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Project Summary

Demonstration of Split-flow Ventilation and Recirculation as Flow-reduction Methods in an Air Force Paint Spray Booth

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The report gives results of a demonstration of split-flow and recirculating ventilation, individually and in combination, as safe and cost-effective methods of reducing paint spray booth exhaust flow rates to lower the costs of both conditioning intake air and controlling volatile organic compound (VOC) emissions in exhaust air.

This Project Summary was developed by EPA's National Risk Management 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).

Background

This study was part of an extended program of investigations into the cost and efficacy of innovative approaches for bringing U.S. Air Force industrial operations into compliance with current and anticipated air pollution environmental standards. Adequate ventilation of paint spray booths requires the movement of large quantities of air, which are slightly contaminated during passage through the booth. Air exhausted from this process requires decontamination, which, although technically achievable at operating flow rates, can be prohibitively expensive. Because emission-control costs depend on the volume of exhaust air being treated, considerable savings can be realized through the application of an acceptable flow-reduction method.

A first principle of industrial hygiene is to employ engineering controls to their limit before invoking personal protection. In dealing with exposures to airborne toxics, the mainstay engineering device is enhancement of ventilation. However, increased ventilation creates enormous volumes of slightly contaminated air, which must be treated before discharge, and in many situations the cost of such treatment is excessive. In such circumstances, a judgment must be made about the relative cost in increased exposure compared to the economic benefit in decreased operating cost. The goal of this study was to provide experimental data to support the development of a general Air Force position and objective criteria for local decisions about the acceptability of using flow-reduction methods in paint spray booths, based on local health-risk/cost-benefit considerations.

Scope

The study consisted of two sets of experimental measurements in Booth 2, Building 845, Travis Air Force Base, CA, plus results of an ancillary effort conducted at Research Triangle Institute (RTI) to verify experimentally that the flame ionization detector used in the ventilation control loop is within its linear response range at the equivalent exposure limit for the mixture of solvents present in the mixed top coat. The first set of experimental measurements was a baseline characterization of the distribution of toxic pollutants at the exhaust face and in the exhaust duct of Booth 2. These data, the RTI results, and the test plan for the second set of tests were reviewed before approval was given to proceed with the recirculation tests. For the second set of tests, the ductwork in Booth 2 was reconfigured to separate exhaust streams from the top and bottom of the booth (split-flow) and to return the upper exhaust stream to the intake plenum for recirculation through the booth. During separate painting sessions, several sets of concentration measurements were made of VOCs, particulates, heavy metals, and isocyanates. Equivalent exposures (E_m) were calculated from these data, and projections of E_m were made for larger recirculation ratios, together with an economic analysis of the corresponding costs to apply VOC emission control devices.

Methodology

To determine exposure concentrations, sampling was performed simultaneously inside and outside the respirator, at 24 locations at the exhaust face, in the exhaust ducts, and, during the second set of tests, at three locations at the face of each of the two intake filters. To determine environmental contributions to the load of pollutants, background air samples were collected at the back of the booth prior to the release of any paint-derived materials. Standard sampling methods were used. Paint usage was determined by weighing the gun after each filling and at the end of each painting session. The percent volatile content of the paint was determined gravimetrically, as percent weight loss to evaporation. Airflows were measured with an anemometer in the booth and with a pitot tube in the exhaust ducts. Painting start and stop times were recorded manually by an observer, stationed at the rear of the booth, who also noted the dimensions and locations of workpieces painted, coatings applied, and other details. Projections of equivalent exposures at different recirculation ratios were calculated by a Lotus 1-2-3 program.

Test Description

In both test series, representative workpieces were prepared and coated according to normal operating procedures. During each such painting run, measurements were made of one of the four pollutant classes using standard methods. A typical painting session lasted 30 to 90 minutes, and included post-painting cleaning of the paint spray gun with methyl ethyl ketone and tidying up of the area. In general, two sets of tests were conducted during an 8-hour shift, corresponding to a typical workday.

Results

Concentrations of airborne toxic pollutants are recorded in the tables of the report. Strontium chromate occurs as the major contaminant during primer coating and was the largest contributing factor to the E_m. Organic exposures were minor during all painting, except that high isocyanate exposure occurred outside, but not inside, the painter's respirator during topcoat application inside a comfort pallet (caused by airflow restrictions in the closed space, and unrelated to the mode of ventilation in the booth). The newly constructed recirculation duct was a source of several metals. These metals were included in E_m calculations, but the concentrations are expected to decrease after the newly constructed surfaces are blown clean. Contributions to E_m from recirculation are significantly less than the Air Force criterion of 0.25 imposed for these tests, and much less, in general, than the contribution from the painting process. The painter showed no evidence of overexposure during the post-test medical evaluation.

Conclusions

Data support the prediction that workplace exposure levels during recirculation of paint spray booth exhausts, especially combined with split-flow extraction of the pollutant-enriched lower portion of the exhaust stream, can be maintained at less than an arbitrarily selected criterion (here, $E_m = 0.25$). Flow splitting alone is considerably less effective, but, in combination with recirculation, it acts to lower the concentrations in the recirculated stream at a given rate of recirculation. Computational projection of E_m to larger recirculation rates, and interpolation of results of an earlier economic analysis of scale-related costs to decontaminate exhaust air, indicated that available cost savings allow projected payback on the order of 1 year for thermal or catalytic incineration.

Recommendations

Improvements should be examined to augment or replace present-generation filter and water particulate control systems. Concurrently, or when the improved technologies satisfy local standards, a combination of flow reduction and VOC control should be implemented in an area of intense regulatory pressure as the definitive prototype. Standardized criteria should be established to guide site selection, design, installation, and maintenance.

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The complete report, entitled "Demonstration of Split-flow Ventilation and Recirculation as Flow-reduction Methods in an Air Force Paint Spray Booth," is a two-volume document:
Volume I (Order No. ABA 286 807; cost, subject to change, $31.00) contains the main report and Appendices A through C.
Volume II (Order No. ABA 286 808; cost, subject to change, $38.00) contains Appendices D through J.
Both volumes will be available only from
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