IN-DEPTH SURVEY REPORT
EVALUATION OF LOCAL EXHAUST VENTILATION SYSTEM FOR THE 010 CULLING SYSTEM

at

United States Postal Service
Merrifield Processing and Distribution Center
Merrifield, Virginia

REPORT WRITTEN BY
Jennifer L Topmiller
Keith G Crouch
Bryan Beamer

REPORT DATE
January 2003

REPORT NO
EPHB 279-14a

U S DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
Division of Applied Research and Technology
Engineering and Physical Hazards Branch
4676 Columbia Parkway, Mail Stop R-5
Cincinnati, Ohio 45226-1998

SITE SURVEYED	USPS Processing and Distribution Center, Merrifield, Virginia
SIC CODE	
SURVEY DATE	June 17-18, 2002
SURVEY CONDUCTED BY	Bryan Beamer, NIOSH Keith Crouch, NIOSH Jenny Topmiller, NIOSH
EMPLOYER REPRESENTATIVES CONTACTED	Tom Potter Senior Mechanical Engineer
EMPLOYEE REPRESENTATIVE CONTACTED	W Corey Thompson, Jr Safety & Health Specialist American Postal Workers Union, AFL-CIO

DISCLAIMER

Mention of company names or products does not constitute endorsement by the Centers for Disease Control and Prevention

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 sorting system - the 010 Culling System The ventilation control system 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 processed by the equipment 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 USPS in evaluating controls for this and other mail processing equipment

The 010 Culling System consists of 2 conveyor systems that size collection mail The first is the Dual Pass Rough Cull (DPRC), and the second is the Loose Mail Distribution System (LMDS) Evaluations were based on a variety of tests including tracer gas experiments, air velocity measurements, and smoke release observations The experiments showed that generally there is good capture by the ventilation system, however, there are some points that require improvement Results of tracer gas tests showed capture efficiencies exceeding 95% for the majority of the positions tested The bypass chute for the LMDS showed poor control (68%) as did the exhaust on belt LL-7 (82%) The other areas of poor control were the flats extractors from the DPRC lines 1 and 2 (23% and 48%, respectively), and the letter channel drop (49%) Smoke release observations and air velocity measurements support these results Smoke tests also revealed an open area near the hamper dumper for the LMDS above the cull belt that was not controlled

Based on these results as discussed in this report, the following recommendations are made to further improve the control of potential contaminants by this mail sorting system

- Improve the ventilation on the letter channels exiting the waterfall area of the DPRC, particularly near the ends where the mail pieces undergo the most agitation

- Add exhaust to the area above the cull belt just after the hamper dumper

- Improve the ventilation for the flats extractors on the DPRC

- Redesign the exhaust hood for the letter channel drop The hood face was covered with mail during operation, preventing the hood from operating properly

INTRODUCTION

The National Institute for Occupational Safety and Health (NIOSH) is located in the Centers for Disease Control and Prevention, 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 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 develop, 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 one of several reports for 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 Ventilation/Filtration System (VFS) for the 010 Culling System

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 emitted from 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 the VFS for the 010 Culling System 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 mail processed by this equipment The control was a prototype that will be changed to further improve its efficiency This system was evaluated at the Merrifield, Virginia Processing and Distribution Center (P&DC) during a field survey that took place June 17-18, 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 is manifested in one of three ways inhalational disease, cutaneous disease, and gastrointestinal disease [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 agitated and compressed in a number of places that could cause the release of substances from the mail

DESCRIPTION OF EQUIPMENT

The USPS 010 Culling System is comprised of 2 conveyor systems that size the collection mail brought to the P&DC into letters, flats (magazine size), and parcels The first system is called the Dual Pass Rough Cull (DPRC) and the second is the Loose Mail Distribution System (LMDS) The hampers of raw mail are loaded into the DPRC Flats and parcels are separated from the letter mail and sent to the appropriate areas of the facility for processing The output of the LMDS sends letter mail to the cancellation equipment Figure 1 shows an overview of the 010 system

At the time of evaluation, the VFS for the 010 Culling System consisted of two separate air handling/filtration units that provided exhaust for various locations of possible contaminant release Air-Handling Unit#1 processed about 19,000 cubic feet per minute (cfm) and could be switched to service various areas depending upon USPS processing needs, including the LMDS area and conveyors that send mail to equipment downstream of the 010 Culling System Air-Handling Unit #2 processed about 18,000 cfm and serviced the primary areas of the DPRC Each of these air-handling units was fitted with three stages of filtration composed of a pre-filter, a MERV 14 filter and a High Efficiency Particulate Air (HEPA) filter Furthermore, several areas of potential contaminant release were enclosed or partially enclosed by the manufacturer so that the VFS could more effectively protect the worker from exposure

METHODS

TRACER GAS

Apparatus

To quantitatively evaluate the capture efficiency of the ventilation system, a tracer gas method was used The gas, chemically pure sulfur hexafluoride (SF_6), was released at a constant rate at points in and near the sorter to determine the capture efficiency of the ventilation and filtration system (VFS) at these release points Release points included areas where workers typically process mail 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 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, 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 an AirCon® high volume air sampler (Gilian Instrument Corporation, W Caldwell, New Jersey) set for approximately 30 lpm. 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 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 few measurements were made with test mail being dumped on the conveyor of the DPRC A list of the sampling sites is given in Table 1

SMOKE RELEASE

Apparatus

A smoke machine (Mini Fogger, Model F-800, Chauvet USA, 3000 North 29th Court, Hollywood, Florida, 33020) 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 qualitatively 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 Smoke release observations were made at the hamper dumper, the hoods over the cull belt, the LL belt, and at any hood or opening through which exhaust was drawn Also, we introduced smoke inside the machine near external gaps, and watched for the escape of the smoke through the gaps In addition, the dynamic behavior of the VFS was observed with smoke The containment that covered the metering and waterfall areas was filled with smoke, and the time required by the VFS to clear the smoke was observed

CAPTURE VELOCITY

Apparatus

An anemometer was used to measure air speeds at exhaust openings on the LMDS and DPRC (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 at the hamper dumper and at exhaust openings around the system Velocity measurement points included typical worker positions during mail processing

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 This data is shown graphically in Figure 2 The measured capture efficiencies ranged from 0 23 to 1 02 at approximately nine different locations around the 010 system

Smoke

Smoke release experiments were conducted to visually determine how effective the exhaust ventilation control is at various points around the mail distribution system Smoke was well controlled in most areas and was found to be effectively captured by the exhaust system Good control was observed in the hamper dumper and waterfall areas of the DPRC Control was somewhat marginal in the area around the letter channel exiting the DPRC, it was determined that the exhaust hood face was covered with mail Smoke was released into the enclosures formed by the curtains that covered the conveyor areas of the DPRC to observed the clearance rates In the metering area, there was good control, and smoke that was injected into the area was quickly removed The clearance in the waterfall area was somewhat slower, although still considered to be adequate to protect a worker who would need access to the area to clear a jam

Additional smoke tests were conducted on the cull belt of the LMDS There were three canopy type hoods with flexible plastic curtains over this portion of the belt The smoke release showed good control in this area However, at the end of this line closest to the hamper dumper area where belt CC-1 dumps onto CC-4, poor control of smoke was noted There is no exhaust in place in this area The other area where poor control was noted was at the end of the line that feeds the AFCS machines, the outlet from the bypass chute was not well controlled

Velocity

Air velocity measurements were taken in areas that require operator access during mail sorting Table 2 list the velocity ranges recorded at the various measurement locations At the DPRC, velocities were measured approximately 100-170 fpm near the hamper dumper in the plane of the plastic curtain At the bypass chute from the LMDS, velocities under the chute were variable but in the range of 50 fpm, significantly below the target velocity of 100 fpm For the belt that feeds the drops to the AFCS machines (LL), the velocities measured near the exhaust hood entrances were approximately 100-200 fpm The face velocities for the three canopy hoods over the cull belt of the LMDS ranged from 96 fpm to 113 fpm

DISCUSSION

Overall, the exhaust ventilation systems on the LMDS and DPRC provided good control as shown by the experiments carried out on June 17 and 18, 2002 The measured capture efficiencies exceeded 95% in most cases and were essentially 100% in many instances The tracer tests showed a few places that require additional ventilation or a change in the hood design The bypass chute on the LMDS had a poor control efficiency of 68% However, it was indicated at the time of the survey that this chute would not be used If it was made operational, it would be important to increase the ventilation flow here Tracer measurements were taken at the hood entrances on the belt that feeds the mail to the Automated Facer Canceller Systems (AFCS) The efficiency measured at LL-7 was 82% although higher efficiencies were obtained at the other locations

The other areas that had unsatisfactory capture efficiencies were the flats extractors for DPRC 1 and 2 (23% and 48%, respectively) This area is of concern as the current ventilation configuration is not effective and needs to be redesigned to obtain better control The letter channel drop onto CC-4 also had a poor collection efficiency of 49% The hood in this area was covered with mail which resulted in the low efficiency It may be sufficient to redesign the hood grille to prevent the mail from attaching to the exhaust surface

The smoke and air velocity tests support the results of the tracer tests and provide some additional information The area above the cull belt where the conveyor from the LMDS hamper dumper drops was not enclosed and showed poor control Smoke clearance tests were conducted on the DPRC enclosures above the metering and waterfall sections Both showed quick clearance of smoke (on the order of < 1 minute), although the clearance in the waterfall area was somewhat slower The clearance rates are important to determine how quickly the majority of a contaminant would be removed from the area if an employee were required to enter the enclosure to clear a jam

RECOMMENDATIONS

Based on the results of the measurements and observations from the survey, the following recommendations are made to further improve the control of potential contaminants by this mail sorting system

- Improve the ventilation on the letter channels exiting the waterfall area of the DPRC, particularly near the ends where the mail pieces undergo the most agitation
- Add exhaust to the area above the cull belt just after the hamper dumper
- Improve the ventilation for the flats extractors on the DPRC
- Redesign the exhaust hood for the letter channel drop The hood face was covered with mail during operation, preventing the hood from operating properly

Table 1 Positions for Tracer Gas Release and Measured Efficiencies

Measurement Number	Description of Measurement Location	Efficiency
1	LMDS, hamper dumper, position A	1.00202
2	LMDS, hamper dumper, position B	1.00023
3	LMDS, hamper dumper, position C	0.99696
4	LMDS, hamper dumper, position D	0.9995
5	LMDS, cull belt, hood 1	1.01414
6	LMDS, cull belt, hood 2	1
7	LMDS, cull belt, hood 3	0.99007
8	LMDS, bypass chute	**0.679**
9	Exhaust on LL-10	0.96525
10	Exhaust on LL-10 (other end)	0.98511
11	Exhaust on LL-11	0.98331
12	Exhaust on LL-7	**0.81936**
13	DPRC, bottom of hamper dumper	1.01063
14	DPRC, upstream of hamper dumper, on conveyor	1.00116
15	DPRC, metering section	1.02174
16	DPRC, 2nd hood after hamper dumper	0.98663
17	DPRC, last dump station, end of conveyor	0.97611
18	DPRC, last dump station	1.00702
19	Letter chute from DPRC 2	1.00904
20	Letter chute from DPRC 1	0.96185
21	MX-2	0.98335
22	Flats extractor, 1	**0.23004**
23	Flats extractor, 2	**0.47809**
24	CC-4, letter channel drop	**0.48556**
25	Feeder 2, letter dump onto conveyor	0.99369
26	Feeder 1, letter dump onto conveyor	0.95964
27	Package dump	0.95262
28	DPRC 1, bottom of waterfall	0.97554
29	Repeat site 28	0.95439

Table 2 Positions for Air Velocity Measurements and Recorded Values

Measurement Position	Velocity Range (fpm)
DPRC, hamper dumper, plane at edge of belt	106-168
Bypass Chute from LMDS	~ 50
LMDS, exhaust on LL-5	205
LMDS, exhaust on LL-6	166
LMDS, exhaust on LL-6 (end of line)	120
LMDS, exhaust on LL-8	106
LMDS, exhaust on LL-10	102
LMDS, exhaust on LL-10 (end of line)	150
LMDS, cull belt, hood 1	113
LMDS, cull belt, hood 2	101
LMDS, cull belt, hood 3	96

Figure 1 Overview of 010 Loose Mail Culling System

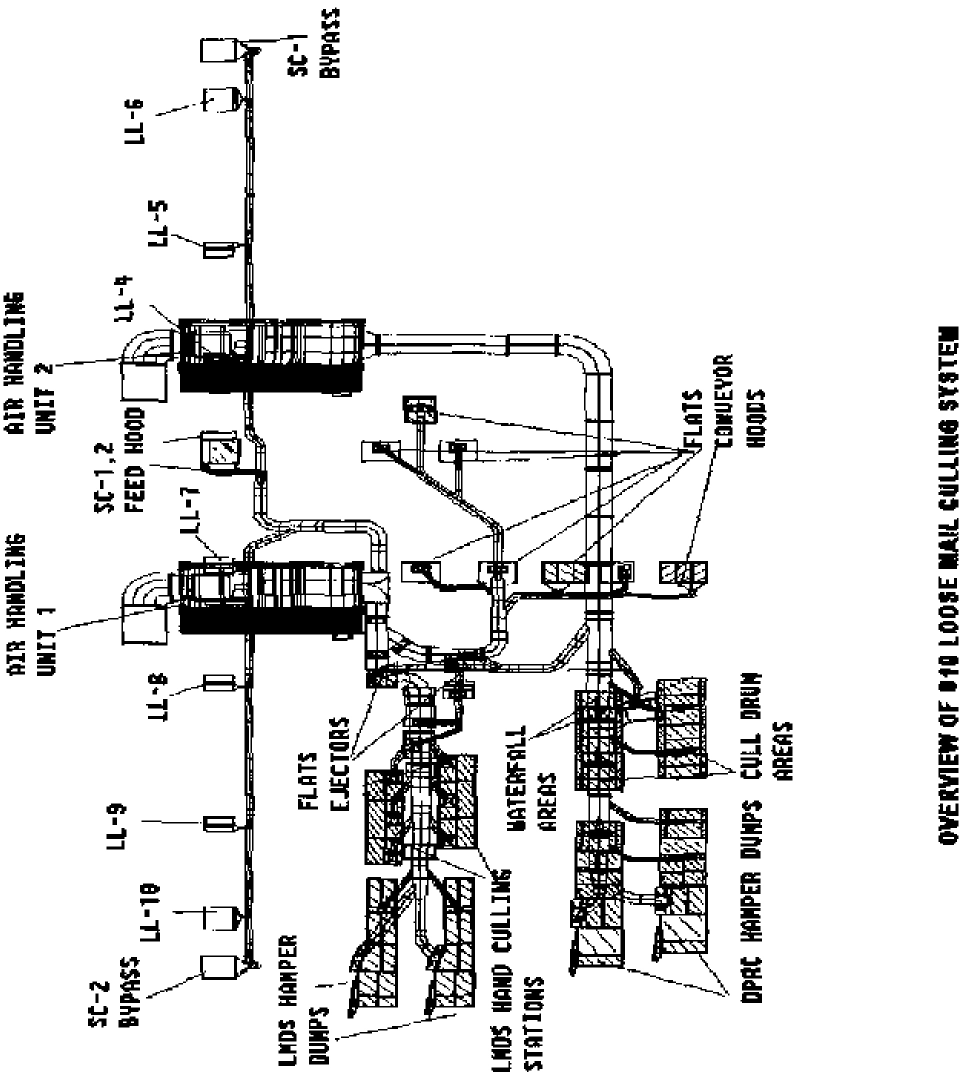
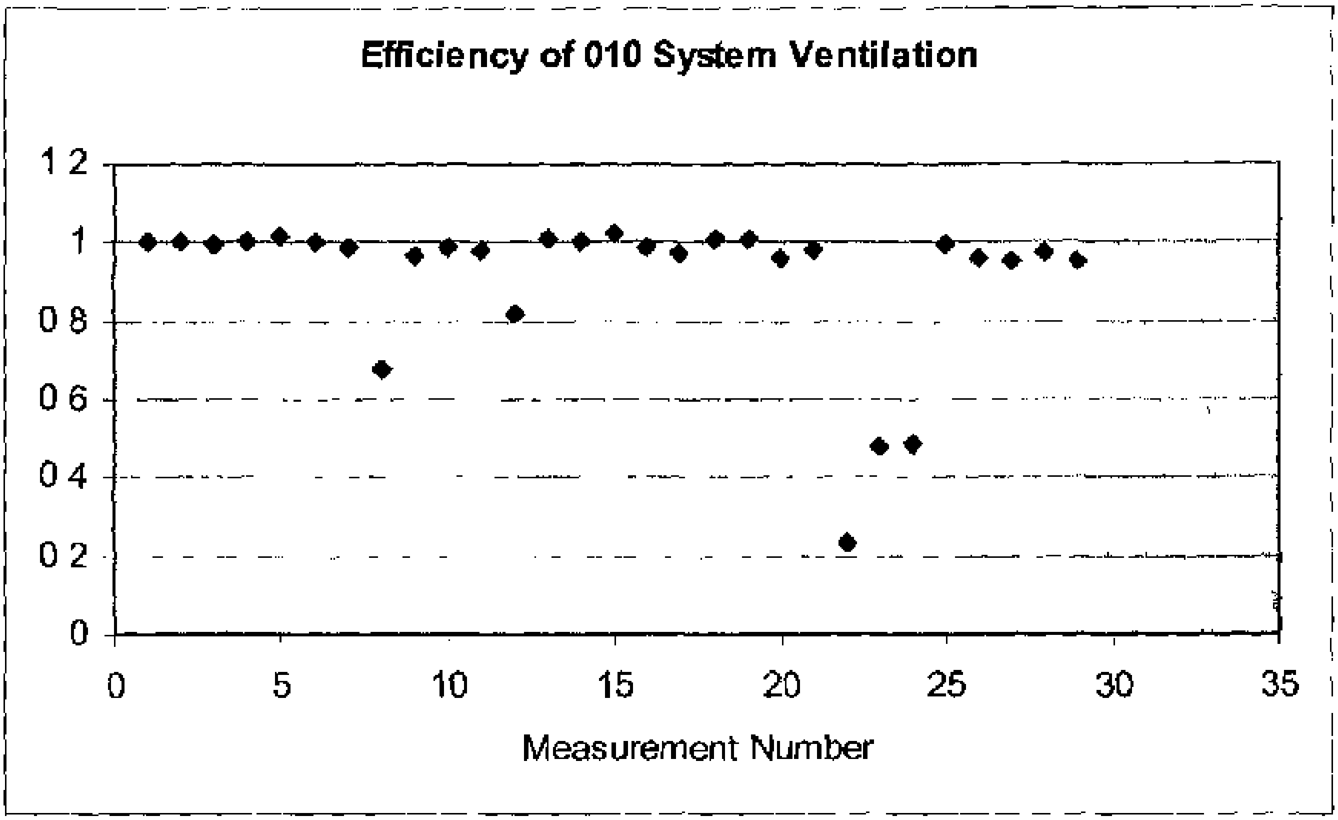


Figure 2 Efficiency of 010 System Ventilation



REFERENCES

1 Pile, James C MD, et al Anthrax as a Potential Biological Warfare Agent Arch Intern Med 158 429-434 1998

2 Mayer, Thom MD, et al Clinical Presentation of Inhalational Anthrax Following Bioterrorism Exposure JAMA 286(20) 2549-2553 2001