IN-DEPTH SURVEY REPORT: EVALUATION OF LOCAL EXHAUST VENTILATION SYSTEM FOR ADVANCED FLAT SORTER MACHINE

at

United States Postal Service
Baltimore Processing and Distribution Center
Baltimore, Maryland

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ABSTRACT

Researchers from the National Institute for Occupational Safety and Health (NIOSH) conducted evaluations of an exhaust ventilation system developed for the Automated Flat Sorting Machine (AFSM) 100 This system was installed by the machine's manufacturer to reduce the potential for employee exposure to harmful substances that could be contained in mailpieces processed by the machine This effort is in response to recent terrorist attacks that used the mail as a delivery system for anthrax NIOSH was asked to assist the United States Postal Service (USPS) in evaluating controls for this and other mail processing machinery

Evaluations were based on a variety of tests including tracer gas experiments, air velocity measurements, smoke release observations, and particle count experiments The experiments showed that, overall, there is good capture by the exhaust ventilation system Tracer gas tests indicated that the capture was essentially 100% between the feed table and the bucket insertion point At the bucket insertion point, the measured capture efficiency was approximately 81% The exhaust ventilation system also exhibited good capture characteristics based on smoke release experiments and air velocity measurements Particle count measurements were inconclusive, it was determined that this method does not produce repeatable enough results for use in this situation

Based on these results and others discussed in this report, the following recommendations are suggested

- Consider adding a ventilated partial enclosure at the point where the mailpieces enter the moving buckets to reduce the potential for contaminant release

- Seal cooling fan openings for fans that have been disconnected These openings allow for the potential release of a substance that has been captured

- Consider more thoroughly evaluating the capabilities of the exhaust system with additional smoke and tracer gas testing, particularly after changes are made to the ventilation and filtration system The tested system only had ventilation on one of the three feeders, and HEPA filters were not installed in the filtration unit

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is located in the Centers for Disease Control and Prevention (CDC), within the Department of Health and Human Services NIOSH was established in 1970 by the Occupational Safety and Health Act at the same time that the Occupational Safety and Health Administration (OSHA) was established in the Department of Labor (DOL) The OSHAct legislation mandated NIOSH to conduct research and education programs separate from the standard-setting and enforcement functions conducted by OSHA An important area of NIOSH research deals with methods for controlling occupational exposure to potential chemical and physical hazards

The Engineering and Physical Hazards Branch (EPHB) of the Division of Applied Research and Technology (DART) has been given the lead within NIOSH to study and develop engineering controls and assess their impact on reducing occupational illness Since 1976, EPHB (and its forerunner, the Engineering Control and Technology Branch) has conducted a large number of studies to evaluate engineering control technology based upon industry, process, or control technique The objective of each of these studies has been to evaluate and document control techniques and to determine the effectiveness of the control techniques in reducing potential health hazards in an industry or for a specific process

This is the second report of a project to evaluate controls that are put in place by the United States Postal Service (USPS) to prevent the release of contaminants into the work area of postal employees This report describes the evaluation of the performance of the exhaust ventilation system for the Automated Flat Sorting Machine (AFSM) 100

BACKGROUND

Researchers from NIOSH were requested to assist the USPS in the evaluation of particulate controls for various mail processing equipment These new controls are being installed to significantly reduce operator exposure to any potentially hazardous contaminants emitting from letter mail during normal mail processing This effort is driven by the recent terrorist attacks which used the mail as a delivery system for anthrax NIOSH researchers have subsequently made several trips to Washington, DC area postal facilities to observe various mail-processing machinery in operation and to study the effectiveness of the newly designed controls

The control evaluated in this report is an exhaust ventilation system (EVS) for the AFSM 100 This control was designed and installed by the manufacturer of the AFSM 100 to significantly reduce the potential for operator exposure to bacterial contaminants and other aerosols that could be contained in mailpieces processed by the AFSM The control was an early prototype that continues to change, and when the testing was performed, the filtration unit did not contain the high efficiency particulate air (HEPA) filters that are planned to be included This exhaust ventilation system was evaluated at the Baltimore, Maryland Processing and Distribution Center

(P&DC) during two separate field surveys Survey 1 took place on March 5, 2002 and Survey 2 took place on March 19, 2002

HAZARDS TO POSTAL EMPLOYEES

The bacterium *bacillus anthracis* is a spore forming bacterium, with spores typically in the size range 1-5 µm Disease caused by anthrax manifests in one of three ways inhalational, cutaneous, and gastrointestinal [1] Recent cases resulting from terrorist attacks in which anthrax spores have been sent by mail to a U S Senator and to media offices have been both inhalational and cutaneous The cutaneous form of the disease generally develops 2-5 days following exposure and is usually successfully treated with antibiotics The onset for the inhalational form is typically 1-6 days after exposure and has a high fatality rate even with appropriate treatment Exposure to anthrax spores by postal employees working in a mail processing facility that serves the U S Capitol resulted in inhalational disease in several of the workers [2] One potential area of exposure is the automated mail processing equipment used to sort collection mail As the mail passes through the machinery, it is compressed in a number of places that could cause the release of substances from the mail

DESCRIPTION OF EQUIPMENT

The system evaluated at the Baltimore P&DC was the AFSM 100 The AFSM 100 is an automated flat sorting machine Mail is fed into the machine with automated feeders, encoded and processed using video images and optical character recognition (OCR) technology [3]

Three automated feeders supply flat mailpieces Once in the transport system, the image of each individual piece is captured An optical character reader reads any barcodes and the content of the address The mailpieces are then injected into one of 759 pockets that circulate around the machine If the correct ZIP code is determined, the mailpiece is released into one of 120 sort bins If the address on the mailpiece cannot be read by the OCR, the image of that piece is sent to a Video Coding Room in the facility A keyer then views the image on a computer monitor and manually enters the address information so the correct ZIP code may be determined The mailpiece is then sent to the proper sort bin If an address cannot be determined for a mailpiece, it will be rejected

The AFSM 100 consists of a number of modules, the modules significant to the control of a potential contaminant in the mail include the feeder module, the Tilter module, the OCR module, and the interface 950 module It is in these parts of the system that the mailpieces undergo the most violent actions as they are loaded onto the machine and fed through the machine by rollers that pinch the mail Also, at the feeder module, the mailpieces are near the worker and have the potential to release a contaminant into the worker's breathing zone

At the feeder module, the mail is manually loaded onto the feeder table The conveyor on the feeder table advances the mail to a destacker where the individual pieces of mail are separated The mailpieces are then tilted in the Tilter module in preparation for entering the OCR module In the OCR module, the mailpieces are passed over a scanner to obtain an image After the OCR module, the mailpieces enter the Interface 950 module where they are spaced and accelerated for injection into the pockets of the carousel

DESCRIPTION OF CONTROL

The evaluated control has been retrofitted for the AFSM by the manufacturer The control is designed to reduce emission of bacterial contaminants such as spores of *B anthracis* into the ambient atmosphere through use of particle collection capabilities and filtration units At the time of the field surveys, the filtration unit in place on the exhaust ventilation system did not contain high efficiency particulate air (HEPA) filters as is planned for the final production model Moreover, the tested control was an initial prototype that has since been modified For example, only one of the three feeders was controlled

By taking advantage of the enclosed Tilter, OCR and Interface 950 Modules on the AFSM, the interior of the machine was ventilated by adding exhaust to the machine cabinet Inside the cabinet, air intakes were placed along the path taken by the mailpieces to collect any contaminant potentially in the mail These intakes focused on the areas around pinch points as these have the highest potential for releasing a substance The feed table of the AFSM was also controlled by air intakes located perpendicular to the feed belt and above the mailpieces

METHODS

TRACER GAS

Apparatus

To quantitatively evaluate the capture efficiency of the EVS, a tracer gas method was used The gas, CP sulfur hexafluoride (SF_6), was released at a constant rate at points in and near the sorter to determine the capture efficiency of the EVS at these release points The gas was supplied through a mass flow controller (Model 1359C-10000SV, MKS Baratron® & Control Products, Six Shattuck Road, Andover, Massachusetts, 01810) set to produce about 4 ppm in the exhaust outlet of the EVS The exhaust from the EVS was returned to the workroom and directed toward the ceiling The concentration of the SF_6 was measured in the exhaust duct, just upstream of the filters In order to sample this air stream uniformly, the exhaust air was drawn through a 1/4 in diameter copper tube having six 3/32 in diameter holes spread uniformly across the duct diameter, inserted into and perpendicular to the exhaust duct After exiting the copper tube, the air was first filtered (HEPA Capsule Filter, Model #12127, Gelman Sciences, Incorporated, Ann Arbor, Michigan, 48106) to remove dust, and then pulled through a MIRAN® 203 Specific Vapor Analyzer (Thermo Environmental Instruments, 8 West Forge Parkway, Franklin, MA 02038), using a personal sampling pump (AirCheck Sampler, Model 224-PCXR4, SKC Incorporated, 863 Valley View Road, Eighty Four, Pennsylvania, 15330) set for approximately 5 lpm, and using Tygon® tubing throughout the sampling system After exiting the pump, the sampled air was simply released into the workroom The analogue output signal from the MIRAN® was recorded by a data logger (Model dl-3200, Metrosonics, 1060 Corporate Center Drive, Oconomowoc, Wisconsin, 53066) and later downloaded to a personal computer for processing

Procedures

For these measurements, the data logger was set to record the output signal from the MIRAN® at 1 minute intervals, averaged over 1 minute Each measurement of capture efficiency was recorded for a 3 to 5 minute interval The MIRAN® concentration corresponding to 100% capture was measured by releasing the SF_6 directly into the duct supplying the exhaust inlet to the feeder table This measurement was made immediately before and after the rest of the capture efficiency measurements, to detect and correct for drift in the 100% level All of the tracer gas measurements were made with the EVS blower turned on About half of the measurements were made with test mail running through the machine and half with no mail in place A list of the sampling sites is given in Table 1, and photos of the sites are shown in Figures 1 - 5 Three locations near the feeder table were tested, referenced to the largest piece of mail that could be handled by the AFSM Tracer gas was released at both ends and the middle of a line defined by the top, outer corner of this maximal mail sitting at opposite ends of the feeder table The "near" position was closest to the feeder inlet

SMOKE RELEASE

Apparatus

In addition to a smoke machine (Mini Fogger, Model F-800, Chauvet USA, 3000 North 29th Court, Hollywood, Florida, 33020), we used a focused, high-intensity projector beam (Basic Lamp, Sage Action, Incorporated, P O Box 416, Ithaca, New York, 14851) to illuminate the smoke

Procedures

By releasing smoke at points in and around the sorter with the EVS operating, the path of the smoke, and thus any airborne material released at that point, could be determined If the smoke was captured quickly and directly by the EVS, it was a good indication of acceptable control performance If the smoke was slow to be captured when released at a certain point, or took a circuitous route to the air intake for the exhaust, the EVS performance was considered marginal at that point We made smoke release observations at the feeder, using the smoke machine Also, we introduced smoke inside the machine near external gaps, and watched for the escape of the smoke through the gaps It was verified that air was flowing into the machine through gaps in the cover by releasing smoke outside the gaps In addition, the dynamic behavior of the EVS was observed with smoke The sorter was filled with smoke, and then the access doors were opened while the degree of containment of the smoke was observed Finally, after filling the sorter with smoke at an operator access point, the time required by the EVS to clear the smoke was measured These observations were made both with no mail in place and with the sorter in operation using test mail The only area that required supplementary illumination with the projector lamp was underneath the sorter, where the mail was injected into the moving buckets

CAPTURE VELOCITY

Apparatus

An anemometer was used to measure air speeds in and around the sorter (Velocicalc Plus Anemometer, Model 8388, TSI Incorporated, P O Box 64394, St Paul, Minnesota, 55164)

Procedures

To measure the velocities achieved by the control at critical points, the anemometer was held perpendicular to the flow direction at those points Velocities were recorded primarily at the feed table since the rest of the machine is substantially enclosed To check the capture velocity at the furthest point from the air intake, the anemometer was held where the outer corner of the largest piece of mail accepted by the machine would be

AEROSOL RELEASE

Although an aerosol release study was conducted during Survey 1, the concentration data that were obtained generally had considerable variability, related in part to the difficulty in releasing a consistent amount of particles into the air in a repeatable manner Since the tracer gas technique can provide very similar kinds of data regarding the control efficiency of the EVS, and the tracer gas data are more consistent, we have decided to discontinue the aerosol-based techniques in favor of tracer gas

RESULTS

Tracer Gas

To produce a 4 ppm concentration of SF_6 in the EVS, the mass flow controller was set for 0 607 lpm This implies an exhaust flow rate of 5390 cfm The relative concentration at each of the tracer gas dosing points, which is the same as the capture efficiency at those points, is given in Table 1 A plot of the MIRAN® relative concentration vs time is given in Figure 6 It is clear that nearly all of the tested points have a measured capture efficiency of 1 00 +/- 0 02, which is the estimated range of accuracy of the measurements The one exception is test run #19, located where the mail was inserted into the buckets, with the sorter in operation At this point, the capture efficiency was 0 81

Smoke

Smoke release experiments were conducted to visually determine how effective the control is at various locations around the machine At the feeder table, smoke was released at the edge of the table with no mail running through the machine The smoke was effectively captured by the control at the feeder table Smoke released in the tilter area was mostly captured although a small amount escaped Smoke that was generated under Buffer 3 stayed in the buffer cabinet A test was also conducted at the injector point where the mail enters the buckets Some smoke was observed to escape through the bottom into the buckets

Velocity

Air velocity measurements were taken primarily around the feed table as this is the only open area that is controlled by the exhaust ventilation Velocities near the slot face ranged from 2000-4000 fpm At the edge of the feeder table belt, the air velocities were approximately 50-120 fpm

DISCUSSION

Overall, the capture efficiency of the EVS was very good between the feeder table and the bucket insertion point, achieving nominally 100% capture under the conditions of the test Because the feeder table is of necessity not enclosed, there is still some potential for emissions generated there to escape to the work room air, in the presence of a strong draft, for example It would be possible to reduce the effect of drafts by adding flanges or curtains around the feeder table However, as long as the feeder table is loaded manually and requires operator access, it will be very difficult to ensure 100% capture under all conditions

At the bucket insertion point, it is our understanding that further improvements to the ventilation system are anticipated Because of the air currents induced by both the moving buckets and the injected mail, simply increasing the flow into the sorter chassis at the insertion slot will not likely solve the problem The mail will entrain some air as it passes from the chassis interior into the buckets, and the external drafts will carry some of this air away, precluding 100% capture efficiency However, if a ventilated partial enclosure were constructed around the bucket, any emissions within the enclosure should be captured, assuming high enough capture velocity at the edges of the enclosure to overcome the air flow created by the moving buckets Further tracer gas measurements or smoke release studies may help our understanding of the emission mechanisms at this point

The smoke release results reinforced the results from the tracer gas tests In addition, the smoke release results indicate that the wash-out rate of airborne material released inside the sorter chassis seems to be adequate to protect a worker who opens a cover during normal machine operations When the new ventilation control was added to the AFSM, cooling fans that had been part of the original design were disconnected However, the openings for these fans were left in place Any opening in the cabinet has the potential for allowing a contaminant to escape

RECOMMENDATIONS

- More fully evaluate the ventilation control for the AFSM 100 with additional smoke and tracer tests after a complete prototype is available
- Consider adding a ventilated partial enclosure at the point where mail is inserted into the moving buckets
- Close the openings in the cabinet for cooling fans that are no longer used to prevent the escape of any hazardous substance contained in the cabinet
- Evaluate the filtration module for the EVS after it has been completed with the addition of HEPA filters

Table 1. Tracer Gas Experiment Positions		
Sampling Site	**Description**	**Measured Efficiency**
1	100% level	1 000
2	Feeder, no mail, outside top far corner	1 002
3	Feeder, no mail, outside middle top edge	1 002
4	Feeder, no mail, outside top near corner	1 019
5	Pinch roller, no mail	1 007
6	Above tilter, no mail, cover down	1 008
7	OCR, middle roller, no mail, cover down	1 004
8	Buffer 2 exit, no mail	1 001
9	Injector at accelerator exit, no mail	1 008
10	Under buckets, no mail	1 018
11	Feeder, with mail, outside top far corner	1 010
12	Feeder, with mail, outside middle top edge	1 001
13	Feeder, with mail, outside top near corner	1 007
14	Pinch roller, with mail	1 011
15	Tilter exit, with mail	0 995
16	OCR, with mail	0 989
17	Buffer 2, with mail	0 976
18	Injector, with mail	1 015
19	Under buckets, with mail	0 805
20	100% level	1 000

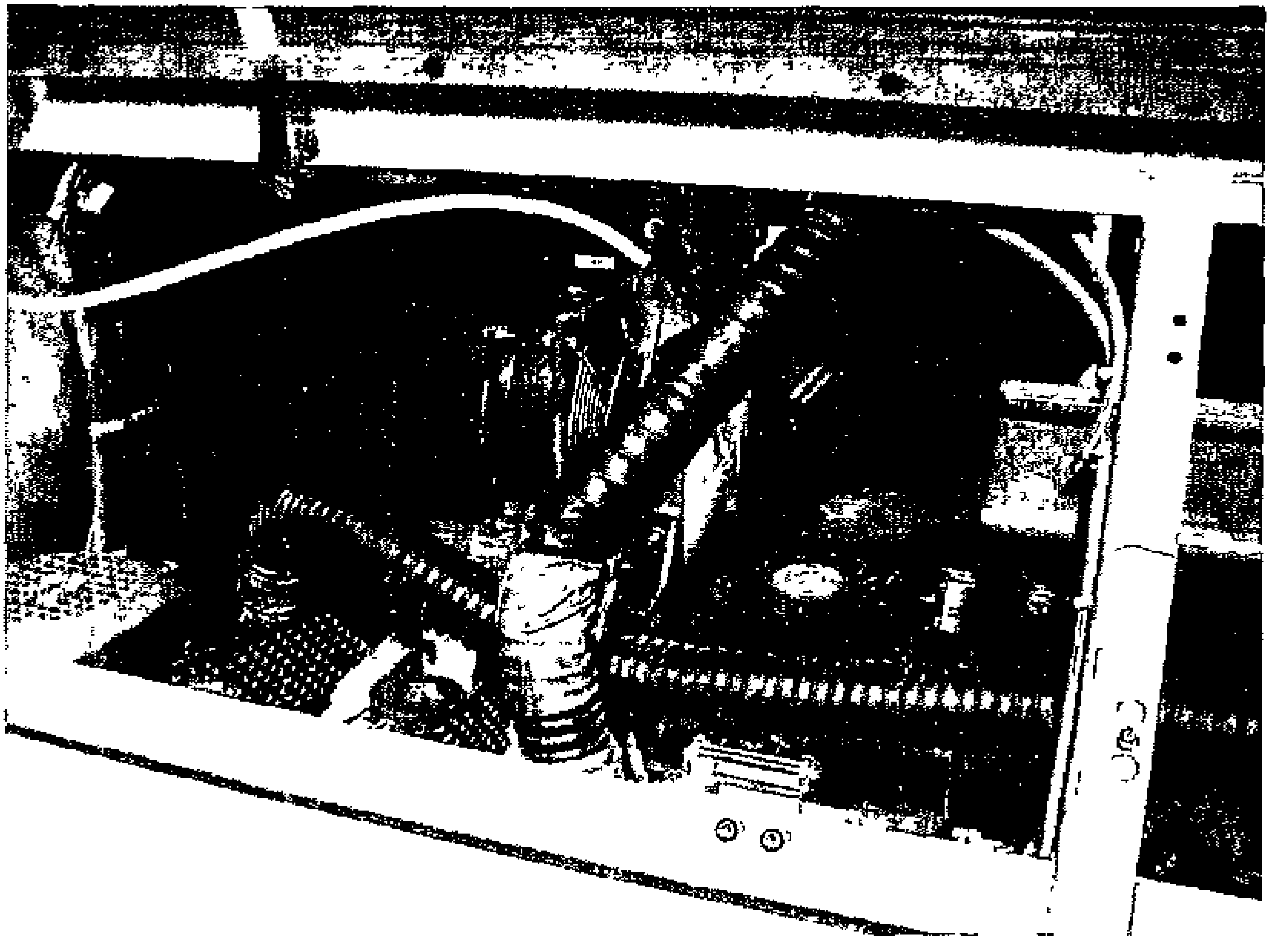


Figure 1   Dosing location for AFSM at pinch roller

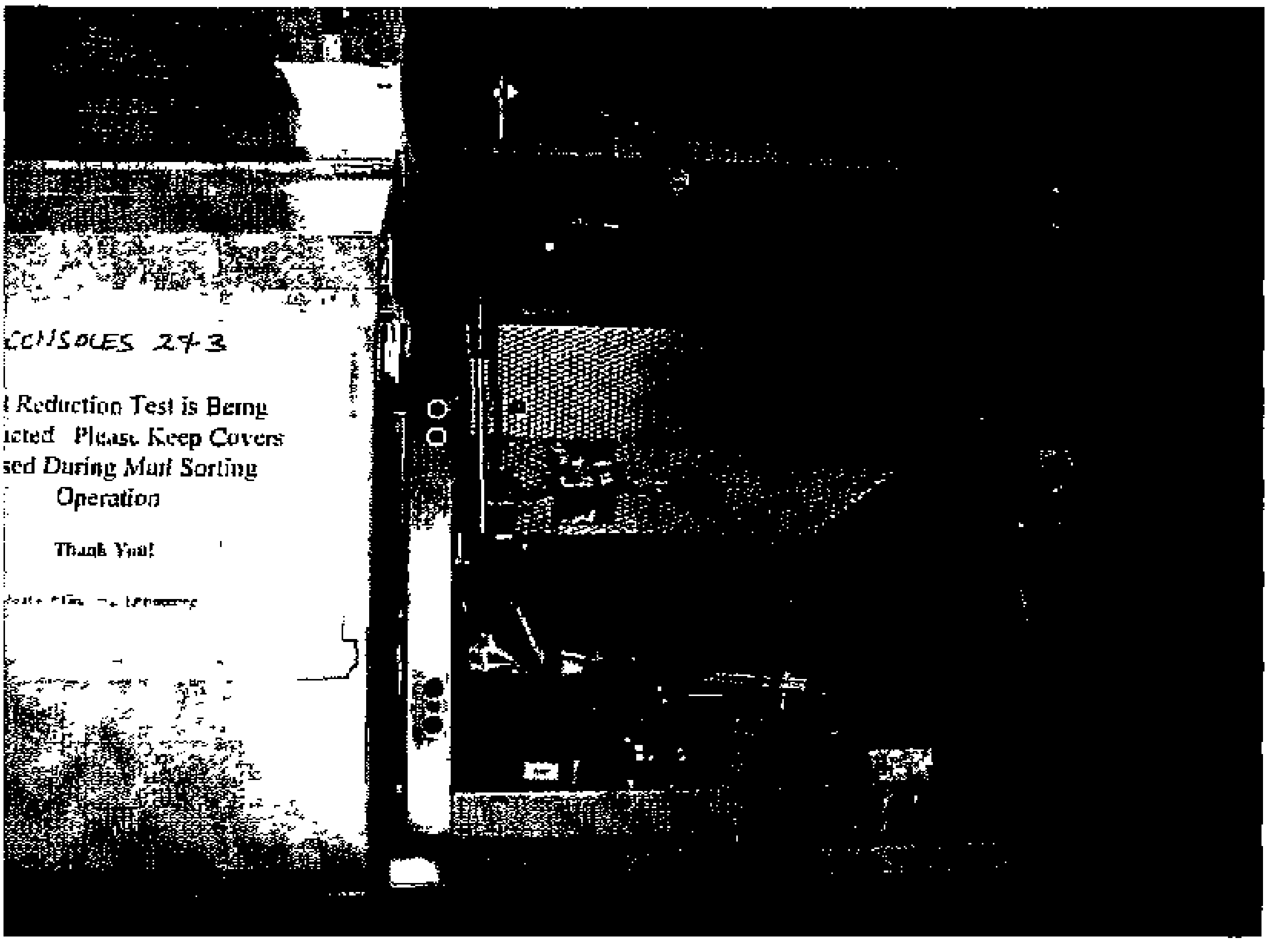


Figure 2 Dosing location for AFSM at filter

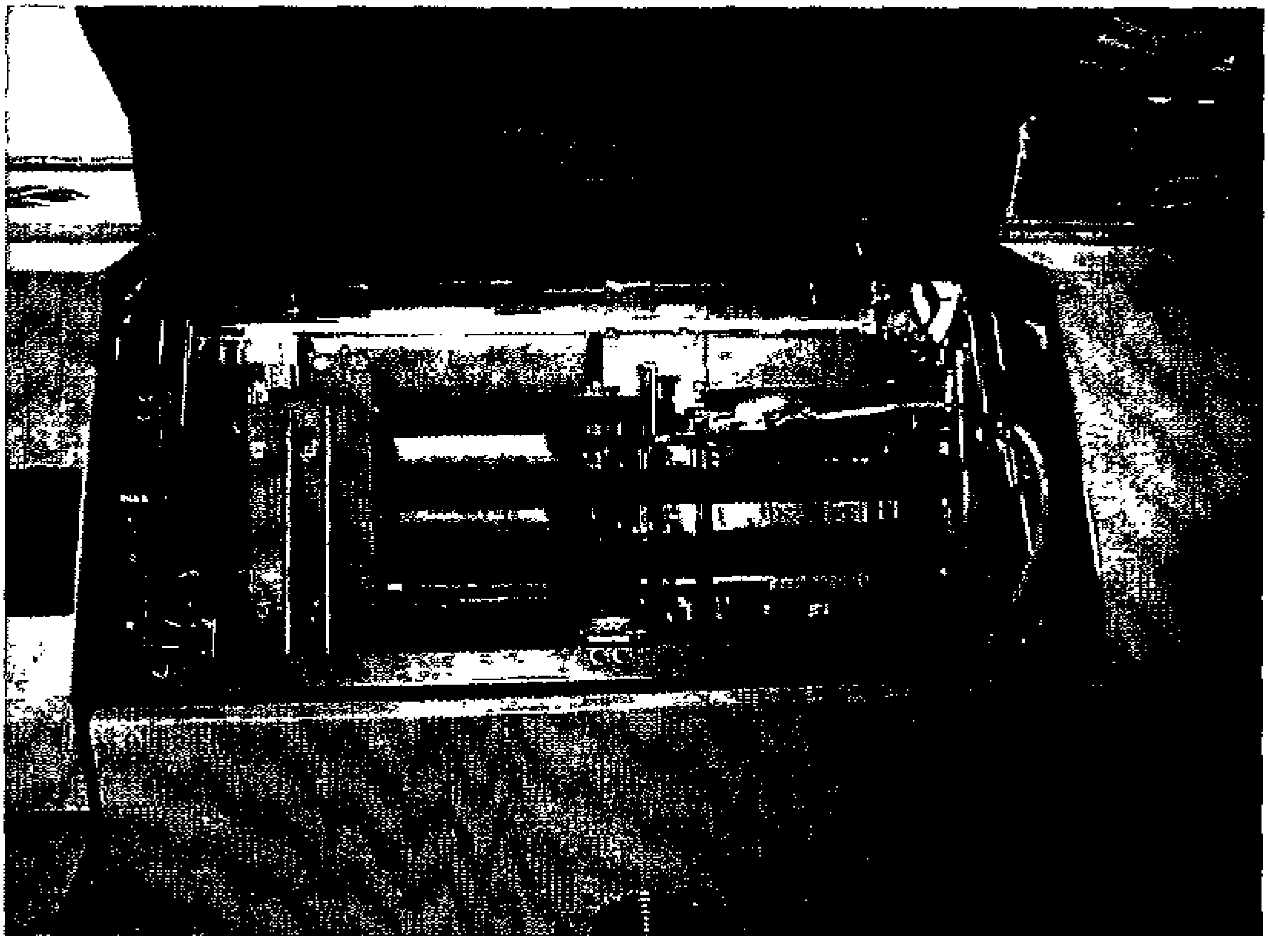


Figure 3 Dosing location for AFSM at OCR

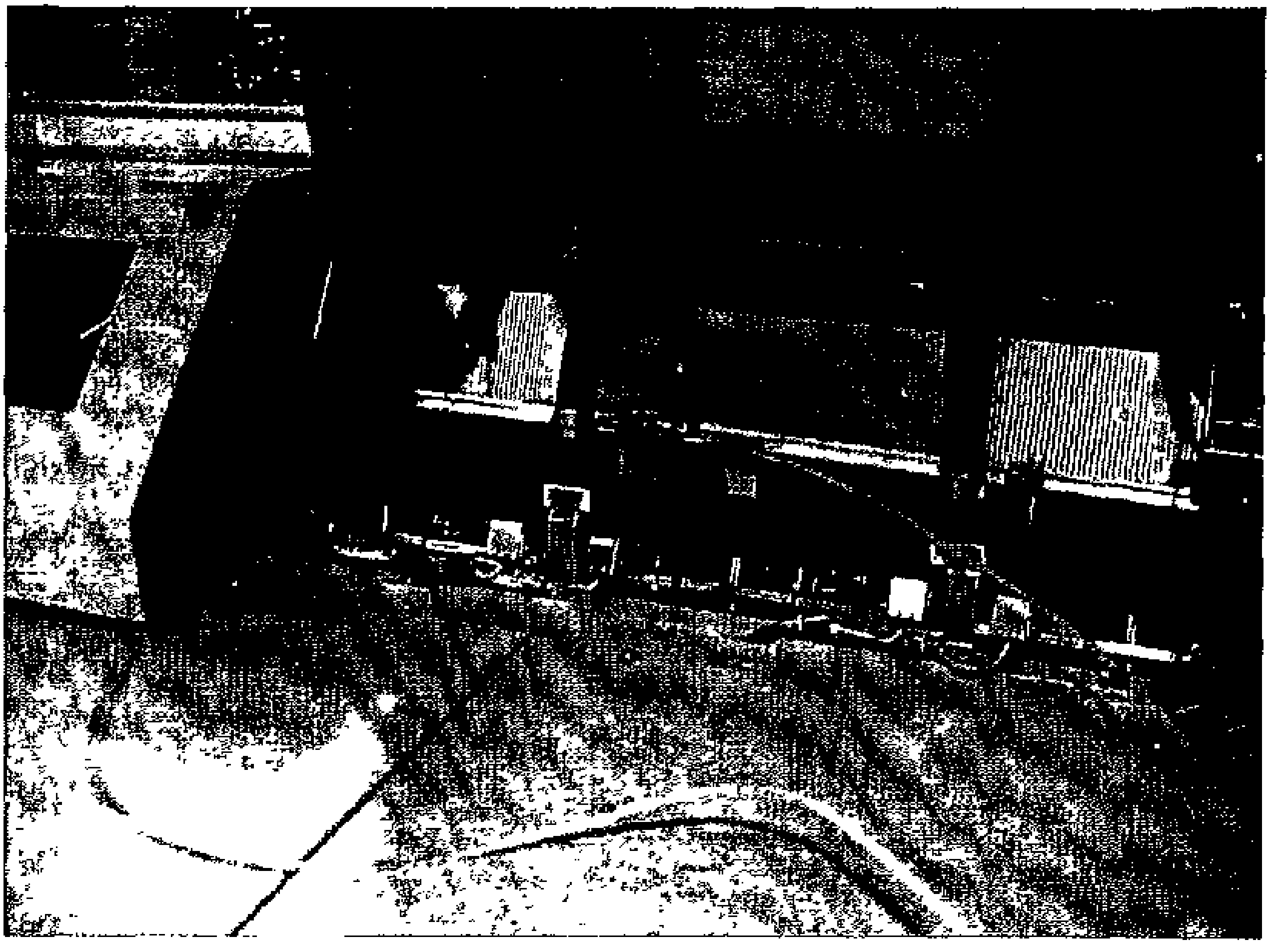


Figure 4 Dosing location for AFSM at buffer 2

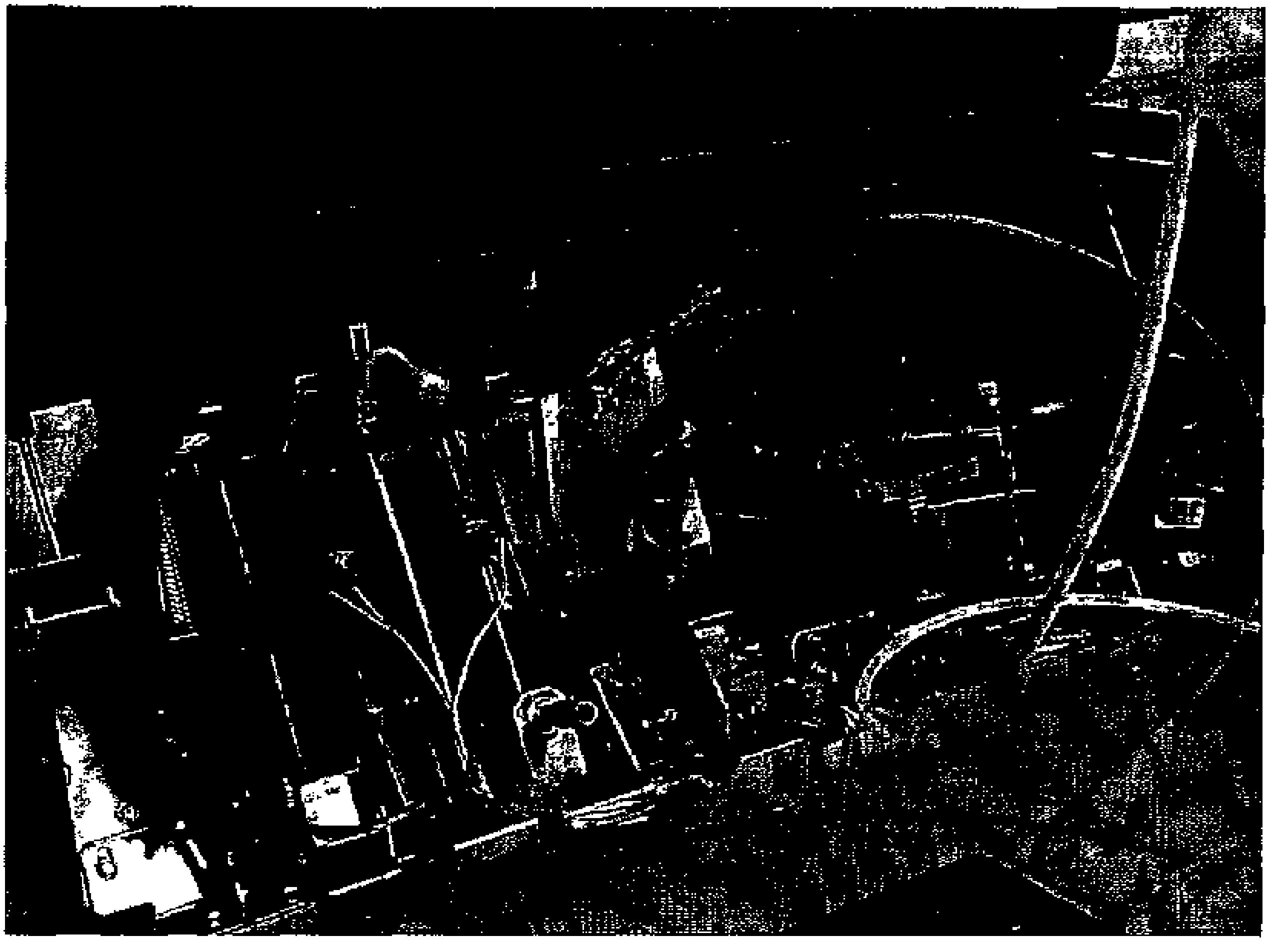
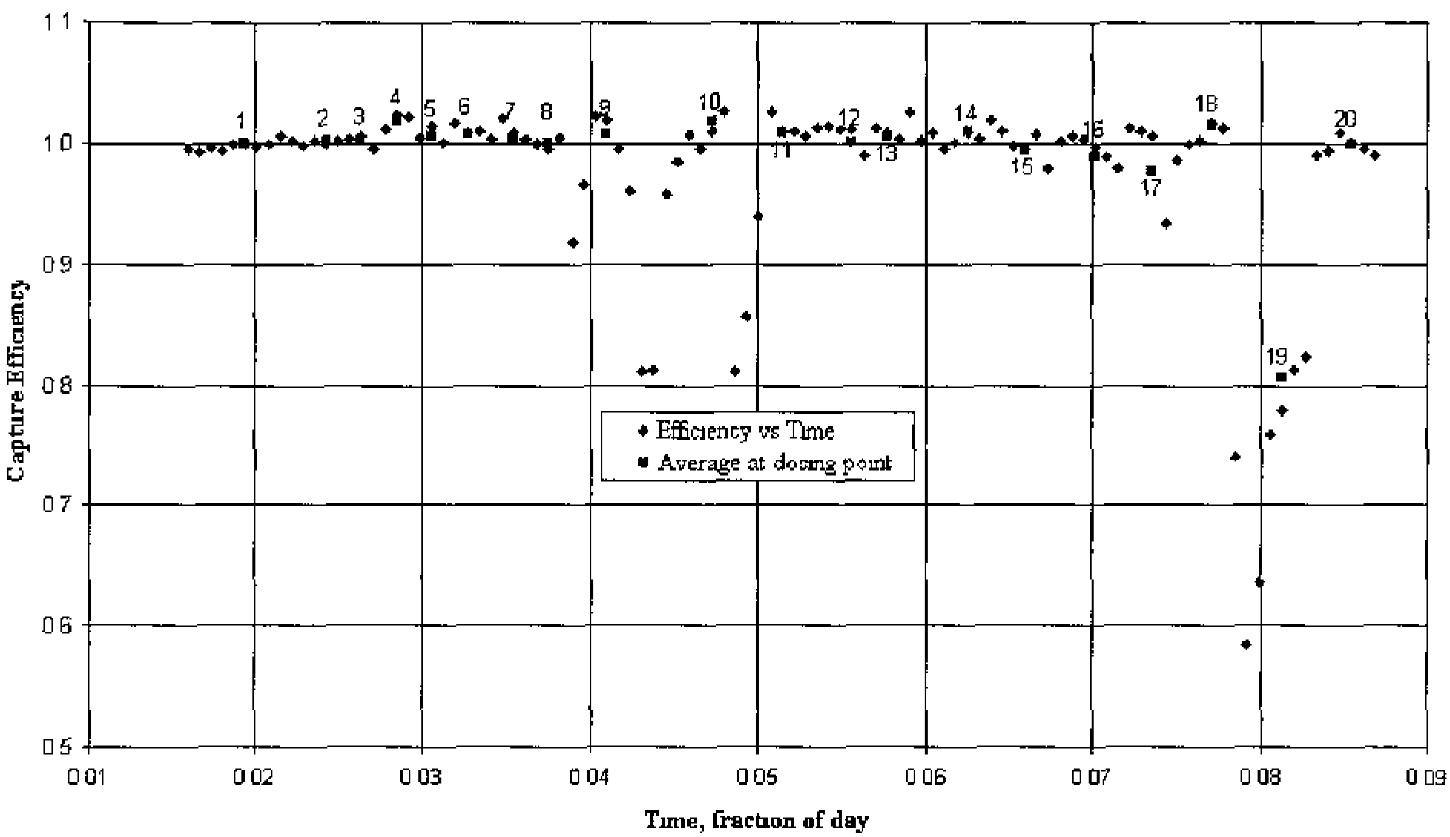


Figure 5 Dosing location for AFSM at injector

Figure 6 Tracer Gas Normalized Concentration vs Time, AFSM, Baltimore, March 19, 2002 (With Averages at Dosing Point)



DRAFT - DO NOT CITE

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