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IN-DEPTH SURVEY REPORT: EVALUATION OF LOCAL EXHAUST VENTILATION SYSTEMS FOR THE ADVANCED FACER CANCELLER SYSTEM

at

United States Postal Service
Cleveland Processing and Distribution Center
Cleveland, OH

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SITE SURVEYED	USPS Processing and Distribution Center, Cleveland, OH
SIC CODE	
SURVEY DATE	March 25-26, 2003
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ABSTRACT

Researchers from the National Institute for Occupational Safety and Health (NIOSH) conducted an evaluation of the Ventilation/Filtration System (VFS) developed for the United States Postal Service (USPS) mail-processing equipment–the Advanced Facer Canceller System (AFCS) The VFS was developed and installed by a private contractor hired by the USPS to reduce the potential for employee exposure to harmful substances that could be contained in mail pieces processed by the equipment This effort is in response to the 2001 terrorist attacks that used the mail as a delivery system for anthrax NIOSH was asked to assist the USPS in evaluating controls for this and other mail processing equipment

Evaluations were based on a variety of tests including tracer gas (TG) experiments, air velocity measurements and smoke release observations to evaluate contaminant capture efficiency; and simultaneous particle count experiments upstream and downstream of the VFS filtration to evaluate system filtration efficiency All three capture efficiency tests indicated that the VFS met or exceeded USPS minimum requirements at all locations not adjacent to the eventual Biohazard Detection System (BDS) installation site Filtration testing showed not only that the entire filtration system met or exceeded High Efficiency Particulate Air (HEPA) filtration parameters with either Donaldson HEPA filters or American Air Filter ® (AAF®) filters installed but also that these filters can be used interchangeably with the VFS system evaluated Furthermore, air velocity measurements made with restricted air flow to simulate "dirty filters" indicated that the capture capabilities of the system still met USPS acceptance criteria at all locations except, intentionally, at locations where the BDS was to be installed This indicates that the system should perform sufficiently well even under conditions of acceptable filter loading

Based on the results of the measurements and observations from the survey, the following recommendations are made to further monitor the capture and filtration of potential contaminants by this VFS

- The VFS for the AFCS should be re-tested when the production model of the BDS is installed onto the system. Furthermore, this testing should take place on a regular basis to ensure adequate capture efficiency in the area of the BDS This is especially important since the exhaust components of the VFS may interfere with proper exhaust and contaminant capture of the BDS
- VFS capture efficiency testing and filtration testing should be made regularly to ensure that USPS workers are continually protected against the effects of another bio-terrorist event
- AFCS VFS Unit # 1 through Unit # 7 should be tested for overall system filtration efficiency VFS Unit # 8 exceeding 99 97% efficiency does not infer that the other seven units will meet this requirement
- Extreme care should be taken when performing any maintenance on the VFS, particularly any operation that could disturb the seal of the filters inside the VFS housing
- Real-time total system integrity testing is the only reliable test method for evaluating total system filtration performance

- Although testing showed adequate capture under acceptable filter loading, care should be taken to perform filter maintenance and change-out on the manufacturer's recommended schedule

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.

Researchers from NIOSH were requested to assist the USPS in the evaluation of contaminant controls for various types of mail-processing equipment. These new controls are being installed to significantly reduce operator exposure to any potentially hazardous contaminants emitted from mail pieces during normal mail processing. This effort is driven by the 2001 terrorist attacks which used the mail as a delivery system for anthrax. NIOSH researchers have subsequently made several trips to USPS Processing and Distribution Centers (P&DCs) to observe mail-processing equipment in operation and to study the effectiveness of the newly designed controls.

The control evaluated in this report is a first-article model ventilation/filtration system (VFS) for the Advanced Facer Canceller System (AFCS). This control was designed and installed by a USPS contractor to significantly reduce the potential for operator exposure to bacterial contaminants that could be contained in mailpieces processed by this equipment. This system was evaluated at the Cleveland, Ohio Processing and Distribution Center during a field survey that took place March 25-26, 2003.

DESCRIPTION OF EQUIPMENT

The AFCS is an automated mail-processing system that culls, orients, cancels, scans, and sorts standard size (5 to 11.5 inches long by 3.5 to 6.125 inches high) mailpieces. The AFCS culls the mail to remove flats and overthick (greater than 0.25 in.) mailpieces. The mail is then properly oriented so it may be cancelled. Optical character recognition technology is used to read the addresses on the mailpiece which is then sorted and distributed to numbered bins for further automated processing. An overview of the AFCS is shown in Figure 1.

Ventilation and Filtration Equipment

The so-called Ventilation and Filtration System for the AFCS consisted of air handling/filtration units that provided exhaust for locations of possible contaminant release The air handling units were fitted with three stages of filtration composed of a pre-filter, a Minimum Efficiency Reporting Value (MERV) 14 filter, and a HEPA filter The effectiveness of the VFS was enhanced by enclosures put in place on the mail-processing equipment by the contractor Hoods/enclosures were fitted around areas that have higher potential for agitating or compressing mailpieces This is the major cause of contaminant release from tainted mailpieces [1]

METHODS

TRACER GAS

Apparatus

To quantitatively evaluate the capture efficiency of the ventilation system, a tracer gas method was used The gas, chemically pure (CP) grade sulfur hexafluoride (SF_6), was released at a constant rate at points in and near the sorter to determine the capture efficiency of the VFS at these release points The gas was supplied through a mass flow controller (Model 1359C-10000SV, MKS Baratron® & Control Products, Andover, Massachusetts) set to produce about 4 parts per million (ppm) in the exhaust outlet of the system. The exhaust from the ventilation system was filtered and then returned to the workroom near 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) to remove dust, and then pulled through a MIRAN® 203 Specific Vapor Analyzer (Thermo Environmental Instruments, Franklin, MA), using an AirCon® high volume air sampler (Gilian Instrument Corporation, W Caldwell, New Jersey) set for approximately 30 liters per minute, and using Tygon® tubing throughout the sampling system. After exiting the pump, the sampled air was released into the workroom. The analogue output signal from the MIRAN® was routed to a PCMCIA 12-bit analog card (Quatech Model # DAQP-12, Akron, OH) which allowed data storage and display at one-second intervals in real-time on a portable computer

Procedures

For these measurements, the output signal from the MIRAN® was recorded at 1 second intervals Each measurement of capture efficiency was recorded for a 2 to 4 minute interval The MIRAN® concentration corresponding to 100% capture was measured by releasing the SF_6 directly into a duct supplying the exhaust intake in that part of the system. This measurement was made immediately before and after the rest of the capture efficiency

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[1] Beamer B, Topmiller JL, Crouch KG [2003] In-Depth Survey Report Evaluation of the Ventilation and Filtration System and Biohazard Detection System for the Automated Facer Canceller System U S DHHS, CDC, NIOSH, NTIS Pub No EPHB 279-18a

measurements, as well as between a number of the efficiency measurements, to detect and correct for drift in the 100% level All of the tracer gas measurements were made with the ventilation system blower turned on A list of the sampling sites is given in Table 1

SMOKE RELEASE

Apparatus

A smoke machine (Mini Fogger, Model F-800, Chauvet USA, Hollywood, Florida) was used to visualize air movement in and around these systems

Procedures

By releasing smoke at points in and around the sorter with the VFS operating, the path of the smoke, and thus any airborne material potentially released at that point, could be determined If the smoke was captured quickly and directly by the VFS, it was a good indication of acceptable control design and 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 VFS design was considered marginal at that point A list of the smoke release sites is given in Table 2

CAPTURE VELOCITY

Apparatus

An anemometer was used to measure air speeds at exhaust openings on the AFCS (Velocicalc® Plus Anemometer, Model 8388, TSI Incorporated, 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 at exhaust openings around the system. To check capture velocities at the furthest point from the air intake, the anemometer was held at the edge of the equipment where a worker would be positioned A list of the measuring sites is given in Table 3

FILTRATION EFFICIENCY

Apparatus

The apparatus used to make measurements to calculate filtration efficiency was a GRIMM Portable Dust Monitor which uses optical scattering technology to measure particle concentration and estimate particle size (Model 1 108, GRIMM Technologies, Incorporated, Douglasville, GA) The GRIMM 1 108 provides continuous monitoring of aerosol particles and measures number (count) concentration per unit volume (typically liters) For the experiments conducted, data concerning concentrations of the following particle sizes were collected $\geq$0 3 μm, $\geq$0 4 μm, $\geq$0 5 μm, $\geq$0 65 μm, $\geq$0 8 μm, $\geq$1 0 μm, $\geq$1 6 μm, $\geq$2 0 μm, $\geq$3 0 μm, $\geq$4 0 μm, $\geq$5 0 μm, $\geq$7 5 μm, $\geq$10 0 μm, $\geq$15 0 μm, and $\geq$20 0 μm.

Procedures

The challenge aerosol used for measurements was the ambient aerosol that enters the HVAC system from air intakes One GRIMM Portable Dust Monitor was placed upstream of the filters to count particles with an isokinetic sampling probe facing the air stream

Simultaneously, another GRIMM Portable Dust Monitor was placed downstream of the filters with an isokinetic sampling probe facing the air stream. The particular GRIMMs used were a matched pair to minimize instrument-to instrument variability Filter penetration [P] was calculated by taking the ratio of the downstream particle counts [C_{down}] to the upstream particle counts [C_{up}] (× 100 gives percent penetration) Filter efficiency is then determined as 100 minus the calculated value for P Filter efficiencies were made both before and during periods of mail processing on the AFCS

It should be noted that only AFCS VFS Unit # 8 was tested for filtration efficiency At the time of the survey the USPS did not require testing for the other 7 AFCS VFS units Furthermore, two total system filtration efficiency tests were conducted on AFCS VFS Unit # 8 1) with Donaldson filters installed as manufactured/shipped, and 2) with AAF® filters installed to show that the results were independent of filters and that filters were interchangeable

"DIRTY FILTER" TESTING

It was advantageous to the USPS to also make some limited testing simulating "dirty" filters This testing was borne out of concern that fully loaded filter media would have a negative effect on the capture efficiency of the VFS "Dirty Filter" simulation was accomplished by placing covers over the exhaust to restrict air flow The pressure alarm, which activates when filter media needs to be replaced, was activated Under these conditions, air velocity measurements were made at a representative sampling of locations (see Table 5 for specific locations)

RESULTS

Tracer gas

The mass flow controller was set to produce a 4 ppm concentration of SF_6 in the ventilation system exhaust when 100% of the gas was being captured The relative concentration in the exhaust as a result of tracer dosing at any point, which is equivalent to the capture efficiency at that point, is given in Table 1 Point estimates for contaminant capture efficiencies at each location tested were greater than or equal to 98% The exception to this statement is at locations "Q" and "R" These locations represented areas that would later be fitted with a Biohazard Detection System (BDS) The BDS is intended to sample for contaminant and as a part of its design, it has its own capture capabilities that are intended not to interfere with those of the VFS for the AFCS *Therefore, the VFS for the AFCS was intentionally designed to provide greatly reduced capture velocities and contaminant capture efficiencies where the BDS is to be installed* Although the BDS was not installed during the time of the survey, capture efficiencies at locations "Q" and "R" reflect the fact that the VFS was intentionally turned down at these points

Smoke

Smoke release experiments were conducted to visually determine the effectiveness of the exhaust ventilation control at various points around the mail distribution system. Smoke was well controlled in all areas tested as it was entrained quickly and directly into the influence of the VFS Again, the exception to these statements is at locations "Q" and "R" where the BDS was to be installed, at these locations smoke was only marginally entrained into the VFS

Air Velocity
Air velocity measurements were taken at various locations All measurements met or exceeded the USPS minimum standard of 100 feet per minute (see Table 3) Note, however, that capture velocities are intentionally lower at locations "Q" and "R" as these locations would later be fitted with a BDS

Filtration Efficiency
The Air Handling Unit # 8 for the AFCS showed system efficiencies greater than 99 97%, which is the minimum HEPA filter efficiency level and minimum USPS acceptance criteria (see Table 4) Tests conducted with Donaldson HEPA filters and AAF® HEPA filters in AFCS VFS Unit # 8 also met USPS acceptance criteria and showed that the filters are interchangeable

"Dirty Filter" Testing
Air velocity measurements made during conditions of restricted air flow (to simulate a fully-loaded or "dirty" filter) showed somewhat lower air velocities, but still met USPS requirements for capture velocity Please refer to Table 5 for details

DISCUSSION

All three tests that evaluate capture efficiency, tracer gas experimentation, smoke release observations, and air velocity measurements, showed that the VFS met or exceeded USPS minimum requirements at all locations not adjacent to the eventual BDS installation site (locations Q and R in Figure 2) It is important, therefore, for the USPS to keep in mind that until the BDS is installed, any contaminant released at this site has the potential to escape into the worker's breathing zone It should be noted, however, that at the time of the writing of this report, the development of production versions of these bio-hazard detection systems was on-track to be rolled out simultaneously with the VFS for the advanced facer canceller system.

Filtration testing showed not only that the entire filtration system met or exceeded HEPA filtration parameters with both Donaldson HEPA filters and AAF® filters installed but also that these filters can be used interchangeably with the VFS system evaluated

Air velocity measurements made with restricted air flow to simulate "dirty filters" indicated that the capture capabilities of the system still met USPS acceptance criteria at all locations except, intentionally at locations where the BDS was to be installed This indicates that the system should perform sufficiently well even under conditions of acceptable filter loading

RECOMMENDATIONS

Based on the results of the measurements and observations from the survey, the following recommendations are made to further improve the capture and filtration of potential contaminants by this VFS

- The VFS for the AFCS should be re-tested when the production model of the BDS is installed onto the system. Furthermore, this testing should take place on a regular basis to ensure adequate capture efficiency in the area of the BDS This is especially important since the exhaust components of the VFS may interfere with proper exhaust and contaminant capture of the BDS

- VFS capture efficiency testing and filtration testing should be made regularly to ensure that USPS workers are continually protected against the effects of another bio-terrorist event
- AFCS VFS Unit # 1 through Unit # 7 should be tested for overall system filtration efficiency VFS Unit # 8 exceeding 99 97% efficiency does not infer that the other seven units will meet this requirement
- Extreme care should be taken when performing any maintenance on the VFS, particularly any operation that could disturb the seal of the filters inside the VFS housing
- Real-time total system integrity testing is the only reliable test method for evaluating total system filtration performance
- Although testing showed adequate capture under acceptable filter loading, care should be taken to perform filter maintenance and change-out on the manufacturer's recommended schedule

Figure 1 Overview of the Advanced Facer Canceller System

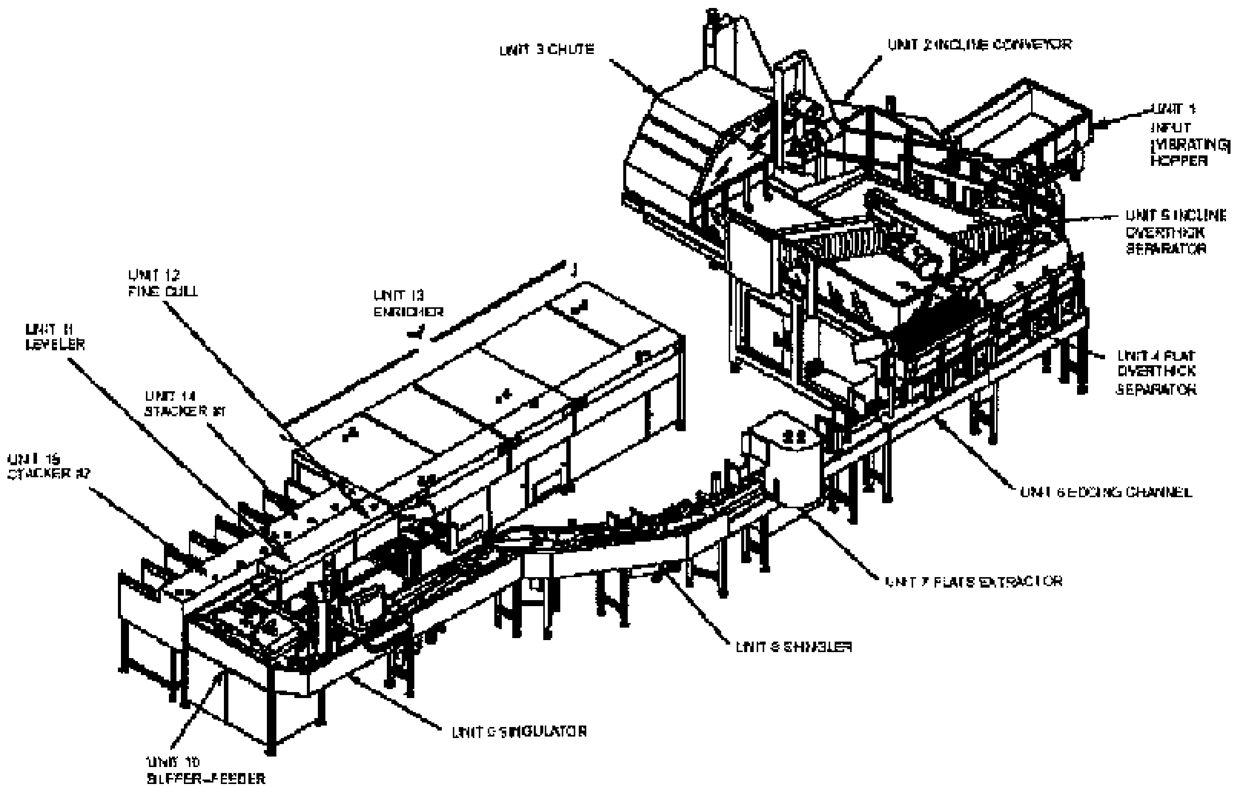

Figure 2 Locations of Capture Efficiency Evaluation

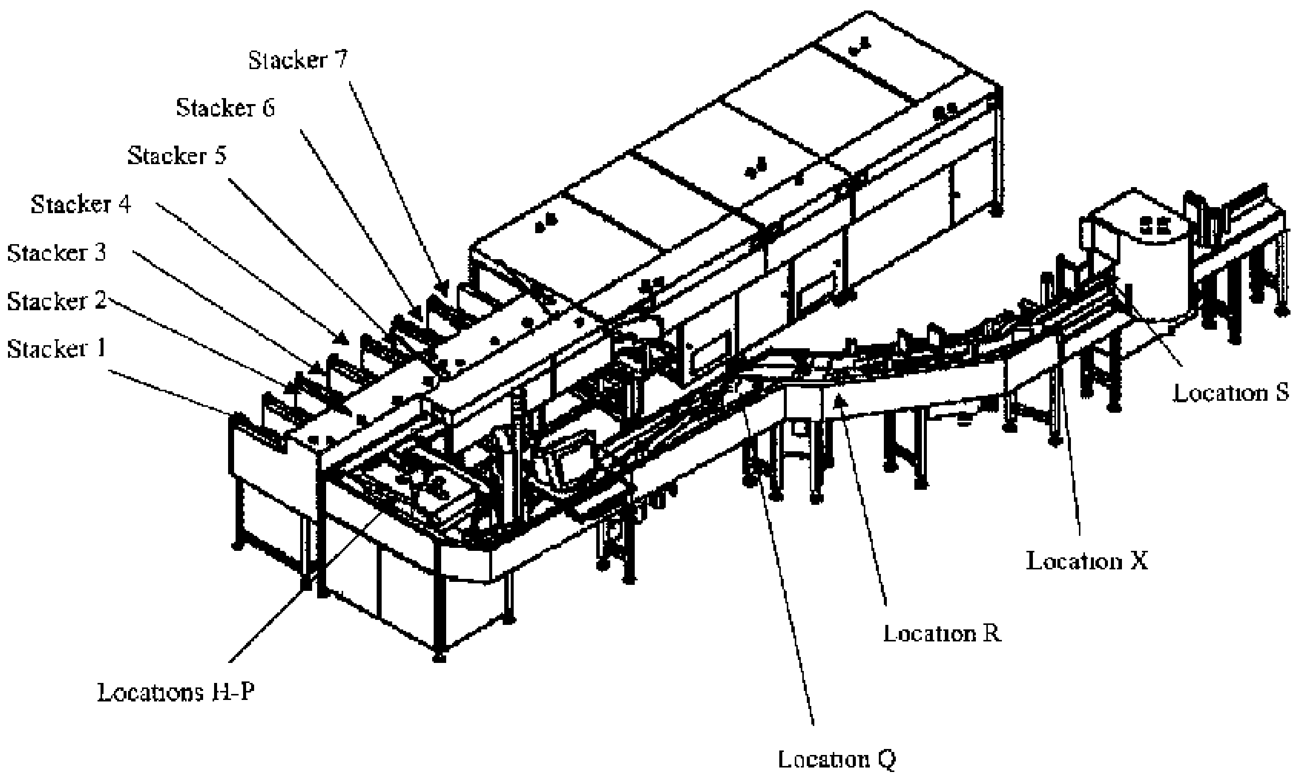

Figure 3 View of AFCS with VFS

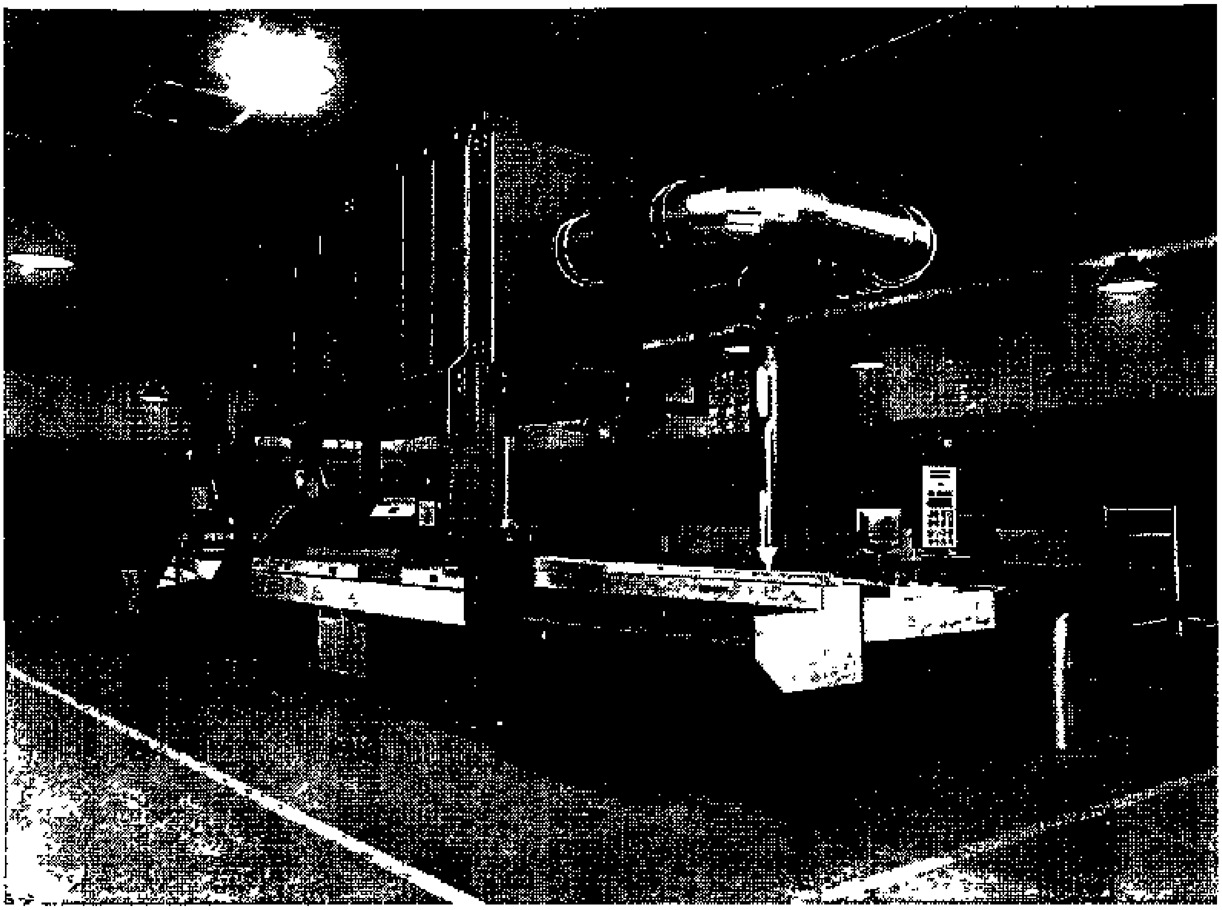

Figure 4 Close-up of locations H-P

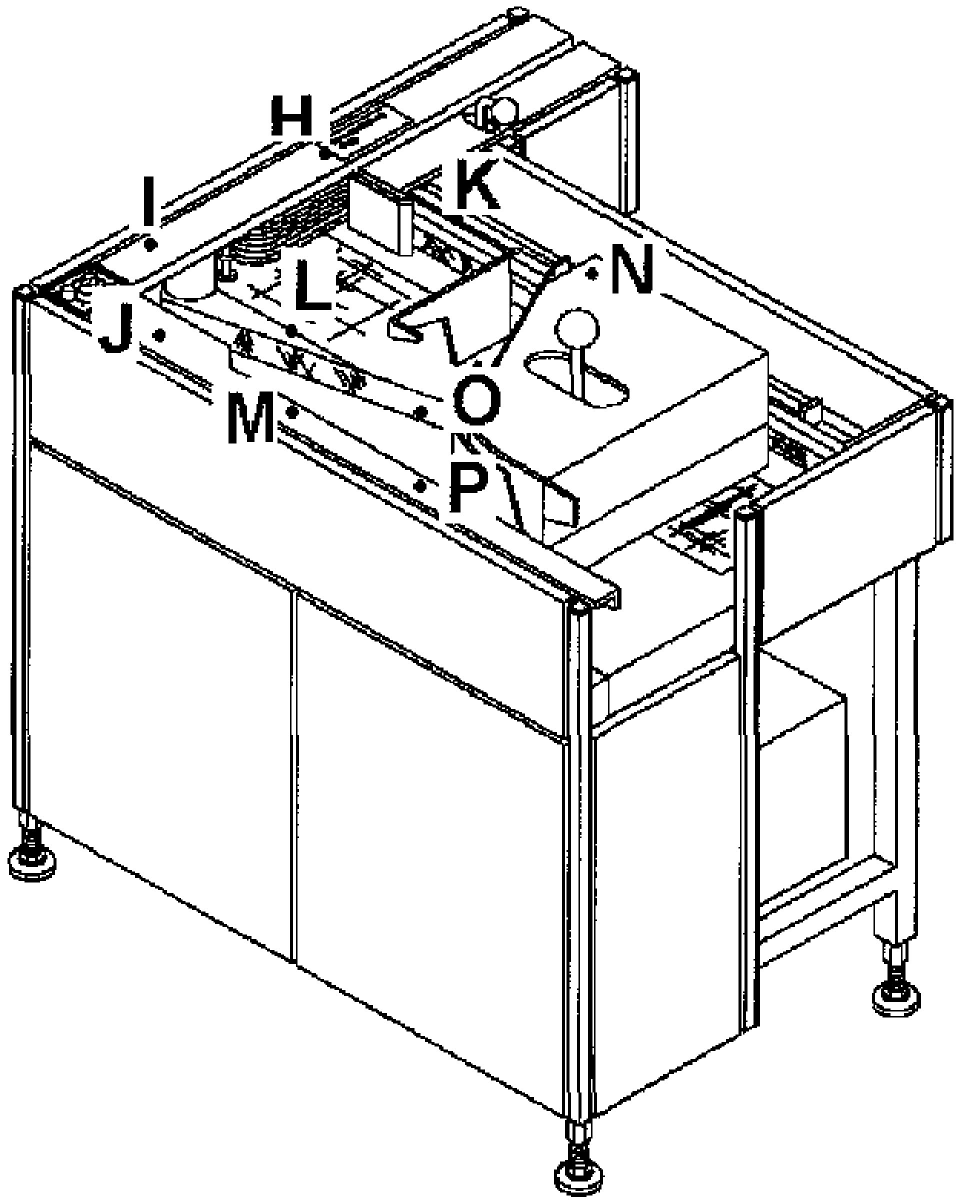

Table 1 Positions for Tracer Gas Release and Measured Efficiencies

AREA	CONTAMINANT CAPTURE EFFICIENCY
STACKER 1	>98%
STACKER 2	98%
STACKER 3	>98%
STACKER 4	>98%
STACKER 5	>98%
STACKER 6	>98%
STACKER 7	>98%
FEEDER MODULE LOCATION "H"	>98%
FEEDER MODULE LOCATION "I"	>98%
FEEDER MODULE LOCATION "J"	>98%
FEEDER MODULE LOCATION "K"	>98%
FEEDER MODULE LOCATION "L"	>98%
FEEDER MODULE LOCATION "M"	98%
FEEDER MODULE LOCATION "N"	>98%
FEEDER MODULE LOCATION "O"	98%
FEEDER MODULE LOCATION "P"	>98%
LOCATION "X", JUST DOWNSTREAM OF FLATS EJECTOR	98%
LOCATION "Q", NEAR DOWNSTREAM FACE OF BDS	***97%***
LOCATION "R", NEAR UPSTREAM FACE OF BDS	***85%***
LOCATION "S", AT FLATS EXTRACTOR	>98%

Table 2 Positions for Smoke Release Observations and Comments

AREA OF RELEASE	OBSERVATION
STACKER 1	RAPID CAPTURE OF SMOKE
STACKER 2	RAPID CAPTURE OF SMOKE
STACKER 3	RAPID CAPTURE OF SMOKE
STACKER 4	RAPID CAPTURE OF SMOKE
STACKER 5	RAPID CAPTURE OF SMOKE
STACKER 6	RAPID CAPTURE OF SMOKE
STACKER 7	RAPID CAPTURE OF SMOKE
FEEDER MODULE LOCATION "H"	RAPID CAPTURE OF SMOKE
FEEDER MODULE LOCATION "I"	RAPID CAPTURE OF SMOKE
FEEDER MODULE LOCATION "J"	RAPID CAPTURE OF SMOKE
FEEDER MODULE LOCATION "K"	RAPID CAPTURE OF SMOKE
FEEDER MODULE LOCATION "L"	RAPID CAPTURE OF SMOKE
FEEDER MODULE LOCATION "M"	RAPID CAPTURE OF SMOKE
FEEDER MODULE LOCATION "N"	RAPID CAPTURE OF SMOKE
FEEDER MODULE LOCATION "O"	RAPID CAPTURE OF SMOKE
FEEDER MODULE LOCATION "P"	RAPID CAPTURE OF SMOKE
LOCATION "X", JUST DOWNSTREAM OF FLATS EJECTOR	RAPID CAPTURE OF SMOKE
LOCATION "Q", NEAR DOWNSTREAM FACE OF BDS	***MARGINAL CAPTURE OF SMOKE***
LOCATION "R", NEAR UPSTREAM FACE OF BDS	***MARGINAL CAPTURE OF SMOKE***
LOCATION "S", AT FLATS EXTRACTOR	RAPID CAPTURE OF SMOKE

Table 3 Positions for Air Velocity Measurements and Recorded Values

AREA OF RELEASE	OBSERVATION
STACKER 1	142
STACKER 2	129
STACKER 3	136
STACKER 4	123
STACKER 5	118
STACKER 6	114
STACKER 7	115
FEEDER MODULE LOCATION "H"	125
FEEDER MODULE LOCATION "I"	202
FEEDER MODULE LOCATION "J"	191
FEEDER MODULE LOCATION "K"	270
FEEDER MODULE LOCATION "L"	172
FEEDER MODULE LOCATION "M"	144
FEEDER MODULE LOCATION "N"	258
FEEDER MODULE LOCATION "O"	205
FEEDER MODULE LOCATION "P"	132
LOCATION "X", JUST DOWNSTREAM OF FLATS EJECTOR	129
LOCATION "Q", NEAR DOWNSTREAM FACE OF BDS	***11***
LOCATION "R", NEAR UPSTREAM FACE OF BDS	***18***
LOCATION "S", AT FLATS EXTRACTOR	117

Table 4 Filtration Efficiencies at Air Handling Unit for AFCS VFS Unit 8

Particulate Size Range	Requirement	Unit 8 with AAF® filters	Unit 8 with Donaldson filter
0 3--0 4 um	99 97%	99 974	99 991
0 4--0 5 um	99 97%	99 980	99 989
0 5--0 65 um	99 97%	99 990	>99 999
0 65--0 8 um	99 97%	>99 999	>99 999
0 8--1 0 um	99 97%	>99 999	>99 999
1 0--1 6 um	99 97%	>99 999	>99 999
1 6--2 0 um	99 97%	>99 999	>99 999
2 0--3 0 um	99 97%	>99 999	>99 999

Table 5 Capture Velocities Reduced Air Velocities ("Dirty Filter" Tests)

AREA OF RELEASE	OBSERVATION
STACKER 1	97
STACKER 4	100
STACKER 7	103
FEEDER MODULE LOCATION "H"	114
FEEDER MODULE LOCATION "L"	162
FEEDER MODULE LOCATION "P"	117
LOCATION "X", JUST DOWNSTREAM OF FLATS EJECTOR	105
LOCATION "Q", NEAR DOWNSTREAM FACE OF BDS	*19*
LOCATION "R", NEAR UPSTREAM FACE OF BDS	*28*