing ovens run at temperature in excess of 200 degrees Celsius (°C).

2-4. POWDER COATING (evaluation and control).

a. The use of spray booths/rooms are the most common control method for spraying operations (see para 2-2). When spray booths and rooms are not used, control involves ensuring that:

(1) The concentration of dust in the air is between the lower and upper explosive limits. This can only be accomplished with adequate ventilation. Spray guns should be interlocked with the exhaust fans to ensure the guns do not operate when the fans are not running.

(2) Sources of ignition are not present, such as hot surfaces and electrical discharges or sparks. The most frequent ignition source is improperly grounded parts

on a paint line. Grounding hazards can be eliminated simply by ensuring all materials are properly grounded and routinely inspected.

b. Protection from excess heat involves wearing appropriate PPE such as heat resistant gloves and maintaining adequate water intake to prevent dehydration.

2-5. BRUSH OR ROLLER PAINTING (recognition). Brush or roller painting does not cause significant aerosolization of paint or primer constituents, and exposure to HDI or pigment contents should not occur. However, solvent concentrations are present in the air from vaporization. Solvent emissions from brush or roller painting will be less than spray painting since the materials are applied without additional thinning and usually less paint/solvent is used. Solvent exposures would be expected only in very confined spaces.

2-6. SPOT PAINTING (recognition). Although spot painting generally involves smaller total surface area of paint used, for vehicles it may be up to 25% of the total surface. For this reason, the same criteria will apply for the selection and use of PPE safety precautions as well as disposal procedures. For more specific information on spot painting, see TB 43-0242 *CARC Spot Painting*.

2-7. INDOOR OR OUTDOOR BRUSH AND ROLLER PAINTING (evaluation and control). The PPE and respiratory protection requirements are determined by the quantity of material being used and the location of the operation. For example, in confined spaces a supplied air respirator is required. In large open bays and outdoors the potential for overexposure is extremely remote and a lesser requirement for a respirator may exist.

2-8. DRYING (recognition). Solvents are released during the drying or curing process. The vapor concentrations measured at many paint operations indicate that levels are usually well below current health standards. However, the solvent vapors are typically irritating to the eyes and have low odor thresholds. Drying painted items in an occupied, unventilated space may cause solvent overexposure. After drying, there is no hazard from the solvents.

2-9. DRYING (evaluation and control).

a. Since ventilation in drying areas is usually very poor, sampling must be performed to determine the air concentrations of the solvents when personnel are working in these areas.

b. The HDI in the polyurethane paint does not present a health hazard after the paint has cured, unless exposed to heat sufficient for thermal decomposition of the coating.

2-10. GRINDING AND SANDING (recognition). The hazards associated with grinding and sanding include:

a. Hazardous concentrations of lead, cadmium, zinc, copper, tin, and chromium VI dusts from primers, paints, and plated metal fasteners and brackets. Toxic metals such as zinc, beryllium, chromium, and nickel are used as alloys in base metals.

b. Grinding and sanding operations can generate significant amounts of noise.

c. Eye hazards associated sparks and flying debris.

2-11. GRINDING AND SANDING (evaluation and control).

a. Grinding operations utilize organic bonded wheels or other shapes rotating at a high rate of speed to smooth a surface. Grinding and sanding operations produce a significant amount of dust. During grinding, the particles generated leave the work surface at a high rate of speed. This is important in terms of designing control measures to capture the particles. Local ventilation is the preferred method of control. The hood used to capture the particles should enclose the operation as much as possible and be positioned to take advantage of the speed and direction of the particles as they leave the work surface. Minimum capture velocities (minimum air velocity of the ventilation to capture the contaminant) for particulates is 3500 to 4500 feet per minute (fpm) is much higher than vapors and gases which is usually 100-200 fpm. For more detailed information on grinding/sanding ventilation system design see the latest edition of ACGIH® Industrial Ventilation A Manual of Recommended Practice. (ACGIH® is a registered trademark of the American Conference of Governmental Industrial Hygienists.)

b. Atmospheric sampling of particulates should be conducted to determine exposure levels. Respirators fitted with High efficiency purifying air (HEPA) filters should be used when grinding or sanding on painted equipment.

c. The potential for eye injuries exists during these operations and protective eyewear should be worn. The area should be posted as an eye hazardous area.

d. See paragraph 2-2c for Noise control methods.

2-12. WELDING AND CUTTING (recognition). There are numerous hazards associated with welding and cutting operations of painted surfaces. They include:

a. Metal fumes are produced when heated vaporized metal begins to cool then condenses into ultra small particles.

b. Toxic gases include carbon monoxide, as poisonous gas formed by incomplete combustion, nitrogen oxides and ozone produced by the ultraviolet (UV) light of arc welding, and phosgene which is formed through decomposition of chlorinated hydrocarbon solvents.

c. Radiant energy in the form of UV light is generated by the electric arc during the welding process.

d. Noise is a common hazard in welding and cutting operations. High noise levels can be generated from both the process and the associated equipment. Processes such as air-carbon arc cutting, gouging and plasma arc cutting, and gouging are associated with high noise levels. Equipment such as combustion engine generators can produce high noise levels.

e. Electrical hazards-contact with energized metal parts can cause injury or death either from the initial shock or a fall resulting from reaction to the shock. The shock associated with arc welding may be classified into two categories:

(1) Primary voltage shock (230-460 volts). Primary voltage shock results from touching a lead inside the welding power source while part of your body is also touching the welder case or other grounded metal. Turning the power off does not turn power off inside the case.

(2) Secondary voltage shock (60-100 volts). Secondary shock comes from touching part of the welding circuit while at the same time touching the grounded metal work piece.

2-13. WELDING AND CUTTING (evaluation and control). When welding or cutting painted surfaces, sand or grind down to the bare metal an area 4 inches on either side of where the heat is applied. If a painted surface is on the other side of the weld spot, it must also be removed. Welding and cutting on CARC-coated metal is prohibited because significant quantities of isocyanate may be released, unless the coatings have been removed down to bare metal.

a. For metal fumes and toxic gases the nature and extent of the hazard depends upon the types of coatings used, type of welding to be performed, the composition of

the metals welded, and the welding rods used, work practices (i.e. position of welders head during welding), size and shape of the workplace, number of operations, duration and frequency of welding required, types and effectiveness of ventilation or PPE currently being utilized. In order to determine which control methods are most appropriate, a risk assessment can be performed. This may include conducting work place air sampling to determine whether or not occupational exposure levels are being exceeded.

(1) Control methods may include substitution of harmful materials with less dangerous ones (less harmful coating materials may not eliminate the need for welding, however it can reduce exposure to toxic chemicals), changing the work procedures or processes(s) to reduce the hazardous exposure(s), installation of engineering controls such as ventilation or use of PPE.

(2) Adequate ventilation may be obtained naturally mechanically or a combination of both. It is determined by:

- (a) The size and layout of the work area.
- (b) The number and type of operations performed.
- (c) The natural airflow in the welding area.
- (d) Location of welder breathing zones with respect to the source.

(3) The Occupational Safety and Health Administration (OSHA) has stipulated certain requirements that must be met to determine if natural ventilation may be sufficient (otherwise mechanical ventilation will be required):

- (a) A space of at least 10,000 ft² per welder.
- (b) A ceiling height of at least 16 feet.
- (c) The welding is not done in a confined space.

(d) The welding space does not contain partitions, balconies, or structured barriers that obstruct cross ventilation.

(4) Mechanical ventilation may be either general or local. General or dilution ventilation is used when the contaminants in question have low toxicity levels and there is good air mixing within the work place. In addition, general ventilation is sometimes used to supplement local ventilation. Local ventilation pulls the

contaminant away from the worker at the source and is the preferred method to use. Air sampling must be conducted to verify toxic gas/fume exposure levels. OSHA also requires respiratory protection in addition to ventilation when cutting/welding certain compounds. (See OSHA 29 CFR 1910.252, *Welding, Cutting and Brazing*.)

b. Control radiant energy is achieved through use of PPE such as a welding helmet with filter plate and safety glasses with side shields. Specific shade numbers are designed for several types of welding processes. For more information consult American National Standards Institute (ANSI) Z87.1 *Practice for Occupational and Educational Eye and Face Protection* or OSHA 1926.102 *Eye & Face Protection*. Note: Welding curtains are designed to protect personnel in the general work area from incidental exposure. Additional protection, such as clothing (i.e., leather garments and gloves), are used to shield against infrared radiation and sparks.

c. See paragraph 2-2c for noise control methods.

d. To minimize the hazards associated with electrical shock:

(1) Train personnel involved with welding operations.

(2) Have all installation, operation, maintenance, and repair work performed by qualified personnel.

(3) Frequently inspect cords for damage or bare wiring, replace cord immediately if damaged.

(4) Wear dry, hole-free, insulating gloves in good condition and protective clothing. Do not touch the electrode with a bare hand.

(5) Use fully insulated electrode holders. Never dip the holder into water to cool it or lay it down on conductive surfaces or the work surface.

(6) Do not allow the electrode holder or electrode to come in contact with any other person or any grounded object.

(7) Do not use worn, damaged, undersized, or poorly spliced cables, welding gun cables, or touch cables. Make sure all connections are tight, clean, and dry.

(8) Do not touch an energized electrode while you are in contact with the work circuit. (See Safety and Health Factsheet No. 5, *American Welding Society*).

2-14. MIXING (recognition).

a. All material which is sprayed must be thinned to achieve the correct viscosity and the two component coatings require a waiting period before use. This is usually done in a separate area. In addition, this area is usually used to store painting materials.

b. Accurate mixing of two component coatings, according to instructions provided with each kit, is crucial since sufficient amounts of material cause chemical polymerization to occur. Graduated containers should be used when mixing small amounts from each component. All mixing containers must be dry and clean. In addition to the operational problems caused by dirty mixing containers or improper mixing proportions, the presence of unreacted Component A or B may present a health hazard to personnel. Unreacted polyurethane paints may result in higher than normal isocyanate concentrations and uncured epoxy resins are known to be strong irritants.

2-15. MIXING (evaluation and control).

a. Mixing must be conducted in a well ventilated mixing room or spraying area away from open flames, welding torches, and combustion heaters. Personnel doing the mixing should wear eye protection (i.e., splash goggles or face shield) and clothes providing full skin coverage, especially appropriate gloves.

b. Since some of the materials used to thin paints are classified as class I fire hazard liquids and they will be dispensed in the mixing room, mechanical ventilation is required. The ventilation system must provide at least 1 cubic foot per minute of exhaust per square foot of floor area, but not less than 150 cubic feet per minute. Refer to the National Fire Protection Association (NFPA) Code 33, listed in Appendix A. The electrical wiring and equipment located in the room must meet class I division 2, requirements of NFPA Code 70.

2-16. OTHER CONSIDERATIONS. Removal of paint by burning is prohibited since toxic gases and vapors will be produced. When chemical paint removers are used, a health hazard may exist since many of these chemicals contain volatile solvents or other materials. Methylene chloride is a constituent of many chemical paint removers.

CHAPTER 3 NONSPECIFIC HAZARDS AND CONTROL METHODS

3-1. CONFINED SPACES.

a. A confined space occurs when airflow is restricted inside a spray booth or outside of a building, e.g. painting the inside of a vehicle. See Appendix D for specific guidelines.

b. Spray painting in confined spaces typically results in excessive atmospheric concentrations of HDI, metals, chromates, and solvents depending on the materials' composition. Therefore, a National Institute for Occupational Safety and Health (NIOSH) approved supplied air (airline) respirator is required.

3-2. PERSONAL PROTECTIVE EQUIPMENT.

a. Respiratory Protection. When respiratory protection is required, only NIOSH approved respirators will be used. The respirator furnished will provide adequate respiratory protection against the particular hazard for which it is designed (see AR 11-34 and/or OSHA 29 CFR 1910.134). Appendix E discusses the respiratory protection requirements in all painting operations.

b. Personal Protective Equipment (other than respiratory protective equipment).

(1) The PPE used in conjunction with the respiratory protection equipment includes cloth coveralls, eye protection, gloves, and head coverings. Gloves must be chosen for the paint solvents used. The glove selection process usually involves choosing a glove that provides sufficient protection for the material being used while at the same time having enough manual dexterity to comfortably perform the task. Most glove manufacturer websites have information on glove material compatibility to make selection easier. When selecting eye protection, full face shields are recommended for operations that may involve splashing liquids as they provide more protection than safety glasses or goggles alone. Always check with your supervisor if you are unsure of what PPE is appropriate for the task.

(2) Spot painters applying paint by brush or roller must wear clothing and gloves affording full skin coverage.

(3) Persons who clean mixing and painting accessories should wear eye protection to protect the eyes and chemical-resistant gloves to prevent skin damage on the hands from splash and preclude solvent absorption and caused by the thinner.

(4) Wearing contact lenses during painting operations is prohibited.

c. Barrier Creams. Barrier creams may be used; however, the usefulness in preventing the absorption of solvent through the skin is not documented. If a solvent with a skin notation in the exposure standard is being used, then impervious gloves must be used. If a barrier cream is used, it must also be applied to clean skin at the start of the work shift, removed at breaks and lunch, and reapplied before returning to work. Remove the barrier cream at the end of the shift. Barrier creams are useful in preventing paint from adhering to the skin and in combating the "dryness" associated with the defatting action of most solvents. Paint solvents should never be used to remove paint/coating from the skin.

3-3. WORK PRACTICES.

a. Work clothing should be provided when performing spray painting operations. Brush or roller application may be performed in the Army field uniform. After completing spray painting or sanding operations, showers should be taken prior to changing into street clothing. All clothing worn during sanding and grinding operations must be laundered at work or sent to a commercial laundry for cleaning.

b. When the paints being sprayed contain lead or chromates, special laundry procedures for work clothing must be followed when an exposure above the permissible exposure limit (PEL) occurs (29 CFR 1910.1025).

3-4. LEGAL REQUIREMENTS. Depending on the concentration of solvents and pigments in the workroom air, added measures such as specific PPE or work practices may be required by federal laws.

CHAPTER 4 HAZARD COMMUNICATIONS

4-1. MATERIAL SAFETY DATA SHEETS.

a. The contractual acquisition of a material safety data sheet (MSDS) is accomplished through the use of Federal Acquisition Regulation clause 52.223-3. This requirement applies to materials with national stock numbers (NSNs) and locally purchased items. The MSDSs for NSN items can be extracted from the Hazardous Materials Information System (NMIS) (see AR 700-141). The solvent composition and pigment composition may vary in each product although all conform to the same specification. An MSDS is appropriate only for a single shipment or batch of material. Because of the variations allowed, the MSDS must be reviewed for each shipment procured on a single purchase order.

b. The MSDS is an integral part of 29 CFR 1910.1200, OSHA's hazard communication standard or "Right to Know" law. The MSDSs are designed to provide workers with the necessary information to protect themselves from hazardous chemical exposures. By law, MSDSs are required for all dangerous chemicals used in the workplace. They must be accessible to all employees. The MSDSs contain information such as a list the hazardous ingredients of the product as well as its physical and chemical properties (i.e. flammability, poison), health effects, handling precautions and other chemicals in which the product can adversely react. It should assist management by directing attention to the need for specific control engineering, work practices, and protective measures to ensure safe handling and use of the material. It will aid the safety and health staff to plan a safe and healthful work environment and suggest appropriate emergency procedures and sources of help in the event of harmful exposure of workers. Other requirements of the hazard communication standard include employee training and labeling of containers. For more information regarding requirements of the hazard communication standard see CFR 29 190.1200 and AR 700-141.

4-2. WARNING LABELS. The specifications require warning labels on products which contain lead or chromium VI.

CHAPTER 5 OCCUPATIONAL AND ENVIRONMENTAL STANDARDS

5-1. ISOCYANATES

a. The most common isocyanate monomer found in aliphatic polyurethane paint is HDI and is the ingredient which has generated the majority of concern. This is because isocyanates, in general, are known to be sensitizers and irritants. The HDI is present in the uncured polyurethane paint coating and may be released during thermal decomposition of cured polyurethane paint coatings.

b. The OSHA has no established PEL values for HDI. The NIOSH has a time-weighted average (TWA) concentration of 0.005 parts per million (ppm) (.035 milligram per meter cubed (mg/m^3)) for HDI.

c. Prepolymers of HDI (also called oligomeric HDI) are present in high concentrations in all CARC formulations. There are no OSHA PELs or ACGIH TLV[®]-TWAs for these compounds but the state of Oregon has published an 8-hour PEL of 0.5 mg/m^3 and a ceiling concentration of 1.0 mg/m^3 for prepolymers of HDI. (TLV[®] is a registered trademark of the ACGIH.)

5-2. SOLVENTS. All paints, primers, and thinners contain organic solvents. In addition, spray operations require thinning with organic solvents to achieve the desired viscosity. Organic solvents are also used to clean up painting equipment and to clean the substrate prior to painting. The solvent composition and percentages for the paints, primers, and thinners vary. However, TLVs or PELs have been established for the solvents such as toluene, xylene, and MEK used in these materials. Per AR 40-5 and DA PAM 40-11, the Army will comply with the more stringent of the TLV or PEL provisions. Some solvents used in newer CARC formulations may not have TLVs or PELs. There are manufacture recommended Occupational Exposure Limits (OELs) or American Industrial Hygiene Association (AIHA) Workplace Environmental Exposure Limits (WEELs) available for some of these compounds.

5-3. LEAD. Pigments used in the paints and primers may contain lead. An OSHA PEL of 0.05 mg/m^3 has been established for lead.

5-4. CHROMIUM VI (HEXAVALENT CHROMIUM). Paints, primers, and primer washes may contain water insoluble chromium VI compounds. These substances have an OSHA PEL of 0.005 mg/m^3 , as chromium, and are recognized as having carcinogenic or cocarcinogenic potential.

5-5. OTHER METALS. Metals present in the pigments must be determined by using the MSDS and/or the analyses. References should be checked to establish appropriate exposure limits.

5-6. ADDITIVE PROPERTIES. When similar chemical compounds are encountered which elicit similar physiological reactions, the additive effects must be considered. Procedures for establishing standards for these compounds are contained in the ACGIH TLV Booklet and the OSHA Standards (29 CFR 1910.1000).

5-7. STATE AND LOCAL AIR POLLUTION REGULATIONS.

a. Many state and local air pollution control agencies have regulations governing the design and operation of paint spray booths. Many states require permits for the installation of new spray paint booths and the modification of existing booths. Implementing CARC painting operations in an existing booth may constitute a process modification and thereby require issuance of a permit or revision to the existing permit. Numerous states are also in the process of developing an air toxics program which may impact on CARC painting operations due to the HDI constituent in the CARC formulations. Also, certain types of solvents and heavy metals (i.e., lead and chromium) may also be regulated under specific state air toxics regulations. Specific air pollution requirements or permit conditions may be obtained through the installation environmental coordinator. This individual is usually located within the Directorate of Engineering and Housing.

b. Spray painting operations are also regulated in many states by local or state air pollution control agencies. In locations designated as nonattainment areas for ozone, restrictions are often imposed on the amounts of VOCs that may be exhausted to the atmosphere. This may affect the types and amounts of thinners and solvents used during painting operations. Any restrictions or limitations for spray painting operations are typically listed in that source's air pollution operating permit. Coordination should be made with the installation environmental coordinator to verify the permit requirements.

CHAPTER 6 SAMPLING

6-1. SAMPLING STRATEGIES. The sampling strategy developed should account for all possible spray painting activities within the booths.

a. The sampling is done during the painting of different vehicles and equipment, when the booths' filters are clean and dirty, when changes or modifications occur in or to the booths, and for each painter.

b. The documentation should be revalidated biennially if the initial sampling results are below one-half of the standard and, semiannually, if greater than one-half of the standard.

c. Additional monitoring is required whenever there has been a production, process, control, or personnel change or whenever there is any other reason to suspect a change that may result in new or additional exposures.

6-2. COLLECTING SAMPLES.

a. Methods of collecting samples for potentially hazardous paint, primer, and solvent components are presented in U.S. Army Public Health Command (USAPHC) Technical Guide (TG) No. 141. Personal sampling is the preferred method for determining personal exposures that can be compared to the published occupational exposure limits. Personal sampling results can also be used to determine or validate appropriate levels of PPE, as well as justify a reduction in the level of PPE if indicated. Area samples should be used to determine the effectiveness of control measures or locate problem areas.

b. The USAPHC TG No. 141 also—

(1) Contains procedures for submitting air samples.

(2) Identifies laboratories performing the analyses. When more than one analysis on a collected sample is desired, the laboratory performing the analysis should be contacted to verify the validity of the sampling method.

(3) Is available on the web at the U.S. Public Health Command Library: <http://phc.amedd.army.mil/Pages/Library.aspx>, and the following direct link: <http://phc.amedd.army.mil/PHC%20Resource%20Library/TG%20141%20Industrial%20Hygiene%20Sampling%20Guide.pdf>

CHAPTER 7

HEALTH EFFECTS FROM HAZARDS FOUND IN PAINT OPERATIONS

7-1. GENERAL. Retrospective epidemiologic studies of painters have demonstrated an increased incidence of neurobehavioral symptoms. However, there is poor evidence of objective neurophysiologic deterioration as measured by behavioral testing, nerve conduction testing, and physical examination findings. Other case-control studies have suggested an increased risk of lung, laryngeal, and esophageal cancers in painters. Painters are exposed to a wide variety of chemicals which can affect specific organ systems or present generalized toxicity. Additionally, painters perform a wide variety of tasks which may increase the risk of exposure to these chemical substances.

7-2. HEALTH HAZARDS.

a. Solvents. A wide variety of solvents (including ethyl acetate, toluene, xylene, MEK, 2-ethoxyethyl acetate, N-Methyl-2-pyrrolidone (NMP), and 1-Chloro-4-(trifluoromethyl) benzene (PCBTF)) are encountered in painting operations. They are generally well-absorbed through the skin and respiratory epithelium. The central nervous system and peripheral nervous system are commonly affected by these compounds. The gastrointestinal, respiratory, hepatic, renal, and hematopoietic systems may also be adversely affected by solvents, depending on the specific type of compound. Solvents act as defatting agents, which may lead to fissuring and reddening of the skin. Misuse of solvents to clean the skin is often implicated in causing dermatitis in painters. Solvent vapors may produce eye irritation. Inhalation of solvent vapors may produce acute effects such as dizziness, nausea, headache, narcosis, or unconsciousness. Solvents are thought to be the agents responsible for the production of neurobehavioral symptoms (such as numbness or tingling in the hands, irritability, depression, or an inability to concentrate) seen in chronically exposed painters. Cellosolve acetate (2-ethoxyethyl acetate), which may be a constituent in CARC will also produce mucous membrane and skin irritation.

b. Isocyanate. The HDI is a constituent in CARC and has been associated with the respiratory effects seen during and after the application of this material. The HDI is highly irritating to the skin and mucous membranes-producing itching and reddening of the skin, a burning sensation of the throat and nose, and watering of the eyes. In sufficient concentrations, HDI may cause acute pulmonary symptoms to include cough, shortness of breath, pain on respiration, increased sputum production, and chest tightness. In a small percentage of the workforce, it may produce asthmatic symptoms through an allergic, Immunoglobulin E-mediated mechanism. The following allergic symptoms may be present: coughing, wheezing, tightness in the chest, or shortness of

breath. This allergic reaction may occur a few days or months after initial exposure to HDI and can occur at atmospheric concentrations lower than those which produce HDI's irritant effects. Sensitive individuals may exhibit a decrease in forced expiratory volume in 1 second (FEV₁,) on pulmonary function testing after being exposed during the work shift, as compared to pre-shift values. A longitudinal study of workers exposed to an analogous compound, toluene diisocyanate, suggests that low level, chronic exposures may result in an increased decrement in pulmonary function, compared to the general population. The HDI may be generated and released during thermal decomposition of CARC.

c. Metals.

(1) Lead exposure usually occurs as a result of aerosolization of lead-based paint, grinding or sanding of painted areas, or welding of unprepared surfaces resulting in the production of lead fumes. Lead has been associated with interference of the heme synthesis pathway, resulting in anemia. Additionally, lead exposure may be associated with abdominal cramping (colic), kidney disease, peripheral nervous system disease, and neuropsychiatric disturbances. Lead can cause adverse reproductive effects in men and women. Short-term, high exposures to lead can result in acute encephalopathy progressing to seizures, coma, and death.

(2) Chromium VI (hexavalent chromium), a component in some paint pigments, is similar to lead in that processes such as aerosolization, grinding, or burning of chromium VI-based paint can increase the risk for exposure. Chromium VI has been associated with penetrating lesions of the skin and nasal septum, dermatitis, and inflammation of the larynx and liver. Chromium VI, as chromate, is a carcinogen producing primarily bronchiogenic carcinomas in exposed workers.

(3) Cadmium, used for corrosion control, is electroplated onto fasteners (nuts and bolts) and brackets. Cadmium can be found in some paint coatings. It is a skin/eye irritant and sensitizer. Acute exposure by ingestion leads to nausea, vomiting, abdominal cramps and diarrhea. Acute poisoning from inhalation may lead to severe bronchial and pulmonary irritation. Cadmium is classified as a suspect human carcinogen.

(4) Beryllium used in metal alloys. The most common route of exposure is from inhalation from sanding or grinding operations. It is insoluble and thus it is not associated with acute effects. Chronic exposure to airborne particulates may lead to a serious condition known as chronic berylliosis. Beryllium is classified as a known carcinogen.

(5) Zinc exposure is derived from welding operations involving galvanized metal. Inhalation of metal fumes containing zinc oxide may cause a condition known as “metal fume fever”. Metal fume fever is characterized by high fever, chills, sweating as well as a metallic taste in the mouth

d. Gases.

(1) Carbon monoxide is a poisonous gas. It is odorless, colorless, and not easily detected. It interferes with respiration by competing for hemoglobin in the blood. High levels can lead to a condition known as “hypoxia” in which there is an inadequate supply of oxygen to the tissues. Carbon monoxide is generated by incomplete combustion. A primary concern for potential carbon monoxide exposure in painting operations comes from the use of oil-lubricated air compressors to supply breathing air. OSHA requires that all breathing air supplied by oil lubricated air compressors have integrated high temperature and/or carbon monoxide alarms (Title 29 CFR 1910.134, *Respiratory Protection*).

(2) Phosgene is highly toxic and a strong irritant reacts with moisture to form hydrochloric acid. Symptoms include severe lung irritation and pulmonary edema (filling of lungs with fluid). Phosgene is formed when metals that have been cleaned with chlorinated hydrocarbon solvents are heated to the high temperatures associated with welding.

(3) Nitrogen oxides, formed during arc welding, are eye, nose, throat, and mucus membrane irritant. High concentrations can result in pulmonary edema.

(4) Ozone is a colorless, odorless highly reactive gas. It is toxic by inhalation, a strong irritant, and a fire and explosion risk, making it a health and physical hazard. It is formed when UV light is exposed to an electrical current.

7-3. PHYSICAL HAZARDS.

a. Flammable material. Improper use and storage of flammable materials such as solvents used to thin paint can create fire and explosion hazards. Inadequately ventilated work spaces particularly in confined spaces could allow flammable materials to reach the Lower Explosive Limit (LEL). The LEL is the lowest concentration (percentage) of a gas or vapor in air capable of producing a flash of fire in presence of an ignition source (arc, flame, heat). Concentrations lower than LEL are 'too lean' to burn.

b. Electrical. Electric shock can result in death or severe injury, including burns. Accidents usually occur from careless use or improperly installed or grounded equipment.

c. Noise. In addition to temporary and permanent hearing loss effects of overexposure to noise include nervousness, nausea, headache, hypertension, sleep disturbance, anxiety, emotional instability.

d. Ultraviolet radiation. Overexposure to UV radiation can result in skin damage and a condition known as “welders flash” caused by burning of the retina.

e. Infrared radiation. Overexposure to infrared radiation can result in thermal burns.

f. Compressed air. Dangers associated with compressed air systems include damage to eyes from flying debris and explosion hazards from ruptured compressed air storage systems. Airless spray paint guns have produced injection injuries of the hand. Paint injected into the hand may initially appear innocuous, but may progress to ischemia or chemical or thermal burns. Solvents may be injected in sufficient quantities to cause systemic symptoms. All personnel with injection injuries will be referred for surgical consultation to minimize the possibility of infection, gangrene, and disability. Compressed air should not be used for general cleaning because it may generate hazardous airborne dust. Potentially hazardous dust (such as paint dust) should be cleaned using wet methods or HEPA-filtered vacuum cleaners.

CHAPTER 8 WASTE MANAGEMENT

8-1. BACKGROUND. On 21 October 1976, the President signed into law the Resource Conservation and Recovery Act (RCRA) which directed the U.S. Environmental Protection Agency (EPA) to develop and implement regulations for the "cradle-to-grave" management of hazardous waste (HW). Since the RCRA's enactment in 1976 and subsequent reauthorization in 1984, the EPA has promulgated an enormous volume of regulations which govern all aspects of HW management including generation, transportation, treatment, storage, recycling, and ultimate disposal. Also, many state environmental regulatory agencies have promulgated HW regulations which are more stringent than the Federal regulations.

8-2. WASTE STREAMS.

a. Painting operations, regardless of the types of paints used, typically generate one or more waste streams which are subject to regulation as HW under the RCRA. These waste streams include, but are not limited to the following:

- (1) Excess or unserviceable paints, paint components, and paint thinners.
- (2) Spent paint thinners and paint stripping solvents.
- (3) Paint-contaminated blasting media.
- (4) Paint-impregnated paper filter elements from paint booth air filtration systems.
- (5) Paint-contaminated water and sludge from paint booth waterfall air filtration systems.
- (7) Paint-contaminated strippable coatings from interior paint booth surfaces.
- (8) Empty paint, paint component, and solvent containers.

b. Whether any of these waste streams would be defined as regulated waste (RW) and thus subject to regulation under the RCRA is dependent on the following two factors:

(1) The waste may be among those specifically listed as an HW by the EPA. For example, unserviceable 1,1,1-trichloroethane is a listed HW (EPA HW number U226); or

(2) The waste may exhibit one or more of the four characteristics of HW as defined in the RCRA regulations (i.e., ignitability, corrosivity, reactivity, and Extraction Procedure (EP) toxicity (heavy metals)). For example, paint-impregnated paper filter elements may exhibit the characteristic of EP toxicity (lead and/or chromium) if the paints they are impregnated with contained lead and/or chromium in their pigment formulations. Knowledge of the paint formulation and/or actual analytical testing of filter elements would be required before this type of determination could be made.

c. There are other factors which must be considered when determining if a particular painting waste stream is subject to regulation as an HW. For instance, many wastes are specifically excluded from regulation under the RCRA. For example, containers which held certain HWs are exempt from regulation if they meet the regulatory definition of empty (e.g. containers less than 1 inch of residue or less than 3% residue by weight). Also, certain HWs are exempt from regulation if they are recycled in a specific manner. For example, off-specification 1,1,1-trichloroethane is not subject to regulation as an HW if it is returned to the manufacturer for regeneration.

8-3. MANAGING THE WASTE. The characterization and management of wastes under the RCRA is a complex issue. On DA installations, the installation environmental coordinator is normally assigned the responsibility for ensuring that RCRA issues are adequately addressed. The environmental coordinator acts on behalf of the installation commander who, under provision of AR 420-47, is ultimately responsible for the management of HW on the installation. Therefore, before taking steps to manage any painting waste stream, the installation environmental coordinator must be notified. The environmental coordinator will be able to evaluate each waste stream to determine if it is an HW and will know which regulations, if any, apply.

8-4. TECHNICAL ASSISTANCE. Additional technical assistance and guidance on the proper management of painting wastes may be obtained from the Commander, U.S. Army Public Health Command, Waste Disposal Engineering Division, Aberdeen Proving Ground, MD 21010-5422, DSN: 584-3651.

APPENDIX A

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APPENDIX B
GENERAL DESCRIPTION

B-1. ENAMEL PAINTS.

a. General. Prior to the introduction of CARC, the standard surface treatment for equipment and vehicles was synthetic alkyd enamel paint.

b. Thinners. The enamel must be thinned for various temperature and humidity conditions.

(1) When the temperature is between 30 degrees Fahrenheit (°F) and 60 °F, xylene (A-A-59760) is used to obtain the correct viscosity.

(2) When the temperature is between 60 °F and 80 °F, mineral spirits (MIL-PRF-680) are used to obtain the correct viscosity.

(3) When the temperature is above 80 °F, butyl cellosolve is added to the mineral spirits thinner in varying proportions depending on the relative humidity.

c. Primers. All metallic surfaces should be primed before painting.

(1) Ferrous metal surfaces are primed with primer meeting SSPC Paint 25.

(2) Aluminum is primed with primer meeting TT-P-1757, MIL DTL-53022 or MIL DTL- 53030, when either olive drab or white enamel is used.

d. Application.

(1) Olive drab ferrous metal surfaces are painted with enamel meeting Master Painters Institute, Reference #8, Exterior Alkyd, Flat, MPI Gloss Level 1; Reference #9, Exterior Alkyd Enamel, Gloss, MPI Gloss Level 6; Reference #47, Interior Alkyd, Semi-Gloss, MPI Gloss Level 5; Reference #48, Interior Alkyd, Gloss, MPI Gloss Level 6; Reference #49, Interior Alkyd, Flat, MPI Gloss Level 1; Reference #51, Interior Alkyd, Eggshell, MPI Gloss Level 3; or Reference #94, Exterior Alkyd, Semi-Gloss, MPI Gloss Level 5. Ferrous metal which is painted white must use enamel meeting Master Painter's Institute, Reference #9, Alkyd, Exterior Gloss, (MPI Gloss Level 6) and Reference #94. Alkyd, Exterior Gloss, (MPI Gloss Level 5).

(2) The olive drab enamel and white enamel used on aluminum metal must meet the same specifications as the enamels used on ferrous metals.

(3) Fiberglass is painted using the same materials that are used to paint ferrous metals.

B-2. LACQUERS.

a. Paints. Lacquers are finish materials that dry by evaporation of the volatile portion only. They deposit a film that is generally thinner than the film provided by other paints.

b. Thinners. Lacquer thinner (A-A-59760) is used for reducing the viscosity of the lacquers to spraying consistency. When high humidity conditions exist, use cellulose nitrate dope and lacquer thinners (A-A-857).

c. Primers. When ferrous metal or aluminum is painted with lacquer, use lusterless alkyd enamel (MIL-DTL-11195, type II) coating as a primer and a top coat.

d. Application. Lusterless alkyd enamel (MIL-DTL-11195) may be used on ammunition and other metals.

B-3. CARC. The application of CARC paint involves four separate steps, each of which must be completed. The steps are cleaning, pretreatment, priming and top coating. Meticulous cleaning prior to pretreatment and painting operations is critical. Applying CARC to bare metal or improperly cleaned surfaces interfere with paint adhesion, resulting in premature paint peeling during service. Use (MIL-DTL-53072D) as a guide for surface preparation of various surfaces.

B-4. METAL PREPARATION. Meticulous cleaning prior to pretreatment and painting operations is critical. Improperly cleaned surfaces interfere with paint adhesion, resulting in premature paint peeling during service. Use (MIL-DTL-53072) as a guide for surface preparation of various surfaces.

APPENDIX C
PAINT BOOTH VENTILATION PROTOCOL

C-1. PURPOSE. This protocol provides information on how to perform ventilation measurements in paint booths, including small, large, and drive-through designs.

C-2. VENTILATION CRITERIA.

Table C-1. ACGIH Criteria

SMALL BOOTH	Recommended Q (cfm/ft²)	
	Airless Spray	Air Spray
Face Area ≤ 4ft.	125	200
Face Area 4 >ft.	100	150

LARGE BOOTH	Recommended Q (cfm/ft²)	
	Airless Spray	Air Spray
Walk-In Booth	60	100
Operator Outside of Booth	60-100	100-150

DRIVE-THROUGH BOOTH Horizontal Flow	Recommended Q (cfm/ft²)	
	Width x Height ≤ 150 ft²	Width x Height > 150 ft²
Air Spray	100	50
Airless Spray/HPLV	60	50

DRIVE-THROUGH BOOTH Downdraft	Recommended Q (cfm/ft²)	
	At 5' Above Floor	
	100-125	

NOTES: (1) Exhaust Duct Velocity minimum = 2000 feet per minute (fpm)
 (2) Face Velocities
 HVLP = High volume low pressure

Table C-2. OSHA Requirements (Dry Systems)

Operating Conditions	Crossdrafts, fpm	Minimum Velocity, fpm
Air Spray	Up to 50	100
Air Spray	Up to 100	125
Electrostatic	Negligible	60

- a. Visual Observation Inside Large Booths (Smoke Testing).
 - (1) Limited cross drafts or turbulence inside of the booth.
 - (2) Uniform airflow from the supply air to the exhaust air plenums.

C-3. EVALUATION METHODOLOGIES. The ACGIH recommends that every ventilation system be tested at the time of initial installation to verify the volumetric flow rate(s) and to obtain other information which can be compared with the original design data. The Army recommends that ventilation systems be evaluated annually and measurements be compared to initial tests to verify system performance. The following methodologies are suggested for spray paint booth evaluations. Details of these procedures are found in the corresponding sections.

- a. Visual Inspection Checklist for the Exhaust System – see Section A.
- b. Measuring the Exhaust Duct Velocity (Pitot Traverse) – see Section B.
- c. Visual check for Air Flow Patterns – see Section C.
- d. Measuring Face Velocities – see Section D.
- e. Measuring Pressure Differential of Spray Paint Booth – see Section E.

C-4. TYPICAL VENTILATION FORMULA.

Q = Volumetric Airflow (cubic feet / minute = cfm) or (liters / second = l/s)

V = Airflow Velocity (feet / minute = fpm) or (meters / second = m/s)

A = Cross-sectional area of booth (width x height), (square feet = ft²) or (square meters = m²)

Vol = Booth Volume (cubic feet = ft³) or (cubic meters = m³)

1 cubic meter = 1000 liters

Volumetric Flow: $Q = V * A$

SECTION A. VISUAL INSPECTION CHECKLIST FOR THE EXHAUST SYSTEM. The purpose for conducting a visual inspection will tell you the general condition of the exhaust system before you go through the time and trouble of taking measurements. See Table C-3 for the questions to help guide you through the visual inspection.

Table C-3. Key Questions to Note.

	Yes	No
Is the duct work in good condition (e.g., no corrosion, no collapsed sections, etc?)		
Is the exhaust fan belt tight?		
Is the exhaust fan belt free of wear and tear?		
Are the pulleys free of wear and tear?		
Is the exhaust system free of excess paint residue?		
Are the filters free of holes, tears, and fitting properly?		

SECTION B. MEASURING THE EXHAUST DUCT VELOCITY.

1. Purpose. Measuring the exhaust duct velocity will tell you if there is enough air velocity in the duct to carry away the air contaminants generated by spray painting. This procedure should be conducted as a baseline characterization of the paint booth and then used again during annual evaluations. Subsequent (annual) measurements can be compared to the baseline measurements. The design velocity should be at least 2000 fpm.

2. Equipment.

(a) Pitot tubes (diameter of tubes should be less than drill bit size, i.e. for a 3/8" bit consider using a 1/4" or 5/16" tube).

(b) Digital or analog manometer (to record velocity pressures).

(c) Electric drill w/appropriate bit (recommend 3/8" diameter bit), if pressure taps have not been previously drilled.

3. Procedure.

(a) Look for previously drilled holes in the exhaust duct. Make sure all the test locations are at least 7 duct diameters (if feasible) downstream of any disturbances such as elbows or branch entries. There may be more than one location where holes were drilled.

NOTE: If a pitot traverse was not previously performed, then drill 2 holes (the size will depend on the diameter of the pitot tube) at a location that is at least 7 duct diameters downstream from a disturbance. These two holes need to be at a 90 degree angle from each other.

(b) Use the manometer and pitot tube assembly to measure **velocity pressure** (VP) in the ductwork. The manufacturer should have written instructions on how to properly set up the assembly.

(c) Use or modify the procedure forms that follow.

(d) Record the appropriate number of VP measurements as recommended by ACGIH. The number of measurements will depend on the size and shape of the duct. Six to 12 measurements are recommended for round ducts 6 inches or less in diameter; 10-20 for round ducts large than 6 inches and 16 to 64 for rectangular ducts. You will

need to take two sets of measurements. The sets will be at 90 degrees from each other. (See Tables C-4 – C-6)

(e) Convert the VP measurements to velocity using the conversion factor:

$$V = 4005\sqrt{VP}$$

(f) Average the total number of velocity measurements.

(g) Compare your results to the criterion of 2000 fpm.

Table C-4. Pitot Traverse Procedure for Round Ducts < 6 inches in Diameter

1st set of measurements	Insertion Distances	Measured VP	Calculated Velocity $V = 4005\sqrt{VP}$
1.	0.043 D		
2	0.290 D		
3.	0.710 D		
4.	0.957 D		
2nd set at 90° from 1st set	Insertion Distances	Measured VP	Calculated Velocity $V = 4005\sqrt{VP}$
5.	0.043 D		
6.	0.290 D		
7.	0.710 D		
8.	0.957 D		
Criterion = 2000 fpm		Average velocity = _____ fpm	

Table C-5. Pitot Traverse Procedure for Round Ducts > 6 inches in Diameter

1st set	Insertion Distances	Measured VP	Calculated Velocity $V = 4005\sqrt{VP}$
1.	0.032 D		
2	0.135 D		
3.	0.321 D		
4.	0.679 D		
5.	0.865 D		
6.	0.968 D		
2nd set at 90° from 1st set	Insertion Distances	Measured VP	Calculated Velocity $V = 4005\sqrt{VP}$
7.	0.032 D		
8.	0.135 D		
9.	0.321 D		
10.	0.679 D		
11.	0.865 D		
12.	0.968 D		
Criterion = 2000 fpm		Average velocity = _____	

Table C-6. Pitot Traverse Procedure for Rectangular Ducts

1st set of measurements	Insertion Distances	Measured VP	Calculated Velocity $V = 4005\sqrt{VP}$
1.	0.061 W		
2	0.235 W		
3.	0.437 W		
4.	0.563 W		
5.	0.765 W		
6.	0.939 W		
2nd set at 90° from 1st set	Insertion Distances	Measured VP	Calculated Velocity $V = 4005\sqrt{VP}$
7.	0.061 H		
8	0.235 H		
9.	0.437 H		
10.	0.563 H		
11.	0.765 H		
12.	0.939 H		
Criterion = 2000 fpm			Average velocity = _____

SECTION C. VISUAL CHECK FOR AIR FLOW PATTERNS.

1. Purpose. This procedure will help you visualize how the air is moving through a spray paint booth indicating if there are any cross drafts or turbulence inside of the booth. Airflow from the supply air to the exhaust air plenums in a spray-painting booth should be uniform. Poor design and improper supply air often cause turbulence. Another common cause of airflow turbulence in a booth is the replacement air entering the booth through inlet louvers or diffusers at high velocities due to insufficient or no mechanical replacement air.

2. Equipment.

(a) Smoke tube (stannic chloride or titanium tetrachloride).

(b) Squeeze pump.

3. Procedure.

(a) Stand perpendicular to face of the small spray paint booth or at the designated profiles of the large booth.

(b) Follow the manufacturer's instructions on using the smoke tube.

(c) Release the smoke inside of the paint booth.

(d) Release smoke as close as possible (near the gaskets) around the closed doors to determine the direction of airflow. No air should be blowing out of the booth or suctioning inward.

(e) Record locations where the air flow pattern is not uniform. Investigate the cause (e.g., clogged filter, work product is blocking flow, design flaw, etc.).

SECTION D. MEASURING THE FACE VELOCITIES.

1. Purpose. Measuring the face velocities of spray paint booths will allow you to compare to measured velocities to established standards (OSHA, NFPA, etc.). Keep in mind that these standards are to control fire and explosions. Health hazards may be also be controlled when face velocities are met, but you will need to conduct statistically valid air sampling to confirm this.

2. Equipment.

- (a) Thermoanemometer (air velocity readings) or swinging vane anemometer.
- (b) Tape measure or laser/sonar distance meter.

3. Procedure—Small booths.

- (a) Make sure the booth is empty.
- (b) Measure the length and width of the face to get the face area.
- (c) Divide the face area into 16 rectangles of equal size.
- (d) Using the anemometer, take velocity measurements at the center of each rectangle.
- (e) Record the values using (or modifying) Tables C-7 and C-8.
- (f) Calculate the average of these velocities.
- (g) Select the ACGIH criterion you will use for comparison.
- (h) Compare the measured value to the ACGIH criterion.
- (i) If it doesn't meet the ACGIH criterion, compare to OSHA requirement.
- (j) If the requirement is not met, investigate potential causes.

Table C-7. Face Velocity Measurements – Small Booth

Calculated Average Velocity	Measured Area	Measured Q	Comparison Criterion	Meets Criterion?
_____ fpm	___ ft ²	$Q = VA$ $Q = \text{_____ cfm}$ $Q = \text{_____ cfm} / \text{_____ ft}^2$ $Q = \text{_____ cfm} / \text{ft}^2$	$Q = \text{_____ cfm} / \text{ft}^2$ (ACGIH) $V = \text{_____ fpm}$ (OSHA)	

4. Procedure—Large and drive-through booths (horizontal flow).

(a) Define a vertical cross section in the working zone in the middle third of the booth. If the booth is longer than 20 feet (6 meters), additional cross-sectional areas may be defined at maximum 10-foot intervals.

(b) Calculate the face area.

(c) Divide the cross-sectional area into 16 equal rectangles.

(d) Using the anemometer, take velocity measurements at the center of each rectangle.

(e) Record the values using (or modifying) the forms that follow.

(f) Calculate the average of these velocities for the cross section.

(g) Select the ACGIH criterion you will use for comparison.

(h) Compare the measured value to the ACGIH criterion.

(i) If it doesn't meet the ACGIH criterion, compare to OSHA requirement.

(j) If the requirement is not met, investigate potential causes.

Table C-8. Face Velocity Measurements, Large and Drive-Through Booth (Horizontal Flow)

First Cross Section				
Calculated Average Velocity	Measured Area	Measured Q	Comparison Criterion	Meets Criterion?
_____ fpm	___ ft ²	Q = VA Q= _____ cfm Q= _____ cfm/___ ft ² Q= ___ cfm/ft ²	Q= _____ cfm/ft ² (ACGIH) V = _____ fpm (OSHA)	
Second Cross Section				
Calculated Average Velocity	Measured Area	Measured Q	Comparison Criterion	Meets Criterion?
_____ fpm	___ ft ²	Q = VA Q= _____ cfm Q= _____ cfm/___ ft ² Q= ___ cfm/ ft ²	Q= _____ cfm/ft ² (ACGIH) V = _____ fpm (OSHA)	
Third Cross Section				
Calculated Average Velocities	Measured Area	Measured Q	Comparison Criterion	Meets Criterion?
_____ fpm	___ ft ²	Q = VA Q= _____ cfm Q= _____ cfm/___ ft ² Q= ___ cfm/ft ²	Q= _____ cfm/ft ² (ACGIH) V = _____ fpm (OSHA)	

5. Procedure – Drive-through booths (downdraft).

- (a) Calculate the horizontal face (floor) area.
- (b) Divide the face area into 16 equal rectangles.
- (c) Using the anemometer, take velocity measurements at the center of each rectangle.
- (d) Record the values using (or modifying) Table C-9.
- (e) Calculate the average of these velocities for each cross section.
- (f) Select the ACGIH criterion you will use for comparison.
- (g) Compare the measured value to the ACGIH criterion.
- (h) If it doesn't meet the ACGIH criterion, compare to OSHA requirement.
- (i) If the requirement is not met, investigate potential causes.

Table C-9. Face Velocity Measurements – Drive-Through Hood, (Downdraft)

5' Above Floor, Average = _____ fpm				
Calculated Average Velocity	Measured Area	Measured Q	Comparison Criterion	Meets Criterion?
_____ fpm	_____ ft ²	Q = VA Q = _____ cfm Q = _____ cfm / _____ ft ² Q = _____ cfm/ft ²	Q = _____ cfm/ft ² (ACGIH) V = _____ fpm (OSHA)	

SECTION E. Measuring pressure differential of spray paint booth.

1. Purpose. Measuring the pressure differential between the inside of the booth as compared to the area outside the booth.
2. Equipment. Digital manometer.
3. Procedure – large and small booths.
 - (a) Make sure the booth doors are closed and sealed.
 - (b) Using the digital manometer, place the tubing inside the booth through a hole or small space around door frame without pinching the tubing.
 - (c) Record the values.
 - (d) Pressure differential should be neutral (zero).
 - (e) If the pressure is not neutral, investigate potential causes.

APPENDIX D PAINTING IN CONFINED SPACES

(This appendix is provided as information only and not to be considered as an all encompassing document on confined space work.)

Note: The term **open space** is any area not testing the definition of confined space.

D-1. INTRODUCTION.

a. Confined space as defined in the glossary, is subject to the accumulation of toxic or Combustible gases or the development of an oxygen deficient or enriched atmosphere. Permit required confined spaces (PRCS) as mandated by OSHA requires a written confined space program including work place evaluation to determine whether PRCS exist and employee training. For details see 29 CFR 1910. 146 *Permit Required Confined Spaces*. Respiratory protection is required when working in a confined space. The type of respiratory protective equipment depends on the type of confined space encountered. See Appendix E Respiratory Protection Requirements for more information on respirator selection. See the glossary for the definitions of oxygen deficient atmosphere, oxygen enriched atmosphere, combustible atmosphere, toxic atmosphere, immediately dangerous to life or health (IDLH) atmosphere, and not immediately dangerous to life or health (NIDLH) atmosphere.

b. Confined spaces include, but are not limited to, storage tanks, process vessels, bins, boilers, ventilation or exhaust ducts, sewers, underground utility vaults, tunnels, pipelines, and open top spaces more than 4 feet in depth such as pits, tubs, vaults, and vessels.

c. Confined spaces may also include areas in and under vehicles or equipment where airflow is restricted.

D-2. STEPS TO BE TAKEN.

a. Employees will be instructed in the nature of the hazards involved, the necessary precautions to be taken, and in the use of PPE and emergency equipment required.

b. Prior to employee entry into areas where an IDLH is likely to occur, appropriate tests of the atmosphere will, be conducted to determine the oxygen content, and if combustible gas or toxic levels have been exceeded. Testing will be conducted in the above order prescribed.

c. Prior to employee-entry is into potential IDLH areas where contents of tanks or vessels may be accidentally filled, electrical control circuits will be locked-out and pipe flanges will be blanked (sealed) or pipes will be completely disconnected (see reference 29 CFR 1910.147 *Control of Hazardous Energy, Lockout/Tagout*).

d. If the tests performed indicate the atmosphere is unsafe, it will be ventilated until the hazardous atmosphere is removed prior to employee entry.

e. Precautions will be continued and atmospheric tests made during operations to prevent the occurrence of a hazardous atmosphere while an employee is in the confined space.

f. Confined space entry into potential IDLH areas requires specific standard operating procedures. Supervisory authorization will be obtained before entering a confined space. A trained attendant will be posted outside the confined space entrance to observe and provide assistance as necessary. Periodic communication will be maintained between the attendant and personnel in the confined space. The establishment of an entry permit system is recommended.

g. In the absence of ventilation or testing, or if air sample results are above the established air contaminant levels, only trained personnel equipped with proper PPE will be allowed entry into potential IDLH areas. Entry requires the use of a supplied air respirator with an auxiliary air supply or a self-contained breathing apparatus, appropriate protective clothing, a safety harness and a lifeline. Protective clothing will provide protection against skin contact and absorption of hazardous materials encountered in the confined space. All equipment that will be used in an explosive atmosphere will be approved as explosion proof or non-sparking or intrinsically safe for the atmosphere involved.

h. Means will be provided for quick removal of employee(s) in case of emergency. Safety harnesses and lifelines will be used for quick removal of an employee's body from the confined space.

APPENDIX E
RESPIRATORY PROTECTION REQUIREMENTS

(This appendix is provided as information only and not to be considered as an all encompassing document on respiratory protection.)

E-1. INTRODUCTION.

a. The most common exposure route associated with spray painting is inhalation. Operations that use toxic materials in the form of vapors, gases, or aerosols (liquid droplets or solid particles dispersed in the air) or create oxygen deficient atmospheres may require the use of respirators.

b. Engineering controls are the preferred method of reducing workplace exposures to hazardous materials to levels below occupational exposure limits (OEL). However, in some instances respirators may be required: (1) Before engineering controls have been installed or if engineering controls are impossible or impractical; (2) During temporary work activities (such as repair or maintenance) in which exposure levels are unknown; (3) operations conducted in confined spaces; and (4) During emergencies.

c. OSHA requires a written respirator program when respirators are worn in the workplace. The written program must contain the following program elements:

- (1) Procedures for respirator selection in the workplace.
- (2) Medical evaluation of employees.
- (3) Fit testing procedures.
- (4) Procedures for proper respirator use, both routine and in emergencies.
- (5) Procedures for inspection, cleaning, disinfection, storage, repairing and discarding of respirators and their components.
- (6) Procedures to ensure adequate air quality, quantity and flow for use in atmosphere supplying respirators.
- (7) Employee training.

Note: Respirator use information must also include a plan for determining cartridge service life, based either on end of service life indicators (ESLI) or change out schedules for cartridges without ESLIs.

d. Details can be found in OSHA 29 CFR 1910.134 *Respiratory Protection*. The type of respirator chosen depends upon an initial determination of the concentration of the hazard or hazards present in the workplace, or the presence of an oxygen deficient atmosphere. Information on choosing the correct respirator is published in the Respirator Selection Logic by the National Institute for Occupational Safety and Health at: <http://www.cdc.gov/niosh/docs/2005-100/default.html>.

E-2. SPRAY PAINTING INDOORS.

a. A pressure demand or continuous flow Type C, full-facepiece hood or helmet supplied-air respirator is the standard respirator to be worn when spray painting indoors. However, alternatives are permitted when authorized by preventive medicine personnel.

b. In all cases, the alternative respirator system must be approved for protection of contaminants at the levels documented by sampling data.

E-3. SPRAY PAINTING OUTDOORS.

a. A pressure demand or continuous flow, Type C, full-facepiece hood or helmet supplied-air respirator must be worn when—

(1) Spray painting outdoors and solvent concentrations exceed the protective capability of an air purifying respirator equipped with organic vapor cartridges or canister, or

(2) Working in a confined space (see para E-5).

b. Alternatives are permitted when authorized by preventive medicine personnel.

c. In all cases, the alternative respirator system must be approved for protection of contaminants at the levels documented by sampling data.

E-4. BRUSH/ROLLER PAINTING INDOORS AND OUTDOORS.

a. Respiratory protection is not required when painting in open spaces and authorized by preventive medicine personnel.

b. A half-mask air purifying respirator equipped with organic vapor cartridges or canister and paint prefilter (or equivalent particulate filter (such as HEPA)) will be required if solvent or pigment atmospheric concentrations exceed standards .

c. A pressure demand or continuous flow, Type C, full-facepiece hood or helmet supplied-air respirator is required if diisocyanate atmospheric concentrations exceed the standards.

E-5. SPRAY/BRUSH/ROLLER PAINTING IN ALL CONFINED SPACES.

d. A pressure demand or continuous flow; Type C, full-facepiece hood or helmet supplied-air respirator may be used in spray, brush, or roller painting in both indoor and outdoor confined space (non-IDLH) operations.

e. A pressure demand or continuous flow, Type C, full-facepiece supplied-air respirator with auxiliary self-contained air supply is required in operations when an—

(1) Individual cannot immediately exit a confined space safely if the primary air supply is interrupted, or

(2) Immediately life threatening toxic environment is present (i.e., IDLH).

f. Alternative respiratory protection for brush and roller operations only are permitted when authorized by preventive medicine personnel.

E-6. GRINDING AND SANDING. Air purifying respirators may be used with:

a. Low hazard particulates (non toxic paint or metal dust) – air purifying respirator with a NIOSH approved R-, N-, or P-95 or 99 rated particulate filter.

b. High hazard particulates (dusts from toxic metals such as lead, chromium or cadmium) – air purifying respirator with a NIOSH approved R-, N-, or P-100 (HEPA) rated particulate filter.

E-7. WELDING AND CUTTING. Air purifying respirators may be used with—

a. Low hazard particulates (non toxic paint or metal dust) – air purifying respirator with a NIOSH approved R-, N-, or P-95 or 99 rated particulate filter.

b. High hazard particulates (aerosols or fumes from toxic metals such as lead, chromium or cadmium) – air purifying respirator with a NIOSH approved R-, N-, or P-100 (HEPA) rated particulate filter.

Table E-1. Respirator Selection Guide

Contaminants/Operations	Types of Respirators							
	Air Purifying						Air Supplying	
	Disposable	½ face ^a or full face ^b					Airline	
	Efficiency %			Chemical Cartridges	Particulate cartridge Efficiency %			
	95	99	100		95	99	100	
Nontoxic paints, metal dusts	X*	X*			X*	X*		
Toxic paint, metals			X*				X*	
Welding fumes	X*	X*	X*		X*	X*	X*	
Gases/Vapors (Spray painting)								
Organic Solvent vapors				X**				
Isocyanates								X
Painting (in confined spaces)								X

Note:

^a - Half mask air purifying respirators can be worn for protection against organic vapors up to ten times the OEL.

^b - Full facepiece air purifying respirators can be worn for protection against organic vapors up to 50 times the OEL; full facepiece respirators also provide eye protection.

* Respirators available in N, R, or P classes, N= no oil mist resistance, R= some oil resistance, P= oil mist resistance.

** Chemical cartridges can be fitted with particulate pre-filters to capture paint aerosols.

GLOSSARY

SECTION I. ABBREVIATIONS

ACGIH	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
AR	Army Regulation
CARC	Chemical Agent Resistant Coating
DA	Department of the Army
DA PAM	Department of the Army Pamphlet
DREW	Department of Health, Education, and Welfare
DHHS	Department of Health and Human Sciences
EP	Extraction-procedure
EPA	U.S. Environmental Protection Agency
EPE	epoxy polyamide enamel
FEV	forced expiratory volume in second
HDI	hexamethylene diisocyanate
HEPA	high efficiency particulate air
HW	hazardous waste
IDLH	immediately dangerous to life or health
MEK	methyl ethyl ketone
MIL STD	military standard
MSDS	material safety data sheet
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
NSN	national stock number
OSHA	Occupational Safety and Health Administration
PEL	permissible exposure limit
PPE	personal protective equipment
RCRA	Resource Conservation and Recovery Act
TB	Technical Bulletin
TG	Technical Guide
TLV	Threshold Limit Values
TWA	Time-Weighted Average
USAPHC	U.S. Army Public Health Command
VOC	volatile organic compound
WD CARC	Water Dispersible Chemical Agent Resistant Coating

SECTION II. TERMS

Aerosols

Liquid droplets or solid particles dispersed in the air which are small enough to remain suspended in the air for a prolonged period of time

Approved

Tested and listed as satisfactory according to standards established by a competent authority (such as NIOSH) to provide respiratory protection against the particular hazard for which it is designed.

Confined space

Any space that—

1. Is large enough and so configured that a person can bodily enter and perform work; and
2. Has limited or restricted means for entry or exit(i.e. tanks, vessels, vaults, hoppers); and
3. Is not designed for continuous occupancy.

Note: all three conditions must be met to be classified as a confined space.

Combustible atmosphere

An atmosphere in excess of 10 percent of the lower explosive limit.

Immediately dangerous to life or health atmosphere

A condition posing an immediate threat to life or health, or an immediate threat of severe exposure to contaminants likely to have adverse delayed effects on health or would interfere with an individual's ability to escape form a dangerous atmosphere.. This condition includes atmospheres where oxygen content by volume is less than 16 percent.

Not Immediately Dangerous to Life or Health Atmosphere

An atmospheric concentration of any toxic, corrosive or asphyxiant substance that poses an immediate threat to life or would cause irreversible or delayed adverse health effects or would interfere with an individual's ability to escape from a dangerous atmosphere.

Open space

Any area not meeting the definition of confined spaces.

Oxygen deficient atmosphere

An atmosphere where the oxygen concentration is less than 19.5 percent by volume.

Oxygen enriched atmosphere

An atmosphere with greater than 21 percent oxygen by volume.

Paint system

The protective paint barrier which covers a painted object and consists of a pretreatment coat, primer coats, and finish or top coats.

Painting

Refers to the application of surface coatings, such as CARC.

Permit Required Confined Space

A confined space with **one or more** of the following characteristics–

1. Contains or has the potential to contain a hazardous atmosphere;
2. Contains a material that has the potential for engulfing an entrant;
3. Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-sectional area;
4. Contains any other recognized serious safety or health hazards.

Toxic atmosphere

An atmosphere where air contaminants are in excess of their respective standard.

**LOCAL REPRODUCTION IS
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**USAPHC (Prov) TG No. 144
DECEMBER 2012**



U.S. ARMY PUBLIC HEALTH COMMAND (Provisional)

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