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Project Summary

VOC Emission Reduction Study at the Hill Air Force Base Building 515 Painting Facility

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The objective of this project was to develop practical technologies for economically reducing volatile organic compound (VOC) emissions from typical Air Force painting operations. The painting facility selected for study is located in Building 515 at Hill Air Force Base, Utah. Practical and economical emission control technologies that may be used at this and other Air Force facilities were developed based on the results of in-booth and exhaust duct sampling for particulate and hazardous constituent concentrations.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back.

Introduction

Under the Clean Air Act and various state and local laws, organic solvents and coating compounds used in routine Air Force maintenance operations are subject to VOC emission regulations. Air Force installations are experiencing increased pressure from regulatory agencies to reduce organic compound emissions from painting and coating operations. The capital and operating costs associated with controlling emissions from such operations are a function of the flow rate of the exhaust gas passing through the control device. The goal of this program was to develop safe and cost-effective VOC emission control strategies.

To characterize the emission rate and distribution of hazardous compounds in the paint booth during painting operations, simultaneous air samples were taken in the exhaust duct and at 22 positions inside the booth. VOC, particulate, and isocyanate air samples were taken during normal operation of the painting facility. A solvent mass balance was performed in which VOC emission rates were compared to paint usage and analysis data to confirm measurement accuracy.

Methodology

Personal sampling pumps were suspended at 22 sampling positions in the paint booth during painting. To determine in-booth particulate concentrations, sample air was drawn through cellulose ester filters connected to the suspended sampling pumps, in accordance with National Institute of Occupational Safety and Health (NIOSH) Method 500. The filters were weighed several times before and after sampling to determine the quantity of particulate collected from the known sample volume. To determine particulate emission rates from the booth, isokinetic particulate samples were drawn from the exhaust duct according to Environmental Protection Agency (EPA) Method 5. For comparison, particulate samples were drawn from the duct using NIOSH Method 500.

Integrated VOC concentration measurements were taken in the booth and exhaust duct by drawing sample air through NIOSH charcoal tubes, in general accordance with NIOSH Method 1300. Organic constituents were adsorbed onto the charcoal, which was subsequently extracted with a solvent formulation developed for this test series. The extract was analyzed with a gas chromatograph/flame ionization detector (GC/FID). Continuous (real-time) organic sampling was performed in the exhaust duct to determine VOC emission rates. Two continuous organic sampling methods were used for this test series: Bay Area Air Quality Management District (BAAQMD) Method ST-7 and EPA Method M25A. Method ST-7 specifies that sample air be drawn through a catalytic furnace, in which the organic constituents are oxidized to CO_2. The sample stream is then passed through a nondispersive infrared detector (NDIR), which monitors the CO_2 concentration. Method 25A specifies that the sample stream be passed through an FID, which measures organic concentrations directly.

Isocyanate concentrations in the booth and exhaust duct were measured according to Occupational Safety and Health Administration (OSHA) Method 42, which specifies that sample air be passed through chemically treated glass fiber filters. Isocyanates are collected on the filters, which are subsequently analyzed using high performance liquid chromatography (HPLC).

Airflow rates were measured in the booth using a calibrated hot wire anemometer and in the exhaust duct according to EPA Method 2 procedures. In addition, paint usage rates were determined by posting a crew member in the booth to monitor paint start and stop times and by weighing the paint-dispensing container before and after the painting cycle.

Volatile and semivolatile organic compound concentrations were measured in the water curtain sump water according to EPA Methods 8240 and 8270, respectively. The total organic carbon (TOC) and residue concentrations were monitored twice daily by collecting water samples and analyzing them according to EPA Methods 9060 and 160.3, respectively.

Test Description

Operating parameters (i.e., flow rates and paint usage rates) were evaluated before and after each painting cycle; sampling was performed during painting. Each day, a different sampling protocol was used (i.e., VOC, particulate, and isocyanate sampling were performed on different days). Because there were two painting cycles per day, each sampling effort was performed in duplicate.

Results

Except for areas directly in the path of the paint spray gun, the highest concentrations of hazardous constituent compounds were found in the lower strata of the booth, at 4 ft (1.2 m) in height. Above 8 ft (2.4 m), nondetectable levels of hazardous compounds were found. Some of the highest VOC concentrations measured were near the painter. Metals, particulate, and isocyanate concentrations were also somewhat high in the vicinity of the painter; however, the highest concentrations were measured at ground level near the booth exhaust face. Occasionally, high concentrations of hazardous compounds were measured in singular isolated areas. It is suspected that these high concentrations resulted from the painter's inadvertently applying paint directly to the sample surface.

Conclusions

The concentration profiles obtained for the hazardous compounds present in the booth indicate that significant stratification occurs during painting. A system for decreasing the flow to a downstream VOC emission control device can be designed that takes advantage of this concentration stratification. Decreasing the flow rate to a VOC emission control device lowers associated control costs. The flow-reduction system proposed on the basis of the test results employs a split-flow exhaust process in which the exhaust stream from the lower zone of the booth (containing the highest concentrations) is vented to a VOC emission control device. The exhaust stream from the upper zone of the booth is vented to the outdoors. A system such as this can lower the flow rate to an emission control device by 50% or more and, at the same time, decrease VOC emissions by 70% or more.

Additional conclusions are that hazardous compound concentrations in the vicinity of the painter are higher than in other regions of the booth and that concentrations of hazardous compounds measured in the exhaust duct are far below the permissible exposure limits (PELs) specified by OSHA. These results indicate that a recirculation system, in which a large portion of the exhaust air is recirculated back into the booth, can be safely adopted as an alternative means of decreasing the exhaust flow rate. In this system, the portion not recirculated is vented to an emission control device.

Recommendations

Emissions may be reduced by a number of system and process alterations. Some emissions can be reduced by replacing the two-part green primer currently used by the facility tested with a three-part, water-reducible primer that is in common use at other Air Force painting facilities.

Cost-effective VOC emission control can be realized by reducing the flow rate to an emission control device. This may be done by either employing a split-flow ventilation system as described above or installing an exhaust air recirculation system. A third option combining these ventilation system modifications is perhaps the most environmentally sound and economical option.

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The complete report, entitled "VOC Emission Reduction Study at the Hill Air Force Base Building 515 Painting Facility," (Order No. ADA 198-092; Cost: $26.00, subject to change) will be available only from:
National Technical Information Service
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