EPA/600/A-97/056

CHOICES AND CHALLENGES - CONTROLLING VOLATILE ORGANIC COMPOUNDS AND HAZARDOUS AIR POLLUTANTS FROM SPRAY PAINTING FACILITIES

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ABSTRACT

Acurex Environmental was contracted by the U.S. Environmental Protection Agency (EPA) to demonstrate an advanced cost reduction strategy at a U.S. Marine Corps maintenance facility in Barstow, California. One booth was modified and two new booths built to use the flow rate reduction strategy, partitioned recirculation. This is the first application in a high volume production environment. Costs for controlling emissions from these facilities are high due to the large air volumes required to produce the minimum face velocity required by the Occupational Safety and Health Administration (OSHA). EPA desired to show that partitioned recirculation, developed over a number of years and projects, could be designed and built as easily as existing non-recirculation booths by using existing industry practices and a minimum of custom design.

At Barstow, partitioned recirculation and other techniques allowed a reduction in volatile organic compound (VOC) control equipment cost by reducing the flow rate from approximately 142,000 to 43,000 cfm while achieving total exhaust treatment. The operating cost was also reduced significantly due to the reduction in flow volume. A post-construction testing program confirmed the partition height and fully characterized the painter environment during painting. Results confirmed that recirculation is a reliable safe means of reducing VOC control costs.

This paper gives a detailed discussion of the various engineering and safety issues related to accomplishing this project. Details discussed include hardware solutions to flow control, real-time VOC level detection in the recirculated stream, maintenance intervals of multistage exhaust filters, and hardware and software solutions to other unique process control challenges.

Application of coatings comprises one of the single largest stationary sources of organic pollutants. In light of increasing attention paid to hazardous air pollutants (HAP) and VOC emissions, split flow recirculation and other engineering strategies become increasingly important in identifying cost reductions to treating these emissions. The success of this project is important to any base with painting or depainting facilities.

INTRODUCTION

The primary challenge facing those controlling emissions of VOCs and HAPs from painting and coating operations related to the large volumes of air normally used to convey these components from the point of application to treatment. Regardless of the VOC control technology chosen, the costs are driven by the overall exhaust flow rate to the control device. OSHA requires a minimum velocity of

100 feet per minute (fpm) through a booth when using conventional spray equipment. This velocity, combined with basic booth dimensions of length and width or height and width, results in a flow rate determined by OSHA and The National Fire Protection Associaton (NFPA) to be the minimum required for safely conveying paint overspray from the work area.

During 1988, EPA and the U.S. Air Force (USAF) began a joint research and development program to control VOC and HAP emissions from paint spray facilities. The first study, conducted at McClellan Air Force Base (AFB), led to a conclusion that control technologies can be more economically applied to spray booths after modifications to permit recirculation of a portion of the booth air. The concerns about health and safety for personnel in the booths (OSHA Regulation 29 CFR 1910.107)[1] were addressed in later studies at Hill AFB[2]. These tests demonstrated to the USAF and OSHA that recirculation could be accomplished without exceeding NFPA code requirements or OSHA workplace permissible exposure limits (PELs) of HAPs. Safety could be ensured by continuously monitoring the recirculated stream.

The USAF and EPA work to characterize the painting environment inside normal paint booths resulted in finding that stratification is a normal occurrence within cross flow paint booths where particles and VOCs tend to leave the booth at heights at or below the point where applied. This phenomenon can be used to partition booths into VOC-rich and -lean regions. Once filtered, the lean region could be recirculated, freeing the control device from the burden of the full exhaust flow. The method to separate these streams was patented under "Paint Spraying Booth with Split-Flow Ventilation" Patent (5,221,230) (Darvin and Ayer) which is jointly held by EPA and Acurex Environmental[3].

This technology was successfully demonstrated by a study at Travis AFB[4] where a booth was baseline tested, modified to partitioned recirculation, and tested again. The first opportunity for a permanent fully integrated booth and control system demonstration came with the Barstow Project, where three existing booths were modified to reduce the cost of an innovative VOC control system based on ultraviolet light and ozone. This project was funded by the Strategic Environmental Research and Development Program (SERDP). This partitioned flow technique, combined with other engineering and management techniques, reduced the flow from the three existing booths by an overall 71 percent. This saved more than $1.1 million in capital costs and more than 53 percent in operating costs.

Barstow is an ideal site for this demonstration because it houses extensive priming and painting operations for Marine Corps and other Department of Defense (DoD) vehicle and ground equipment. The three paint booths are located in a single building, the Marine Corps Multi-Commodity Maintenance Center (MC^3). Booth 1 is a large drive-through vehicle booth primarily used for topcoat application to armored personnel vehicles, Humvees, and other Marine equipment. The booth dimensions are approximately 18 feet high, 20 feet wide, and 60 feet long. Ventilation air is introduced through an intake plenum at the rear of the booth and exits through filters at the front of the booth. Booth 2 is a smaller (10 feet high, 30 feet wide, and 20 feet long) booth with an overhead conveyor designed for painting small vehicle components. The critical parameter in determining partition height was that significant wash-primer-containing hexavalent chromium was used in this booth. Fresh air is introduced through a perforated plate into the ceiling plenum at the front of the booth. Contaminated air exits through a filter bank covering the entire back wall. Booth 3 is similar to Booth 2 (10 feet high, 22 feet wide, and 10 feet long) and is designed for painting pallet loaded equipment. As with Booth 2, the wash primer was the primary driver in determining partition height.

One important goal for this project as defined by EPA was to design and install the spray booths using as many standard approaches as possible to simplify its application to similar facilities and industrial applications. By enforcing this throughout the design, EPA hoped to expedite the availability of this to the general corrosion control industry, thereby providing economical approaches to regulations driven by the Clean Air Act Amendments of 1990[5]. For those unable to meet emissions limits by using reformulated paints, economical approaches will be needed for control technology. For the vast majority of the design elements employed at Barstow, such as sheet metal, doors, and ducting, standard practices were applied that are presently used in spray booth construction. A number of exceptions did require varying levels of custom design including:

- Constant flow rate through each booth: This will be needed for any booth with VOC controls. Control equipment is sized for specific overall flow rates. Maintaining flow rates consistent with OSHA's minimum required velocities saves considerable cost.

- Exhaust filter system: Many downstream elements are protected by application of high performance particulate filtering including ducting, VOC control equipment, and (in the case of recirculation booths) operators.

- Coordination of paint booth/Air Pollution Control System (APCS) system operations: Paint booths are relatively simple processes. VOC controlled booths are not. Close coordination of the operations of the booths to the VOC control system is required to maintain air regulation compliance. Multiple booths connecting to a single control device increase the challenges of this requirement substantially.

- An efficient, fully integrated safety monitoring system: Many variables affect booth VOC concentrations and, therefore, operator exposure. The purpose of the safety monitoring system is to ensure compliance with applicable OSHA exposure standards without limiting booth operating schedules or process flexibility. A real-time VOC measurement becomes an effective process window providing insight into booth or operator problems such as high paint usage or paint equipment malfunctions.

These issues were of primary importance in developing an efficient and properly integrated Marine Corps Logistics Base (MCLB) paint booth/APCS system, and are therefore discussed in detail.

ADVANTAGES OF FLOW CONTROL

Irrespective of recirculation considerations, booth ventilation rates should be controlled within set limits for several reasons. Typical paint booth ventilation systems are designed with fixed drive fans that are rated sufficiently high to ensure that the OSHA mandated 100 fpm requirement (for standard spray guns) is met even under severe system operating conditions such as when the exhaust and/or intake filters are heavily loaded with overspray particulate. The conventional approach is to use fixed drive fans which are typically sized with a large safety margin. This correspondingly produces excessively high flow rates under "clean filter" conditions. While this approach ensures compliance with applicable health and safety standards under all operating conditions, it also increases the capital, installation, and operating costs of an APCS, because the capacity of the device must be sufficiently large to process the highest flow rates generated under "clean filter " conditions. Therefore, accurately controlling the booth ventilation rates to continuously maintain the 100 fpm velocity reduces the air pollution emission control costs. Another benefit is gained from ventilation rate uniformity. Higher ventilation rates than required by OSHA can adversely affect paint application efficiency. Painters in booths without control may have to make small continuous adjustments in technique to balance the effect of varying face velocities. Flow controlled booths reduce face velocity changes to those created by vehicle profile changes only. This permits painters to develop strategies and experiences for each vehicle type that transfer paint smoothly to all other examples of that vehicle. Minimizing fan speeds to OSHA requirements also saves energy. Controlling ventilation rate by fan speed is an approach preferred by utility companies as opposed to energy inefficient methods such as control dampers or, in the case of conventional booths, no flow control.

A final reason for controlling flow rates in recirculation/flow-partition systems is related to the need to accurately and consistently partition the flow into exhaust and recirculated regions. Flow partitioning takes advantage of constituent stratification patterns that typically occur in paint booths to increase the recirculation rate to the greatest extent possible. The ventilation air that passes to the

APCS therefore contains higher levels of overspray particulate. Flow rate control balances the differential loading that is imposed on the particulate filters thereby maintaining consistent face velocities.

FLOW CONTROL SYSTEM DESCRIPTION

The flow rate through each booth is controlled with a feedback loop composed of a flow measurement probe, a transmitter, a process controller, and a variable frequency drive (VFD) equipped fan motor. The probe is located in the duct and senses the flow. It then sends a pneumatic signal to the flow transmitter which measures the signal and relays a flow proportional electrical signal to the process controller which compares it to the desired or setpoint flow. The controller then decides which way the flow needs to change to maintain the setpoint flow and communicates this electrically to the variable frequency drive, which directly controls the fan motor speed.

Available flow rate metering devices include those defined by the American Society for Mechanical Engineers (ASME) such as low loss flow tubes, venturis, and orifice plates. In addition to these a number of proprietary designs are available. Each of these methods presents different challenges to design such as ducting arrangement and fan power losses. Some metering methods present lower ultimate pressure losses reducing energy usage. Other probes yield greater signal amplification, thereby increased accuracy, which may be necessary for low velocity systems. For Barstow, flow sensing is done using pitot grid array probes that are manufactured specifically for heating, ventilation, and air-conditioning (HVAC) and process flow applications. These probes deliver a signal proportional to the square of the flow velocity and are designed to provide the accuracy of a full pitot traverse such as described in EPA Method 2[6]. Two probes are installed in each duct to reduce error attributed to cyclonic flow induced by elbows, fans, and other disturbances. Each flow probe pair is connected in parallel to a high precision pressure transmitter. Measurement errors are minimized by using high performance pressure transmitters that typically have combined errors of less than 0.1 percent of full scale. Duct velocities in the final design ranged from 2071 to 3019 feet per minute (fpm) which resulted in consistent flow signals.

The transmitters employed are the "smart sensor" type; each is equipped with a calibration data table that is stored in the sensor by the manufacturer and which supports field configuring. Errors for these transmitters are typically expressed as a percentage of the configured upper range, which produces substantially lower errors than transmitters having error rates expressed as a percentage of full range. An additional feature of the transmitters installed on the MCLB paint booths is built-in temperature detection and correction capability. By using these transmitters, flow measurement deviations are estimated at less than 2 percent.

The flow controller, chosen for its accuracy and operational flexibility, is an important component of the feedback control loop. The controller receives a signal from the transmitter, calculates the process error, and generates a correction in its signal to the VFD. Of all components in the feedback control loop, the flow controller requires the greatest effort to trim and configure to the system operation. Loop tuning, which is required to provide smooth flow corrections without process overshoot or undershoot, can be a long laborious process. To reduce loop tuning efforts, automatic (self tuning) controllers were installed on the MCLB paint booths; this capability enabled the system programmer to quickly establish estimated values for the proportional, integral, and derivative photoionization detector (PID) settings (which define the controller response characteristics). After the approximate settings were defined, the desired characteristics were manually adjusted. Final PID settings were established after the booths were connected to the APCS by trimming the booth system responses to match the APCS induced draft fan characteristics.

The VFD components were selected to be consistent with the APCS drives. Each drive accepts a 4-20 mA signal from the controller. Each VFD is equipped with a number of diagnostic messages on the front panel and many registers for customizing. A readout in Hz enables the user to monitor fan speed as a function of fan flow.

SAFETY MONITORING SYSTEM

To answer effectively the obvious questions of personal safety, the development plans of partitioned recirculation included a real-time monitor to measure the quality of the air stream as it enters the booth. Added to this monitor are alternate modes of booth operation to reduce VOC levels if needed. Initially, studies concentrated on easily available, fully developed, monitoring devices such as those based on the flame ionization detector (FID) and the PID. This type of monitor indicates VOCs by total carbon counts. Its single readout must be qualified by response factor calculation based on many laboratory calibration trials using mixtures of the process stream components. This works well for constant streams of relatively few compounds. As the number of possible paints increases and the number of compounds increases, determining accurate response factors becomes impractical. This led to investigating another instrument based on the Fourier Transform infrared (FTIR) detector. Its greatest advantage is its ability to measure and report concentrations of multiple compounds in a single stream. By using comprehensive libraries of previously fingerprinted compounds, this instrument can easily be reprogrammed to accommodate new paint formulations.

The safety system employs an FTIR to continuously monitor the recirculation stream organic concentrations. This system assesses the quality of the recirculation air as it exits the paint booth on a real-time basis performing a measurement approximately each minute. Each measurement includes the concentrations of 12 separate compounds. These concentrations are combined with OSHA PEL data to arrive at a combined exposure factor. This calculated value is compared to safety setpoints described later to determine if adjustment is required. Booth 1 was equipped with a dedicated safety monitoring system, and Booths 2 and 3 share a single monitoring system. This configuration was selected because Booth 1 must be capable of full operation at all times, whereas Booths 2 and 3 were designed to operate sequentially.

Each safety monitoring system is programmed with two alarm setpoints, or action levels, based on the combined exposure level or OSHA factor, which modify the booth operation to reduce recirculation stream constituent concentrations. If the recirculation duct organic concentrations measured by the FTIR exceed the first action level, the paint delivery system is shut down, which immediately curtails coating delivery to the paint gun, and stops the release of hazardous constituents. The paint delivery system remains in the off mode until concentrations in the recirculation duct drop below the established setpoint. If for some reason the concentration continues to increase to the second action level (such as if a large quantity of paint is spilled in the booth), the booth control system activates dampers to convert the booth to single-pass operation. Such action instantly reduces the in-booth hazardous constituent concentrations. This alarm is latched, meaning that the alarm remains in effect until a supervisor reviews the situation and intervenes, or resets the alarm. For the second action level as with the first, the paint delivery system remains in the off mode until concentrations in the recirculation duct drop below the established setpoint.

In practice the system has proven to be reliable, and high VOC excursions have become more and more infrequent due to changes in painter practices. Typical practices that can result in excursions include 1) pointing the spray gun up toward the recirculation filter face unnecessarily; and 2) mixing paint with the fans off for extended periods, thus contributing to solvent vapor buildup in the booth before turning on the fans.

The availability of real-time data has furthered our knowledge of paint booth recirculation, exhaust emissions levels, and contributing factors such as painter technique and the effects of target profile. A number of observations that have been made regarding the relationship between painter technique and recirculated stream VOC concentrations include:

- The operator's technique contributes to booth VOC levels more than originally anticipated.
- Differences in application efficiency between operators are reflected in the VOC levels reported by the FTIR.

- Differences between operators can affect VOC levels in the booth more than differences in target profile height.
- The operator's application efficiency can be increased through booth improvements such as increased lighting or through training.

HIGH PERFORMANCE PARTICULATE FILTRATION

The coating operations in Booths 2 and 3 employ small quantities of a wash primer that contains hexavalent chromium for which a very low PEL has been established. The Booth 2 and 3 partition height calculations were influenced to a great extent by the potential presence of hexavalent chrome in the overspray that is directed to the recirculation duct.

A 3-stage, high performance filtration system was selected for the MCLB application to minimize the solid-phase hazardous compound concentrations in the recirculation duct and to reduce particle fouling of the exhaust ducting and the APCS. This decision was reached after a series of tests to determine characteristics such as pressure drop vs. paint loading rates for various coating materials and included tests with samples of the coatings used at Barstow.

Typical booth paint filter systems that achieve moderate filtration efficiencies are designed with single-stage media such as fiberglass or kraft paper that have clean pressure drop readings of less than 0.2 inch w.c., and which are replaced when the pressure differential across the media reaches 1 inch w.c. or less. However, high efficiency, multistage filters tend to have relatively higher clean pressure drop readings, and are also somewhat more expensive than traditional filter systems. As such, there is an economic incentive to drive the filters to a reasonably high pressure drop prior to replacement.

However, establishing a reasonable filter life cycle involves the consideration of several related factors. For instance, less frequent filter replacements require higher pressure differentials which in turn require higher fan and motor capacities as well as sturdier, heavier exhaust plenums, ducting, and dampers. One of the first tasks was to establish the limits of the MCLB paint booth exhaust plenums, as well as the selected 3-stage high-efficiency filter system. The results of this evaluation indicated that the plenums are capable of withstanding a 3 inch w.c. pressure drop, whereas the filters can easily handle a 7 inch w.c. pressure drop (or more).

The operating life of each stage of the 3-stage filter system varies as a function not only of the filter material, but also of the painting operation characteristics such as workpiece configuration, aerosol size distributions, coating transfer efficiency and dropout, and operator habits. To establish the replacement frequency of each of the filter stages in the MCLB paint booths, two representative filter elements were selected (one above the partition in the recirculation zone, and one below the partition in the exhaust zone), and pressure differential gages were installed across each stage of these representative elements. The elements were selected to reasonably represent the median particulate loading level in each of the two zones. By installing a static pressure probe between stages 1 and 2 and one between stages 2 and 3 and referencing these to booth and plenum pressures, respectively, three discrete pressure signals are available from each representative element. The probes are connected to manometer gages mounted on the exterior of the booth, thus providing a means of measuring the pressure differential across each stage. These gages provide information for determining whether the first, second, or third stage needs replacing when the overall pressure exceeds 2.5 inch w.c.

Clean filter pressure drop is directly proportional to the linear face velocity through the filter. Therefore, controlling the flow rate through each booth produces the added benefit of reducing the clean pressure drop insofar as possible. For booths 2 and 3, the face velocity through the exhaust filters is 134 fpm, which corresponds to a clean filter pressure differential of approximately 0.5 inch w.c. across all three stages. The original Booth 1 exhaust face was configured such that, even with the flow rate reductions achievable by flow control, a 200 fpm face velocity would be generated after the retrofit modification. This was considered too high to achieve reasonable filter replacement intervals, thus the exhaust system was redesigned to accommodate an additional row of filters. This successfully reduced the linear face velocity through the Booth 1 exhaust filters to 167 fpm, which corresponds to a clean filter pressure differential of 0.87 inch w.c.

For each booth, the pressure gages provide input to the booth control panel, and notify the operator of impending filter replacement requirements via a 2-level warning system. The first level is triggered at a 2.5 inch w.c. pressure drop, and notifies the operator to schedule a filter change. The second level, which occurs at 3.0 inch w.c., disables the booth fans, thereby maintaining a reasonable pressure differential in the plenums and ductwork. This 0.5 inch w.c. margin was provided in an effort to reasonably extend filter life and minimize operating costs.

Day-to-day operation revealed much about operating with 3-stage filtration that was not apparent during design. Our design included roll media for the first stage to save money and replacement time. The first filter rack used for retaining this stage was cumbersome and formed a less-than-satisfactory seal. As a result of early experiences, the booth contractor, Spray Booth Systems, Inc., redesigned the rack, which was installed during a subsequent visit. This new retention design includes a 0.5 in. channel perimeter around each rack of panel filters which form the second and third stages. This channel accepts the first-stage roll media, which is rapidly installed using a special rotary disk tool. Each panel, ranging from 33 to 55 ft^2, is installed in minutes, and the first stage is tightly sealed to prevent particles from bypassing to later stages.

The replacement intervals for 3-stage filters are much more difficult to determine than when single-stage filters are used. Instrumenting each filter stage with separate gages is helpful, but the decision of when to replace a particular stage is not obvious at a glance. Rules and guidelines have yet to be established to guide the operator or technician responsible for filter changing. Future designs will address this by integrating modern process controls to provide guidance on optimal changeouts.

FINAL FLOW RATES

The results of the Baseline Study indicated that significant flow reductions could be achieved for the MCLB paint booths. The initial, projected, and actual booth exhaust flow rates achieved are summarized in Table 1. The data presented in Table 1 in the Final Configuration column reflect actual operating conditions that currently exist and which were established as a result of the Phase II retrofit efforts.

Table 1: Summary of Flow Rate Reductions Achieved for MCLB Paint Booths[a]

Booth	Initial Volume Flow Rate m^3/m (cfm)	Projected from Baseline Study		Final Configuration		Overall Flow Reduction Achieved %
		Volume Flow m^3/m (cfm)	Exhaust Flow m^3/m (cfm)	Volume Flow m^3/m (cfm)	Exhaust Flow m^3/m (cfm)	
1	1,500 (53,000)	1,019 (36,000)	566 (20,000)	962 (34,000)	572 (20,210)	62
2	1,783 (63,000)[b]	906 (32,000)	580 (20,500)	906 (32,000)	604 (21,330)	66
3	778 (27,500)[c]	623 (22,000)	393 (13,900)	623 (22,000)	415 (14,660)	47
Total	4,061 (143,500)	2,548 (90,000)	1,539 (54,400)	2,491 (88,000)	1,176 (41,540)[a]	71[b]

[a] Booths 2 and 3 are not operated simultaneously; the highest booth exhaust flow rate to the control device is 20,210 + 21,330 = 41,540 cfm.

[b] Based on maximum flow allowed in APCS.

[c] Based on 125 fpm estimated face velocity.

The significant flow reduction achieved in the MCLB paint booth retrofit efforts is attributed to the following design factors:

1) Flow Control - With the VFDs, a constant flow rate is maintained in each booth, which ensures compliance with OSHA requirements while minimizing exhaust flow rates. Of the flow reduction achieved, 32 percent is attributed to the flow control feature.

2) Recirculation/Flow-Partitioning - Through installation and operation of recirculation/flow-partitioning, the exhaust flow rate to the APCS was reduced by an additional 31 percent. Note that the level of flow reduction achieved by recirculation/flow partitioning was limited primarily by a conservative decision to establish large safety margins for the recirculation duct OSHA factor. Greater flow reductions may be achieved via recirculation for facilities that either employ more stringent protective equipment, or adopt an approach that is less conservative.

3) Booth 2 Enclosure - Booth 2 was originally configured as an open face booth, and therefore operated at a significantly higher flow rate than is necessary for a fully enclosed booth of similar size. By enclosing Booth 2, the flow rate vented to the APCS was reduced by an additional 23 percent.

4) Production Schedule Management - By alternating the operating schedules for Booths 2 and 3, the volumetric flow rate vented to the APCS was reduced an additional 14 percent.

The sequential operation of Booths 2 and 3 is controlled from a single interface panel. Although each booth is internally equipped with full operating capabilities, the circuitry is designed such that only one booth can be run at a time. The operating booth is selected via a front panel switch, which is locked for supervisor control. The safety monitor is devoted to whichever booth is operating, and the sample inlet direction is controlled with a 3-way valve connected to the panel-mounted switch.

PAINT BOOTH/APCS SYSTEM INTEGRATION REQUIREMENTS

The MCLB paint booth operating schedules are frequently demanding and generally variable. The two booth areas, 11 (Booths 2 and 3) and 18 (Booth 1) are managed by different supervisors. Booths 2 and 3, which cannot be operated simultaneously, are designed for sequential operation due to the flow capacity of the APCS. Given the process constraints and area management structure, the importance of adequately linking booth ventilation systems with APCS operation was apparent. To develop the necessary system coordination procedures and handshake signals between the booths and the APCS, various startup and operation strategies were identified through a detailed "what if" analysis.

The APCS design included a Management Information System (MIS) in its original design which included a comprehensive network of data handling modules and controllers. A personal computer is used as the operator interface. The booths were designed primarily as standalone components including the minimum control logic necessary for VOC alarms, door interlocks, and paint gun interlocks. It was apparent that to successfully link the booths to the APCS required significant data sharing and passing of handshake, or initialization, signals. During design, the booths were then added to the APCS network to permit data sharing between the two systems. This network provides the APCS startup control over the booths. If the APCS is down for maintenance, booth operation is suspended or is prevented from starting. Depending on which booth starts and whether a booth is currently online, the APCS refers to pre-programmed responses. This provides tighter control over critical system parameters such as induced draft pressure.

The startup strategy was developed based on the premise that the booths and the APCS form an integrated process, thus all painting operations rely on proper functioning of the APCS. Booth operators must be able to detect at a glance whether the APCS is available for service, or is down for maintenance. After this is determined, and the start button is pressed, startup becomes a series of automatically executed steps that include several system condition tests. The booth ventilation system and APCS operations are activated only after these checks are satisfactorily completed to ensure simultaneous, smooth, and safe system integration.

ANNISTON PROJECT

Building on the experience of Barstow, several important improvements are planned for a facility for the Anniston Army Depot. Two truck-sized drive-through booths are being installed with a dedicated regenerative thermal oxidizer (RTO) for each. The inside dimensions of each booth are 40 feet long, 24 feet wide, and 18 feet high.

Many VOC control technologies were considered during the proposal stages including adsorption based, thermal based, and hybrids such as rotary zeolite adsorber/thermally desorbed. The procurement of this facility included a requirement for estimated maintenance costs over a 20 year lifetime. This drove the choice to use RTOs for VOC controls because of their inherent design simplicity and energy efficiency. The basic design of these units has been improved over a number of years, arriving at the latest multibed units which bring 95 percent thermal efficiency with 99 percent or more VOC destruction. This design maturity is advantageous to production painting facilities which cannot afford unplanned down time.

The complexity of integrating paint booth and APCS operations can be effectively handled by many different types of hardware. The Barstow booths employ local relay logic control and standalone process controllers, and the APCS is managed by a network of distributed control. A more integrated control system offers many advantages. For Anniston Army Depot, programmable logic controller (PLC) processors will be used to control both the booth operation and the RTO operation. PLCs have gained wide industry acceptance for small to medium size process control installations. By using identical control hardware on the major components, diagnostics can be performed by any person familiar with this industry standard approach. For each booth/RTO pair, the two processors communicate and share signals via a local network connection; both processors will be available by telephone connection. The primary advantage of this system is that the telephone link will allow diagnosing any signal line of the processors. These will include such signals as:

1. Thermocouple sensors in the RTO
2. RTO poppet valve function
3. Alarm modes for the RTO
4. Recirculation flow rates
5. Exhaust flow rates
6. Filter pressure drops in the booth
7. Fan motor power

The RTO and booth share a single blower, preventing the need to match two competing fans. RTO and recirculation blowers will be flow-rate controlled and the heating makeup air unit will be controlled using booth static pressure.

Other advantages to more thoroughly linking booths with VOC control hardware include the ability to support more complex modes of operation. For example, Anniston's control processors will be programmed to support a standby mode which will be used to throttle the booths and the RTOs down during extended breaks and preparation periods when paint guns are idle. Energy use will drop below a quarter of that needed during painting operation. Another possibility will be a timed ramp down mode to be used at the end of shift to prevent the loss of VOCs flashing off the day's final work. By linking the FTIR to these modes of operation, personal exposure data will need to be collected only during painting modes, preventing the accumulation of volumes of data when guns are turned off.

7. CONCLUSION

The partitioned recirculation paint spray booth system can address emissions from a significant portion of DoD's aircraft and vehicle service sector, which can be considered a leading toxic materials usage area. Such a solution is important to DoD's adherence to the 1995 National Emissions Standards for Hazardous Air Pollutants for Source Categories: Aerospace Manufacturing and Rework Facilities[7] and existing requirements for VOC emissions in ozone non-attainment areas.

Broad application of advanced split-flow recirculation paint spray booth systems can have a major impact on reducing energy usage and regulated emissions from DoD facilities. Aircraft servicing is a significant generator of toxic emissions with 5 of the top 10 toxic compounds found in the paints used at typical aircraft maintenance facilities.

Most spray coating facilities can be retrofitted with partitioned recirculation ventilation to reduce the cost of controlling VOC emissions, whether vented to a conventional or advanced control system. Because this technology operates separately from the APCS, it is compatible with all emission control systems. Fiscal analysis indicates that a booth similar to the Barstow installation with a 32-percent recirculation will yield a 25- to 30-percent reduction in the typical total capital and operating cost of $1.5 million over a 10-year lifetime. Because the degree of flow reduction is a function of many parameters, each booth operation must be individually assessed. For example, the flow rate reduction in a large hanger operation exhausting 250,000 cfm in which two or three paint stations are used, could be 80 percent or higher. Conversely, the flow reduction in a small booth may be as low as 20 percent, but in practically all cases translates into cost savings.

Even in locations which are not required to control the VOC emissions, the application of this technology may provide substantial cost savings by reducing the heating or cooling load required to condition large volumes of air. This can be a critical concern for facilities located in less temperate zones of the country or in foreign installations.

Table 2: Metric Conversion

To convert from	to	multiply by:
Feet (ft)	Meter (m)	0.3048
Feet/minute (fpm)	Meter/sec (m/sec)	0.00508
Inch w.c. (in. H_2O, 60° F)	Pascal (Pa)	249
Inch (in.)	Meter (m)	0.0254
Square Feet (ft^2)	Square meter (m^2)	0.093
Cubic feet/minute (ft^3/min)	Liter/sec [m^3/sec]	0.472 [0.000472]

ACKNOWLEDGMENTS

The authors wish to thank Dr. Joseph Wander of the Environics Directorate of Armstrong Laboratory at Tyndall Air Force Base, Florida, and the Marine Corps Logistics Branch in Barstow, CA, and in Albany, GA.

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NRMRL-RTP-P-218

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completi

1. REPORT NO. **EPA/600/A-97/056**

2.

3. I

4. TITLE AND SUBTITLE

Choices and Challenges--Controlling Volatile Organic Compounds and Hazardous Air Pollutants from Spray Painting Facilities

5. REPORT DATE

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S) D. Proffitt (Acurex), C. Darvin (EPA), and J. Ayer (Air Quality Specialists)

8. PERFORMING ORGANIZATION REPORT NO.

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10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO. 68-D4-0111

12. SPONSORING AGENCY NAME AND ADDRESS

EPA, Office of Research and Development
Air Pollution Prevention and Control Division
Research Triangle Park, NC 27711

13. TYPE OF REPORT AND PERIOD COVERED Presented paper; 10/95-1/97

14. SPONSORING AGENCY CODE EPA/600/13

15. SUPPLEMENTARY NOTES APPCD project officer is Charles H. Darvin, MD-61, 919/541-7633. Presented at 1997 DOD/Industry Aerospace Coatings Conference, Las Vegas, NV, 5/12-15/97.

16. ABSTRACT The paper gives a detailed discussion of the various engineering and safety issues related to the demonstration of an advanced cost reduction strategy at a U.S. Marine Corps maintenance facility in Barstow, CA. Details discussed included hardware solutions to flow control, real-time volatile organic compound (VOC) level detection in the recirculated stream, maintenance intervals of multistage exhaust filters, and hardware and software solutions to other unique process control challenges. One paint booth was modified and two new booths were built to use the flow rate reduction strategy, partitioned recirculation. This is the first such application in a high-volume production environment. Costs for controlling emissions from these facilities are high due to the large air volumes required to produce the minimum face velocity required by the Occupational Safety and Health Administration (OSHA). EPA desired to show that partitioned recirculation, developed over a number of years and projects, could be designed and built as easily as existing non-recirculation booths by using existing industry practices and a minimum of custom design. At Barstow, partitioned recirculation and other techniques allowed a reduction in VOC control equipment cost by reducing the flow rate from about 142,000 to 43,000 cfm (67 to 20 cu m/sec) while achieving total exhaust treatment.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution	Pollution Prevention	13B
Emission	Stationary Sources	14G
Painting	Paint Booths	13H
Circulation	Partitioned Recirculation	
Organic Compounds		07C
Volatility	Volatile Organic Compounds (VOCs)	20M

18. DISTRIBUTION STATEMENT

Release to Public

19. SECURITY CLASS *(This Report)* Unclassified

20. SECURITY CLASS *(This page)* Unclassified

21. NO. OF PAGES

22. PRICE

EPA Form 2220-1 (9-73)